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OCP Oracle Database 10*g*: New Features for Administrators Exam Guide

Upgrade Your Certification for Oracle Database 10*g*

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SAM R. ALAPATI

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Oracle 10*g* New Features for Administrators
Study Guide

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San Francisco • London

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To Mary Christine and the Kids
—Bob Bryla

To Shiji and Joshua
—Biju Thomas

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—Bob Bryla

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—Biju Thomas

Contents at a Glance

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Introduction

The information technology (IT) industry has high demand for professionals, and Oracle certifications are the hottest credential in the database world. You have made the right decision to pursue an upgrade to your certification, because keeping your Oracle certification current will give you a distinct advantage in this highly competitive market.

Most readers should already be familiar with Oracle and do not need an introduction to the Oracle database world. For those who aren't familiar with the company, Oracle, founded in 1977, sold the first commercial relational database and is now the world's leading database company and second-largest independent software company, with revenues of more than $10 billion, serving more than 145 countries.

Oracle databases are the de facto standard for large Internet sites, and Oracle advertisers are boastful but honest when they proclaim that "the Internet runs on Oracle." Almost all big Internet sites run Oracle databases. Oracle's penetration of the database market runs deep and is not limited to dot-com implementations. Enterprise resource planning (ERP) application suites, data warehouses, and custom applications at many companies rely on Oracle. The demand for database administrator (DBA) resources remains higher than others during weak economic times.

This book is intended to help you upgrade from an Oracle *9i* Certified Professional to an Oracle 10*g* Certified Professional (OCP), clearing the way to pursue an Oracle Certified Master (OCM) certification. Using this book and a practice database, you can learn the new features of the Oracle 10*g* Database (Oracle 10*g*) and pass the 1Z0-040 Oracle Database 10*g*: New Features for Administrators exam.

Why Become an Oracle Certified Professional?

The number-one reason to become an OCP or maintain an OCP certification is to gain more visibility and greater access to the industry's most challenging opportunities. Oracle certification is the best way to demonstrate your knowledge and skills in Oracle database systems.

Certification is proof of your knowledge and shows that you have the skills required to support Oracle core products. The Oracle certification program can help a company identify proven performers who have demonstrated their skills and who can support the company's investment in Oracle technology. It demonstrates that you have a solid understanding of your job role and the Oracle products used in that role.

OCPs are among the best paid in the IT industry. Salary surveys consistently show the OCP certification to yield higher salaries than other certifications, including Microsoft, Novell, and Cisco.

So, if you have an Oracle *9i* OCP certification, you have a solid practical background as a DBA, and you're ready to upgrade your certification to Oracle 10*g*, this book is for you!

Oracle Certifications

Oracle certifications follow a track that is oriented toward a job role. The certifications consist of database administration, application developer, and web application server administrator tracks. Within each track, Oracle has a multitiered certification program.

In addition to this multitiered approach, Oracle provides upgrade paths from previous versions of Oracle as well as special accreditations that you can attach to your certification.

The material in this book will address only the upgrade from the Oracle 9*i* to the Oracle 10*g* database administration track and the exam 1Z0-040 Oracle Database 10*g*: New Features for Administrators. Other Sybex books at `http://www.sybex.com` can help students new to the DBA world prepare for the OCA exam 1Z0-042 Oracle Database 10*g*: Administration I and for the OCP exam 1Z0-043 Oracle Database 10*g*: Administration II.

See the Oracle website at `http://www.oracle.com/education/certification` for the latest information on all of Oracle's certification paths along with Oracle's training resources.

The role of the DBA has become a key to success in today's highly complex database systems. The best DBAs work behind the scenes but are in the spotlight when critical issues arise. They plan, create, maintain, and ensure that the database is available for the business. They are always watching the database for performance issues and to prevent unscheduled downtime. The DBA's job requires broad understanding of the architecture of Oracle database and requires expertise in solving problems.

Since this book focuses on the DBA track, the following sections present a closer look at the different tiers of this track.

Oracle Database 10*g* Administrator Certified Associate

The Oracle 10*g* Administrator Certified Associate certification is a streamlined, entry-level certification for the database administration track and is required to advance toward the more senior certification tiers. This certification requires you pass the following exam that demonstrates your knowledge of Oracle basics:

- 1Z0-042 Oracle Database 10*g*: Administration I

Oracle Database 10*g* Administrator Certified Professional

The OCP tier of the database administration track challenges you to demonstrate your continuing experience and knowledge of Oracle technologies. The Oracle 10*g* Administrator Certified Professional certification requires achievement of the Administrator Certified Associate certification, as well as passing the following exam:

- 1Z0-043 Oracle Database 10*g*: Administration II

In addition, the OCP candidate must take one instructor-led in-class course from the following list:

- Oracle Database 10*g*: Administration Workshop I
- Oracle Database 10*g*: Administration Workshop II
- Oracle Database 10*g*: Introduction to SQL
- Oracle Database 10*g*: New Features for Administrators
- Oracle Database 10*g*: Program with PL/SQL

If you already have your OCP 9*i* or earlier and have elected to take the upgrade path, you do not need to take a class to achieve your OCP for Oracle 10*g*.

You should verify this list against the Oracle education website (`www.oracle.com/education`), as this list may change without any notice.

Oracle Database 10g Certified Master

Oracle Database 10*g* Administration Certified Master is the highest level of certification that Oracle offers. To become a certified master, you must first achieve Certified Professional status, then complete two advanced instructor-led classes at an Oracle education facility, and finally pass a hands-on, two-day exam at Oracle Education. The classes and practicum exam are offered only at an Oracle education facility and may require travel.

More details on the required coursework will be available in late 2004.

Oracle 10*g* Upgrade Paths

Existing OCPs can upgrade their certification in a number of ways: A single exam can upgrade an Oracle 8*i* DBA directly to Oracle Database 10*g* certification in addition to the certification upgrade from Oracle 9*i* to Oracle Database 10*g* covered in this book. Also, Oracle 7.3 and Oracle 8 DBAs can upgrade to an Oracle 9*i* certification with a single exam.

Oracle Database 10*g* Administrator Special Accreditations

New to the Oracle certification program are the Oracle Database 10g Administrator Special Accreditation programs. These accreditations formally recognize the specialized knowledge of OCPs, in particular database administration areas such as high availability, security, and 10*g* Grid Control. OCPs who pass one of these special accreditation exams will receive a certificate that formally recognizes their specialized competency. The first Oracle Database 10g Special Accreditation will be the High Availability Special Accreditation, available in 2004.

Oracle Database 10*g* DBA Assessment

Oracle also provides an optional (and free) prerequisite to all the proctored exams, which is the following online exam:

- 1Z0-041 Oracle Database 10*g*: DBA Assessment

This exam evaluates your proficiency with basic administration and management of Oracle Database 10*g*, and upon passing this online exam you receive a certificate of completion from Oracle University. Although anyone can take this exam, it is designed for those new to Oracle and is an excellent measurement of how familiar you are with the new Oracle 10*g* database.

Oracle Exam Requirements

The Oracle Database 10*g*: New Features for Administrators exam covers a number of core subject areas. As with many typical multiple-choice exams, you can follow a number of tips to maximize your score on the exam.

Skills Required for the Oracle Database 10*g*: New Features for Administrators Exam

To pass the Oracle 9*i* to Oracle 10*g* certification upgrade exam, you need to master the following subject areas in Oracle 10*g*:

- Installation
- Server configuration
- Data loading and unloading
- Automatic management
- Manageability infrastructure
- Application tuning
- Support for analytical applications
- System resource management
- Automating tasks with the Scheduler
- Space management
- Improved VLDB support
- Backup and recovery enhancements
- Flashback any error
- General storage enhancement
- Automatic storage enhancement
- Software maintenance
- Security
- Miscellaneous new features

Tips for Taking the OCP Exam

Use the following tips to help you prepare for and pass the exam:

- The OCP upgrade exam contains about 55–80 questions to be completed in 90 minutes. Answer the questions you know first so that you do not run out of time.
- Many questions on the exam have answer choices that at first glance look identical. Read the questions carefully. Do not just jump to conclusions. Make sure you clearly understand what each question asks.
- Some questions are based on scenarios. Some of the scenarios contain nonessential information and exhibits. You need to be able to identify what's important and what's not important.
- Do not leave any questions unanswered. There is no negative scoring; always answer a question rather than leave it blank. After selecting an answer, you can mark a difficult question or one that you're unsure of and come back to it later.
- When answering questions you are not sure about, use a process of elimination to get rid of the obviously incorrect answers first. Doing this greatly improves your odds if you need to make an educated guess.
- If you are not sure of your answer, mark it for review and then look for other questions that may help you eliminate any incorrect answers. At the end of the test, you can review the questions you marked earlier.

You should be familiar with the exam objectives, which are included in the front of this book as a perforated tear-out card. You can also find them at `www.oracle.com/education/certification/objectives/index.html?40.html`. In addition, if you would like information about recommended classes and passing scores, visit `www.oracle.com/education/certification/index.html?dba_upgrade.html`.

Where Do You Take the New Features Exam?

The 1Z0-040 Oracle Database 10*g*: New Features for Administrators exam is available at any of the more than 900 Sylvan Prometric Authorized Testing Centers around the world. For the location of a testing center near you, call 1-800-891-3926. Outside the United States and Canada, contact your local Sylvan Prometric Registration Center.

To register for a proctored OCP exam at a Sylvan Prometric test center, follow these steps:

1. Determine the number of the exam you want to take. For the New Features exam, it is 1Z0-040.
2. Register with Sylvan Prometric online at `http://www.prometric.com` or in North America by calling 1-800-891-EXAM (800-891-3926). At this point, you will be asked to pay for the exam. At the time of this writing, the exams are $125 each and must be taken within one year of payment.
3. When you schedule the exam, you'll get instructions regarding all appointment and cancellation procedures, the ID requirements, and information about the testing location.

You can schedule exams up to six weeks in advance or as soon as one working day before the day you want to take it. If you need to cancel or reschedule your exam appointment, contact Sylvan Prometric at least 24 hours or one business day in advance.

What Does This Book Cover?

This book covers everything you need to pass the Oracle 10*g* New Features for Administrators exam. Each chapter begins with a list of exam objectives.

Chapter 1 In this chapter, we discuss the new Oracle 10*g* installation procedures, either for an upgrade from a previous installation or for a new installation.

Chapter 2 This chapter explains the Oracle 10*g* Job Scheduler, the new Data Pump export and import features, and enhancements to external tables.

Chapter 3 In this chapter, we discuss the various automated management features of Oracle 10*g*, such as the new statistics collection methods, the Automatic Workload Repository (AWR), and the Resource Manager enhancements.

Chapter 4 In this chapter, you will learn about the storage and space management enhancements, including the `SYSAUX` tablespace and bigfile tablespaces.

Chapter 5 This chapter explains the automated space management enhancements in Oracle 10*g*, including how to set up and manage an Automatic Storage Management (ASM) instance with ASM disk groups. In addition, this chapter covers proactive space management features and new segment space management features.

Chapter 6 In this chapter, we discuss performance enhancements, especially in the areas of statistics collection, SQL statement tuning, and Automatic Shared Memory Management (ASMM).

Chapter 7 This chapter explains the new database availability features in Oracle 10*g*. In addition to a number of Recovery Management (RMAN) enhancements, several new types of human error correction methods are covered: Flashback Database, Flashback Drop, Flashback Versions Query, Flashback Transaction Query, and Flashback Table.

Chapter 8 Here, we discuss security enhancements related to Virtual Private Databases (VPDs), as well as a number of miscellaneous enhancements in data warehouse and analytical application environments.

Each chapter ends with a list of exam essentials, which summarize the chapter, with a slant on the topics you need to be familiar with for the exam. The chapters conclude with 20 review questions specifically designed to help you retain the knowledge presented. To really hone your skills, read and answer each question carefully.

How to Use This Book

This book provides a solid foundation for the serious effort of preparing for the Oracle 10*g* OCP upgrade exam. To best benefit from this book, use the following study method:

1. Take the assessment test immediately following this introduction. (The answers are at the end of the test.) Carefully read the explanations for any questions you get wrong, and note in which chapters the material is covered. This information should help you plan your study strategy.
2. Study each chapter carefully, making sure you fully understand the information and the test objectives listed at the beginning of each chapter. Pay close attention to any chapter related to questions you missed in the assessment test.
3. Complete all hands-on exercises in the chapter, referring to the chapter so that you understand the reason for each step you take. If you do not have an Oracle database available, be sure to study the examples carefully. Answer the review questions related to that chapter. (The answers appear at the end of each chapter, after the "Review Questions" section.)
4. Note the questions that confuse or trick you, and study those sections of the book again.
5. Take the two bonus exams included on the accompanying CD. This will give you a complete overview of what you can expect to see on the real test.
6. Remember to use the products on the CD included with this book. The electronic flashcards and the Sybex Test Engine exam preparation software have been specifically designed to help you study for and pass your exam.

To learn all the material covered in this book, you will need to apply yourself regularly and with discipline. Try to set aside the same time period every day to study, and select a comfortable and quiet place to do so. If you work hard, you will be surprised at how quickly you learn this material. All the best!

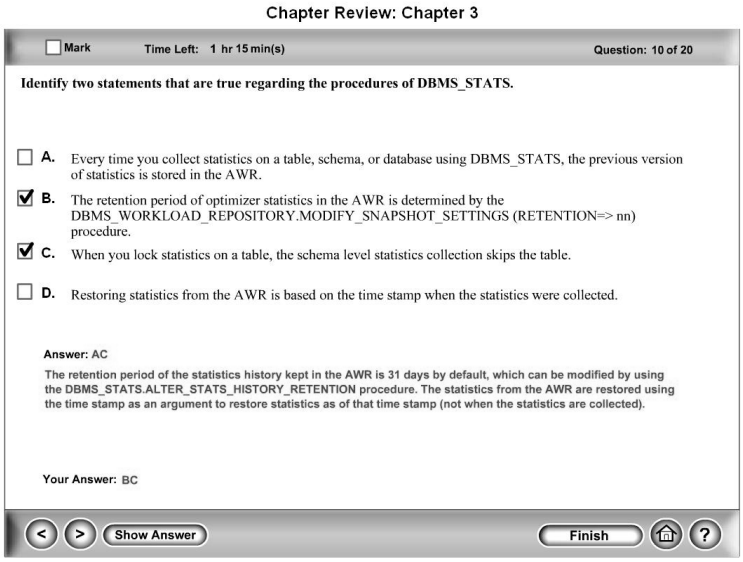
What's on the CD?

We have worked hard to provide some really great tools to help you with your certification process. All the following tools should be loaded on your workstation when you're studying for the test.

The Sybex Test Engine Preparation Software

This test-preparation software helps you to pass the 1Z0-040 Oracle Database 10*g*: New Features for Administrators exam. In this test, you will find all the questions from the book, plus two additional bonus exams that appear exclusively on the CD. You can take the assessment test, test yourself by chapter, or take the practice exams. The test engine installs on both a Windows platform and Linux platform.

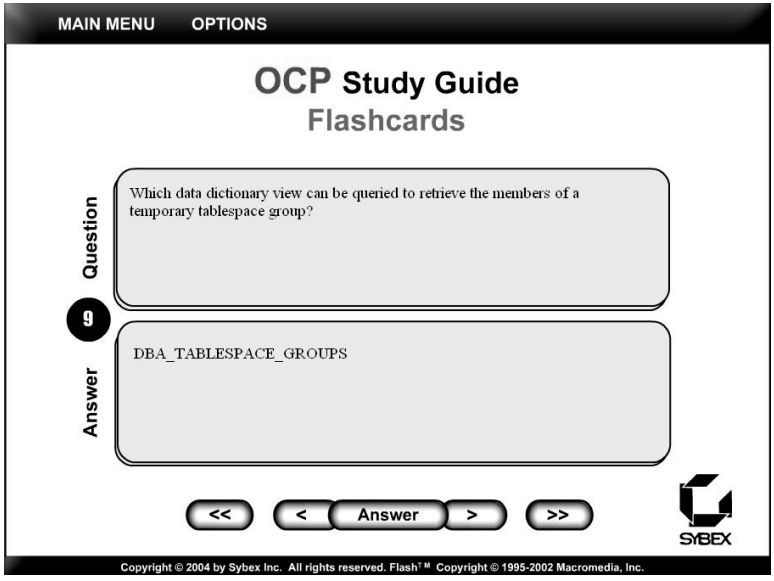
Here is a sample screen from the Sybex Test Engine:



Electronic Flashcards for PC and Palm Devices

After you read the *OCP: Oracle 10g New Features for Administrators Study Guide*, read the review questions at the end of each chapter, and study the practice exams included in the book and on the CD. You can also test yourself with the flashcards included on the CD.

The flashcards are designed to test your understanding of the fundamental concepts covered in the exam. Here is what the Sybex flashcard interface looks like:



OCP: Oracle 10g New Features for Administrators Study Guide in PDF

Many people like the convenience of being able to carry their study guide on a CD, which is why we included this book in PDF. This will be extremely helpful to readers who fly or commute on a bus or train and don't want to carry a book, as well as to readers who find it more comfortable reading from their computer. We've also included a copy of Adobe Acrobat Reader on the CD.

How to Contact the Authors

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To contact Biju Thomas, you can e-mail him at `biju@bijoos.com` or visit his website for DBAs at `http://www.bijoos.com/oracle`.

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Biju Thomas is an Oracle 7.3, Oracle 8, Oracle 8*i*, Oracle 9*i*, and Oracle 10*g* Certified Professional with more than 11 years of Oracle database management and application development experience. He is a senior database administrator for Delinea Corporation and resides in Fort Worth, Texas. He maintains a website for DBAs at `http://www.bijoos.com/oracle`.

Assessment Test

1. When manually upgrading an Oracle 9*i* database to Oracle 10*g*, which shutdown option must be used in Oracle 9*i* before starting the database in Oracle 10*g* for upgrade?
   - **A.** `SHUTDOWN UPGRADE`
   - **B.** `SHUTDOWN MIGRATE`
   - **C.** `SHUTDOWN IMMEDIATE`
   - **D.** `SHUTDOWN ABORT`
2. When installing the Oracle 10*g* database software Enterprise Edition with the Enterprise Manager (EM) Database Control, how many CDs are required?
   - **A.** 2
   - **B.** 1
   - **C.** 3
   - **D.** 4
3. Identify the statement that is true regarding the `COMPATIBLE` parameter in Oracle 10*g*.
   - **A.** For upgrading a database to Oracle 10*g*, you must have the `COMPATIBLE` parameter set to 9.2.0 or higher.
   - **B.** After upgrading the database to Oracle 10*g* and starting the database with `COMPATIBLE=10.1.0`, you can restart the database using `COMPATIBLE=9.2.0` if you did not like the optimizer plans generated by the Oracle 10*g* database.
   - **C.** When upgrading an Oracle 8*i* database to Oracle 10*g*, the `COMPATIBLE` parameter must be set to 8.1.7.
   - **D.** If you do not explicitly set the `COMPATIBLE` parameter in the initialization parameter file while upgrading to Oracle 10*g*, you can downgrade the database to Oracle 9*i*.
4. Which Data Pump parameters can be used to unload or export data from SCOTT.EMP table where the rows belong to DEPT=10? (Choose three that apply.)
   - **A.** `EXCLUDE`
   - **B.** `INCLUDE`
   - **C.** `QUERY`
   - **D.** `CONTENT`
   - **E.** `ROWS`

5. Using calendaring expressions to schedule a job, how would you specify the Wednesday two weeks prior to the last Wednesday of every month?
   - **A.** `FREQ=MONTHLY; BYDAY=-2WED`
   - **B.** `FREQ=WEEKLY; BYWEEK=-2`
   - **C.** `FREQ=MONTHLY; BYWEEK=-2WED`
   - **D.** `FREQ=WEEKLY; BYDAY=-2WED`

6. Identify the statement that best describes the behavior of AWR snapshots.
   - **A.** Snapshots are created every 60 minutes, and the interval cannot be changed.
   - **B.** Snapshots are created every 60 minutes, and the interval can be changed by setting an initialization parameter.
   - **C.** Snapshots intervals must be 30-minute increments.
   - **D.** The `DBMS_WORKLOAD_REPOSITORY.MODIFY_SNAPSHOT_SETTINGS` procedure can be used to set the interval of snapshots.

7. Which two parameter settings enable Automatic Shared Memory Management in Oracle 10*g*?
   - **A.** `SGA_MAX_SIZE`
   - **B.** `SGA_TARGET`
   - **C.** `TIMED_STATISTICS`
   - **D.** `STATISTICS_LEVEL`
   - **E.** `OPTIMIZER_MODE`

8. Identify the attribute that is not valid when setting `DBMS_RESOURCE_MANAGER.SET_CONSUMER_GROUP_MAPPING`.
   - **A.** `SERVICE_MODULE`
   - **B.** `MODULE_NAME_ACTION`
   - **C.** `CLIENT_PROGRAM_ACTION`
   - **D.** `CLIENT_MACHINE`
   - **E.** `SERVICE_NAME`

9. A bigfile tablespace can consist of how many datafiles?
   - **A.** One
   - **B.** Only one, and there can be only one bigfile tablespace per database
   - **C.** Limited only by the `DB_FILES` initialization parameter
   - **D.** Two—one for tables, and one for indexes

10. Which tablespaces are required in an installation of Oracle 10*g*? (Choose all that apply.)

A. USERS

B. UNDO

C. SYSTEM

D. SYSAUX

E. TEMP

F. All of the above

11. Which types of files can be copied using the COPY_FILE and PUT_FILE procedures? (Choose all that apply.)

A. Tablespace datafiles

B. A 4TB binary LOB

C. Files that do not need character set conversion

D. Binary files that are a multiple of 1,024 bytes

12. Which of the following statements is not true about temporary tablespace groups?

A. A temporary tablespace may belong to no temporary tablespace groups.

B. A temporary tablespace group can have no members.

C. A temporary tablespace may belong to one and only one temporary tablespace group.

D. Users can be assigned a temporary tablespace or to a temporary tablespace group.

13. Given the index HR.IDX_PK_EMP on the table HR.EMPLOYEES and following ALTER INDEX command

```
ALTER INDEX HR.IDX_PK_EMP COALESCE;
```

which of the following commands also accomplishes this task? (Choose the best answer.)

A. `ALTER TABLE HR.EMPLOYEES SHRINK SPACE CASCADE;`

B. `ALTER TABLE HR.EMPLOYEES SHRINK SPACE;`

C. `ALTER TABLE HR.EMPLOYEES SHRINK SPACE COMPACT;`

D. `ALTER INDEX HR.IDX_PK_EMP REBUILD;`

14. Which type of queue is supported by sorted hash clusters?

A. DEQUE

B. LIFO

C. FIFO

D. A queue represented by a two-way linked list

15. Automatic Storage Management disk group mirroring is done at which level?

A. Tablespace level

B. Extent level

C. Segment level

D. Datafile level

16. Which of the following statements is not true about segment shrink operations?
    A. The compaction phase of segment shrink is done online.
    B. During the compaction phase, the entire segment is locked but only for a very short period of time.
    C. When the second phase of segment shrink occurs, the HWM is adjusted.
    D. User DML can block the progress of the compaction phase until the DML is committed or rolled back.
    E. Using the `COMPACT` keyword, the movement of the HWM can occur later during nonpeak hours by running the command without the `COMPACT` keyword.

17. What value for `OPTIMZER_MODE` will allow you to minimize resource costs for executing queries and return all rows?
    A. `ALL_ROWS`
    B. `CHOOSE`
    C. `RULE`
    D. `FIRST_ROWS`

18. Which of the following are not default components of the cost optimizer model? (Choose two.)
    A. CPU usage
    B. Memory usage
    C. Session waits
    D. I/O usage

19. Which of the following RMAN commands will create a full backup of the database in compressed backupset format?
    A. `BACKUP AS COMPRESSED BACKUPSET DATABASE;`
    B. `BACKUP DATABASE AS COMPRESSED BACKUPSET;`
    C. `BACKUP FULL DATABASE;`
    D. `BACKUP AS COMPRESSED IMAGE DATABASE;`

20. Which type of file is not backed up in the flash recovery area? Choose two.
    A. The control file
    B. RMAN files
    C. Online redo log files
    D. Datafile copies
    E. Archived log files
    F. Control file autobackups
    G. Password files

21. The Flashback Table functionality provides all of the following advantages except for which option?

A. A Flashback Table operation is performed in place while the database is online.

B. Restoring a table that was dropped.

C. All dependent objects are restored as a single transaction along with the target table.

D. Flashback Table can often be used instead of point-in-time recovery of the database or a tablespace.

22. Which of the following initialization parameters ensures that all database files will use OMF to name the files at the operating system level? Choose two.

A. `DB_CREATE_FILE_DEST`

B. `DB_RECOVERY_FILE_DEST_SIZE`

C. `DB_RECOVERY_FILE_DEST`

D. `DB_CREATE_ONLINE_LOG_DEST_`*n*

23. Which statement is not true regarding the enhancements to the `MERGE` statement in Oracle 10*g*?

A. The `ON` clause is optional, which lets you perform unconditional inserts.

B. You can provide the `DELETE` in the `WHEN MATCHED` clause to delete rows.

C. You can add an optional `WHERE` clause to the `WHEN MATCHED` and `WHEN NOT MATCHED` clauses.

D. You may omit the `WHEN MATCHED` or `WHEN NOT MATCHED` clauses.

24. Choose the policy type that is default in Oracle 10*g* when creating a security policy.

A. Static

B. Dynamic

C. Shared static

D. Context sensitive

25. Which attribute enables Oracle 10*g* to perform end-to-end application tracing in a multitier environment?

A. Service name

B. Module name

C. Action name

D. Client identifier

Answers to Assessment Test

1. C. For database upgrade, the database must have a clean shutdown. `SHUTDOWN IMMEDIATE`, `NORMAL`, or `TRANSACTIONAL` can be used for a clean shutdown. `SHUTDOWN ABORT` should never be used. `SHUTDOWN MIGRATE` and `SHUTDOWN UPGRADE` are not valid options. For more information about startup and shutdown options when upgrading a database, refer to Chapter 1.

2. B. Oracle 10*g* facilitates installing the most common database features—the EM Database Control, database templates, and sample schema—from one CD. The companion CD includes JPublisher, Java libraries, and Legato Single Server. For more information on the components that can be installed from each CD, read Chapter 1.

3. A. The minimum value for the `COMPATIBLE` parameter in an Oracle 10*g* database is 9.2.0. For upgrade, this must be the minimum value. Once the database is started using `COMPATIBLE=10.1.0`, you cannot start the database with `COMPATIBLE=9.2.0` because of the irreversible datafile compatibility. If you do not set the `COMPATIBLE` value, the default is `10.0.0`; hence, you cannot start the database in Oracle 9*i* for downgrade. To learn more about the steps involved in the database upgrade to Oracle 10*g* and the restrictions on the `COMPATIBLE` parameter, read Chapter 1.

4. B, C, D. The parameters should be `INCLUDE=SCOTT.EMP`, `CONTENT=ALL`, and `QUERY='WHERE DEPT=10'`. `ROWS` is not a supported Data Pump parameter. `INCLUDE` and `EXCLUDE` parameters are mutually exclusive. To learn about Oracle Data Pump, read Chapter 2.

5. A. `FREQ=MONTLY` specifies the repeat interval is every month. `BYDAY=-2WED` specifies the second-to-last Wednesday. To learn more about calendaring expressions and the components of the scheduler, refer to Chapter 2.

6. D. The `MMON` process takes the AWR snapshots are taken by every hour, and you can change the interval using the `MODIFY_SNAPSHOT_SETTINGS` procedure. The minimum value for the interval is 10 minutes, but the increments need not be 30 minutes. For more information on the AWR and the manageability infrastructure, read Chapter 3.

7. B, D. To enable Automatic Shared Memory Management, the `STATISTICS_LEVEL` parameter should not be `BASIC` and the `SGA_TARGET` should be a nonzero value. The default for `STATISTICS_LEVEL` is `TYPICAL`. To learn more about the automatic features of Oracle 10*g*, read Chapter 3.

8. C. The `SET_CONSUMER_GROUP_MAPPING` procedure is used to set the consumer group when logged into a session. `CLIENT_PROGRAM` is the valid attribute, and `CLIENT_PROGRAM_ACTION` is not. For more information on resource manager enhancements in Oracle 10*g*, read Chapter 3.

9. A. The correspondence between bigfile tablespaces and their datafiles is 1:1, and every tablespace in the database can be a bigfile tablespace. Also, a database can contain both bigfile and smallfile tablespaces. Chapter 4 discusses bigfile tablespaces.

10. C, D. Only the SYSTEM and SYSAUX tablespaces are required for an installation of Oracle 10*g*. However, it is strongly recommended that default tablespaces for both permanent and temporary segments such as USERS and TEMP be created to prevent contention in the SYSTEM tablespace. The UNDO tablespace supports automatic undo management and is also recommended but is not required. Chapter 4 discusses the new SYSAUX tablespace in detail.

11. A, C, D. Copying files with the procedures PUT_FILE and COPY_FILE in the DBMS_FILE_TRANSFER package can transfer only binary files with an upper limit of 2TB and must be a multiple of 512 bytes; also, only files that do not need character set conversion can be copied with COPY_FILE and PUT_FILE. To learn about copying database and other binary files with Oracle directories and the DBMS_FILE_TRANSFER package, refer to Chapter 4.

12. B. A temporary tablespace group cannot exist without any members; dropping the last temporary tablespace from the group drops the group itself. The syntax for adding a user to a temporary tablespace is identical to the syntax for adding a user to a temporary tablespace group. To learn more about temporary tablespace groups, see Chapter 4.

13. A. Using the CASCADE keyword in any segment shrink operation will shrink the free space in any dependent objects such as indexes. Chapter 5 discusses segment shrink functionality.

14. C. Sorted hash clusters are similar to standard hash clusters except that they store data sorted by nonprimary key columns and make access by applications that use the rows in a first in, first out (FIFO) manner very efficient; no sorting is required. Chapter 5 covers how sorted hash clusters are created and used.

15. B. Disk group mirroring for ASM is done at the extent level. To learn about Automatic Storage Management mirroring, see Chapter 5.

16. B. During the compaction phase, locks are held only on individual rows, causing some minor serialization with concurrent DML operations. For more information about segment shrink, see Chapter 5.

17. A. ALL_ROWS, the default for OPTIMIZER_MODE, maximizes throughput and minimizes the resources needed to complete the entire statement. CHOOSE and RULE are no longer valid. FIRST_ROWS (along with FIRST_ROWS_*n*) optimizes resources to improve response time for the initial rows returned from the query. Chapter 6 discusses changes to initialization parameters related to the optimizer.

18. B, C. As of Oracle 9*i*, CPU usage can be factored into the cost model to accommodate CPU-only or CPU-intensive operations. As of Oracle 10*g*, CPU+I/O is the default. Chapter 6 discusses enhancements to the Oracle query optimizer.

19. A. The BACKUP AS COMPRESSED BACKUPSET DATABASE command will create a compressed backupset backup. All other choices are syntactically incorrect. You may omit the AS COMPRESSED BACKUPSET clause if the default backup type for DISK is set to COMPRESSED BACKUPSET. Chapter 7 discusses creating and maintaining compressed backups.

20. C, G. Online redo log files are used for recovery after an instance failure and should not be backed up under any backup scenario. Chapter 7 details using the flash recovery area. Password files are not backed up to the flash recovery area.

21. B. Flashback Drop restores a table that was dropped. To learn about Flashback Table and all the other flashback options, see Chapter 7.

22. A, D. Both `DB_CREATE_FILE_DEST` and `DB_CREATE_ONLINE_LOG_DEST_n` enable the DBA to use OMF for file naming in the database area. The parameters `DB_RECOVERY_FILE_DEST_SIZE` and `DB_RECOVERY_FILE_DEST` do not directly enable OMF, but files can be created in the flash recovery area using OMF. To learn more about using OMF with the flash recovery area, see Chapter 7.

23. A. The `MERGE` statement allows you to perform unconditional inserts by using a constant predicate for the `ON` clause, for example, `ON (1=0)`. To learn more about `MERGE` statement and other SQL enhancements, read Chapter 8.

24. B. Dynamic was the only policy type available in Oracle 9*i*. Though other policy types are available in Oracle 10*g*, the dynamic policy type is the default. Learn more about security enhancements in Chapter 8.

25. D. The client identifier uniquely identifies a client and is carried through all tiers to the database server. To read more about end-to-end application tracing and other Oracle 10*g* enhancements, read Chapter 8.

Chapter 1

Installing and Upgrading to Oracle 10*g*

ORACLE DATABASE 10*g* NEW FEATURES FOR ADMINISTRATORS EXAM OBJECTIVES COVERED IN THIS CHAPTER:

- ✓ **Installation**
  - Describe installation new features support
  - Describe installation performance enhancements
- ✓ **Server Configuration**
  - Simplify instance configuration using a subset of initialization parameters
  - Use policy-based database configuration framework
  - Use DBCA to clone database
  - View database usage statistics through EM
- ✓ **Maintain Software**
  - Understand the supported upgrade paths to Oracle Database 10*g*
  - Use new utility to perform pre-upgrade validation checks
  - Use simplified upgrade process that automatically determines components to be upgraded
  - Start up the database using a new mode when upgrading

Exam objectives are subject to change at any time without prior notice and at Oracle's sole discretion. Please visit Oracle's Training and Certification website (`http://www.oracle.com/education/certification/`) for the most current exam objectives listing.

With the release of Oracle Database 10*g* (Oracle 10*g*), DBAs have a database that is simple to set up, more robust, and self-managing. Oracle 10*g* is full of new features, most of which the DBAs long awaited and many of which are designed with the DBA in mind. Though this book is not intended to review and explain all the new features of Oracle 10*g*, we will explain all the features relevant to the OCP New Features for Administrators exam.

According to the International Oracle Users Group (IOUG), DBAs spend more than 50 percent of their time managing the database, which includes tuning, managing space, managing storage, and performing backup and recovery. Oracle 10*g* has put a lot of focus on the managing database area so that you can spend your time on proactive and strategic planning. Oracle 10*g* is a self-managing database. Automatic management of the database includes storage management, SQL management and tuning, resource management, space management, and backup recovery management.

The *g* in Oracle 10*g* stands for *grid*. Grid computing is designed to reduce costs, make the most efficient use of all resources, and easily adapt to the ever-growing needs of the business. Oracle's grid architecture combines all the available resources (network, servers, and disk) into a large pool of resources (the grid); users can subscribe to these resources based on their requirements. Grid computing uses sophisticated workload management that makes it possible for applications to share resources across many servers. Data processing capacity can be added or removed on demand, and resources within a location can be dynamically provisioned. According to Larry Ellison, grid computing for end users is like subscribing to the electric (utility) company. You consume what you need. When you consume more, more resources are made available. The subscriber does not know where the generator is or how the electric grid is wired.

In Oracle 10*g*, you can clone a database and the Oracle software installation (the Oracle installation home directory) to a location on the same server or to a remote server. The Enterprise Manager comes with several out-of the box policy verifications that can alert you to the database security and configuration issues. In this chapter, we will discuss the installation features, configuration enhancements, and upgrade options available for Oracle 10*g*.

Installing Oracle 10*g*

With Oracle 10*g*, the emphasis is on self-managing and keeping things simple. Oracle has removed many redundant and obvious choices from the installation. As a DBA, you need to enter only minimal (that is, absolutely required) information to install an Oracle database.

For a clean and trouble-free install, you must install the software to an empty directory. Do not install in the same directory where you have a previous version of Oracle software installed. For

all platforms, read the platform-specific installation document to make sure you have minimum required hardware and OS versions. On Unix platforms, you need to adjust the kernel parameters.

You can find the installation documentation—Oracle Database Quick Installation Guide—at http://www.oracle.com/technology/documentation/database10g.html.

In the following sections, we will discuss using the Oracle Universal Installer (OUI) to install Oracle 10*g* software, what new features of Oracle 10*g* the OUI supports, what installation checks the OUI performs, and enhancements made to the installation process.

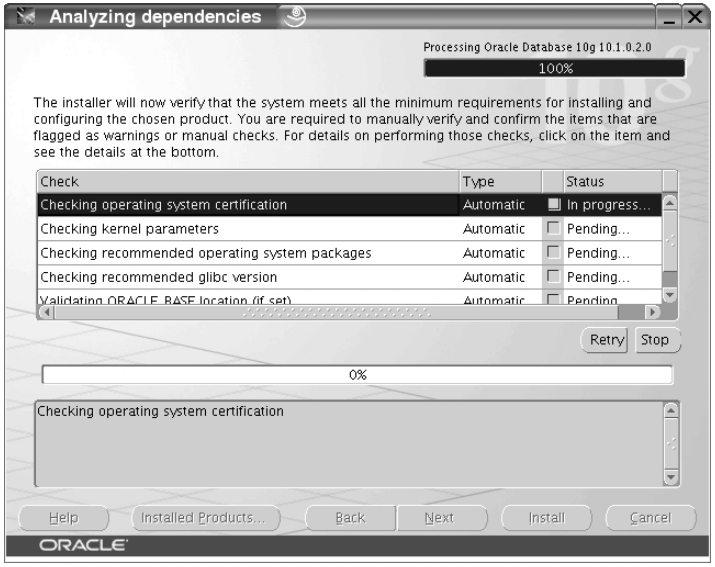
Using the Oracle Universal Installer

As in the previous releases of Oracle, Oracle 10*g* uses the OUI to install the software. With the OUI, the Oracle 10*g* installation process is simple. The most common Oracle 10*g* installation can be performed with just one CD. The OUI performs the necessary preinstall checks to make sure the operating system is certified and properly configured, the necessary patches are applied, and enough resources are available. If any problems are detected, it even recommends corrective action.

On the Windows platform, the OUI is invoked automatically when you insert the CD. To manually invoke the OUI, simply double-click the `setup.exe` icon from the root directory of the CD. On Unix platforms, you invoke the OUI by executing the `runInstaller` script. In the Oracle 10*g* database CD, `runInstaller` is in the root directory. If you're using the DVD, this script is under the `db` folder.

The OUI in Oracle 10*g* does a lot more checking for necessary resources before the installation begins. Figure 1.1 shows the OUI checking the necessary system requirements.

FIGURE 1.1 The OUI verifying install requirements



On Linux (and Unix) platforms, you invoke the OUI by using the script `runInstaller`; you may use the `-ignoreSysPrereqs` option to continue with Oracle 10*g* install, even if the flavor of Linux is not certified by Oracle. If you do not use this flag, `runInstaller` will fail. You do not have to use this flag on Red Hat 2.1, Red Hat 3, and United Linux 1.0.

In the next section, we will discuss the preinstall checks performed by the OUI before installing the Oracle 10*g* software, the software components you can install, and the options for creating a database along with the software install.

Checking Preinstall Requirements

The OUI automatically performs the following verifications (some steps are specific to the Linux/Unix platform):

- Checks for certified version of operating system software. For example, only the SuSE SLES-7, Red Hat Advanced Server 2.1, and United Linux 1.0 platforms are supported under Linux, and only Solaris 2.8 or higher is supported for Sun platforms. (Always verify current certifications at `http://technet.oracle.com`.)
- Checks to make sure 32-bit Oracle 10*g* software components are not installed to an Oracle home directory with 64-bit Oracle 10*g* software and vice versa.
- Verifies that all the required operating system patches are installed.
- Checks for all the required kernel parameters.
- Checks if the `DISPLAY` variable and X Server permissions are set.
- Verifies sufficient swap space and temporary space are available.
- Verifies that the Oracle home directory where the software being installed is either empty or has the supported version of software components. Previous versions of Oracle were allowed to install software to an Oracle home directory with a different software version, but Oracle 10*g* does not allow this. It warns you if the software directory is not empty.

Choosing the Components to Install

The Select Installation Type screen lets you choose the components of the database to install. The components are preconfigured into two major categories: Enterprise Edition and Standard Edition. You should choose the right component based on the requirement and license agreement.

Enterprise Edition includes all the database components, which may be essential for mission-critical applications. Standard Edition does not have certain features enabled, such as the data compression, materialized view query rewrite, transportable tablespaces, and so on.

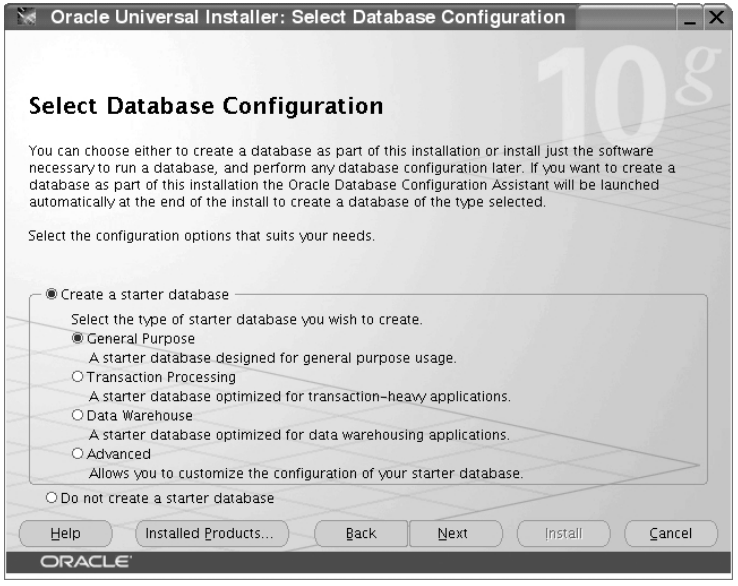
Windows platforms have an additional installation option: Personal Edition. This is similar to the Enterprise Edition and meant for single-user applications. Real Application Clusters (RAC) is not included in the Personal Edition.

You can also choose a custom installation type, where you can pick and choose the components to install.

Introducing Starter Database Options

The OUI, along with the software installation, can create an Oracle 10*g* database for you. If you're not creating a database along with the software install, you can specify that by choosing the Do Not Create a Starter Database option in the Select Database Configuration screen (see Figure 1.2).

FIGURE 1.2 The OUI: Select Database Configuration screen



The next screen you see will depend on which option you select in the Select Database Configuration screen. If you choose Do Not Create a Starter Database, the OUI shows the installation summary and proceeds with the software installation. If you choose General Purpose, Transaction Processing, or Data Warehouse as the type of the database, the OUI will get minimal information such as database management, file storage, backup location, and password for default accounts. After the software is installed, OUI will invoke the *Database Configuration Assistant (DBCA)* tool in noninteractive mode to create the database. The DBCA is a GUI tool to create a new database, configure an existing database, delete a database or clone a database.

The DBCA is discussed in detail later in the section "DBCA Enhancements."

If you choose Advanced as the database type, the OUI will install the software and at the end of installation invoke the DBCA utility interactively to get more information on the database options.

You can install sample *schemas* using the DBCA when creating the database. Sample schemas are schema objects with sample data in them. The following are the five schemas in the sample schema installation:

- HR
- IX
- OE
- PM
- SH

Most of the examples and sample code provided in the Oracle documentation are based on these sample schemas. Oracle will install the EXAMPLE tablespace using the following transportable tablespace method:

```
imp transport_tablespace=y
file=/orahome/product/10.1.0/assistants/dbca/
      ➥templates/example.dmp
log=/ora1/admin/ORA10GP/create/tts_example_imp.log
datafiles=/ora5/oradata/ORA10GP/example01.dbf
tablespaces=EXAMPLE
tts_owners=hr,oe,pm,ix,sh
```

You can install Oracle 8, Oracle 8*i*, Oracle 9*i*, and Oracle 10*g* databases in multiple (separate) Oracle home directories on the same computer and have Oracle 8 (8.0.6), Oracle 8*i* (8.1.7), Oracle 9*i* (9.2), and Oracle 10*g* clients connecting to any or all the databases. When using a client version older than the database release, all features specific to the release of the database may not be available to the client.

Examining the OUI Support for New Features

Oracle 10*g* is feature rich with Automatic Storage Management (ASM), Flashback database, Enterprise Manager Database Control, RAC control, and so on. The OUI includes screens to set up these options if you decide to create a starter database.

These screens will display only if you install a preconfigured database. For a custom install, or for using advanced database options, you obtain this information through the DBCA interface.

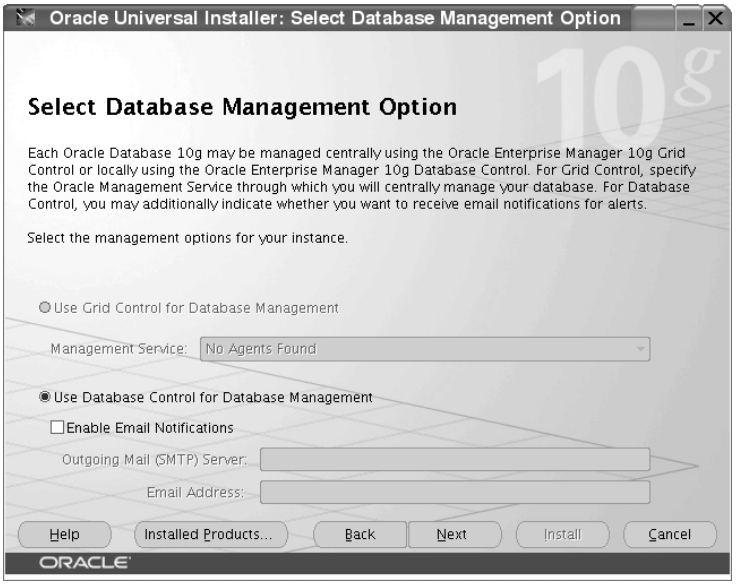
We will look at these options and how to install them in the following sections.

The specifics of these features will be discussed throughout the book.

Introducing Database Management Options

You can manage Oracle databases using the web-based tool *Oracle Enterprise Manger (EM)*. EM is a GUI tool to manage the Oracle environment, which includes database, host server, listener, HTTP server, and web applications. In the Select Database Management Option screen (see Figure 1.3), you can choose to manage all databases at a centralized location or manage a single database using the EM.

FIGURE 1.3 The Select Database Management Option screen



EM is installed by default if you install a preconfigured database (if you choose a custom install, you have the option not to install it). The options available are as follows:

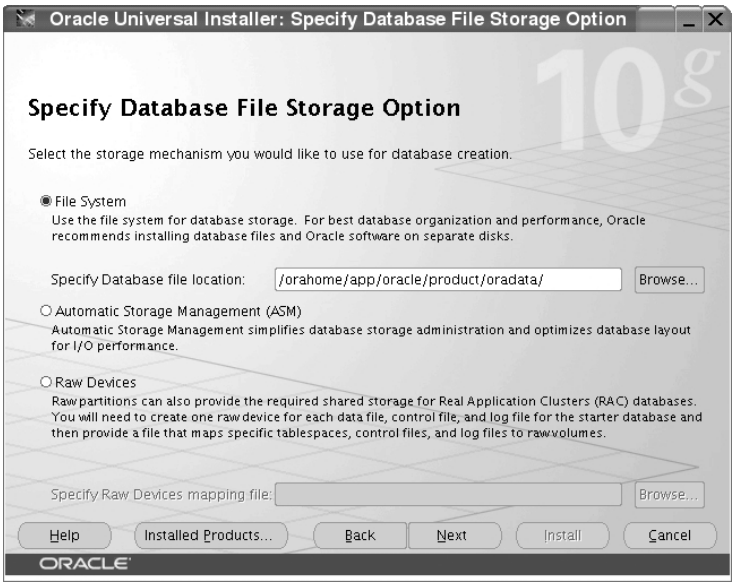
Use the Grid Control for database management Choose this option if you want to manage more than one database using a single EM interface. To deploy EM centrally, at least one Oracle Management Repository, at least one Oracle Management Service, and Oracle Management Agent must be installed on every server that you want to manage. EM 10*g* Grid Control is installed from a separate CD.

Use the Database Control for database management This option is selected by default if an *Oracle Management Agent* is not installed on the computer. Oracle Management Agent is responsible for monitoring all targets on the host, for communicating that information to the middle-tier Management Service, and for managing and maintaining the host and its targets. However, even if a Oracle Management Agent is installed, you can still choose to configure the Database Control to manage the database. Using this option, you can also specify an e-mail address where you want to receive the database alerts.

Introducing Database File Storage Options

The OUI gives the option to specify the type of storage you want for the database using the Specify Database File Storage Option screen, as shown in Figure 1.4.

FIGURE 1.4 The Specify Database File Storage Option screen



Oracle 10*g* supports the following three types of storage for its data:

File system Oracle database files are created under the directory you specify in this option. This method is the most commonly used and the easiest to set up. Oracle recommends creating the database files in a different file system that stores the Oracle software or operating system files. The file system could be a disk physically attached to the computer, a RAID/Logical Volume Manager configuration, or an NFS-mounted file system. Once File System is chosen, the next screen will accept the location of the data files.

Automatic Storage Management (ASM) Choose this option if you would like the data files to be stored in ASM disks. *Automatic Storage Management (ASM)* is a new feature in Oracle 10*g*. ASM manages the disk for database use and tunes I/O automatically. To use ASM, one or more ASM disk groups must exist. A disk group is a set of disk devices that ASM manages as a single unit. ASM spreads data evenly across all the devices in the disk group to optimize performance and utilization. When you choose ASM, Oracle checks if an ASM instance is running on the machine; if not, it will create one for you.

Raw devices If you choose this option, Oracle data files will be stored on disk directly, bypassing the operating system layer. Raw devices are disk partitions or logical volumes that have not been formatted with a file system. When using raw devices for database file storage, Oracle writes data directly to the partition or volume, bypassing the operating system's file system layer.

Introducing Backup and Recovery Options

You may enable automated database backup using the Specify Backup and Recovery Options screen (see Figure 1.5). Oracle uses Recovery Manager (RMAN) to back up the files and can set up a job to perform the backups.

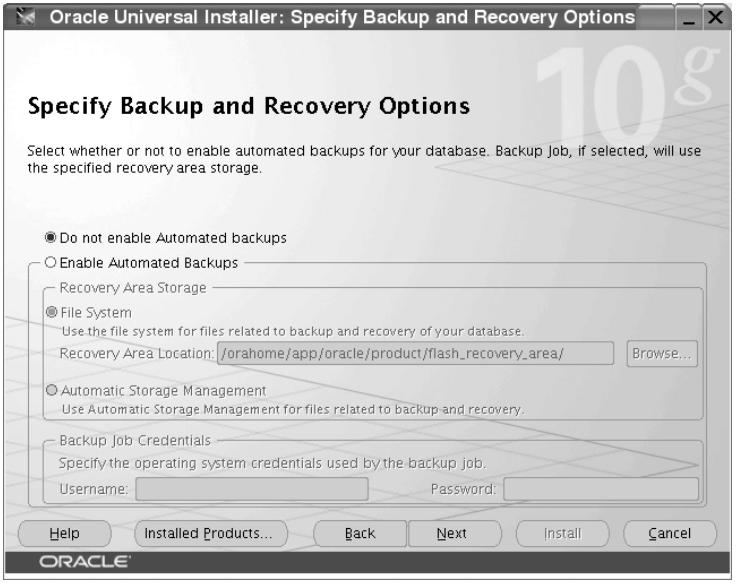
You can choose the following options from this screen:

Do Not Enable Automated Backups Choose this option if you do not want the OUI to set up backups. All databases should be backed up, so if you choose this option, make sure you define other methods to back up the database for data protection.

Enable Automated Backups Choose this option to set up backup job to run automatically every day. The backups can be written to a file system area or to ASM storage. The default disk quota configured for the flash recovery area is 2GB. The default job execution time is 2 a.m.

For ASM disk groups, the required disk space depends on the redundancy level of the disk group you choose. Normal redundancy is two-way mirroring, and high redundancy is three-way mirroring.

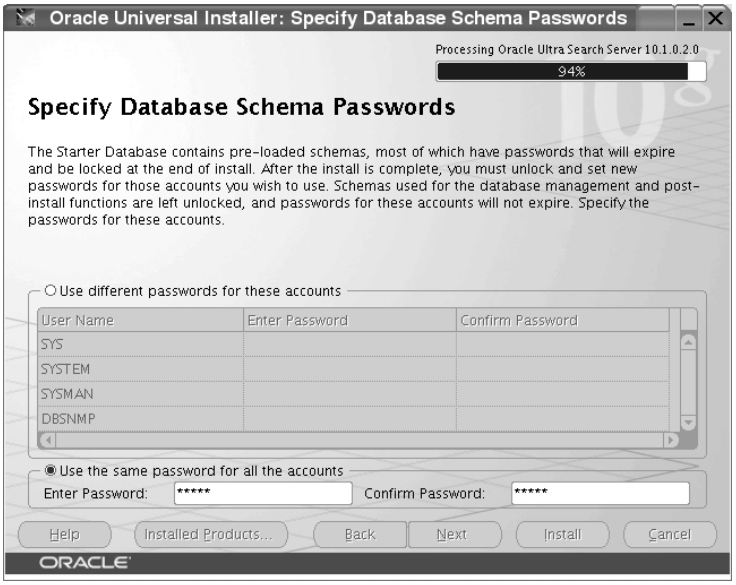
FIGURE 1.5 The Specify Backup and Recovery Options screen



Introducing Database Schema Password Options

Using the Specify Database Schema Passwords screen (see Figure 1.6), you can provide separate passwords for each administrative user, such as SYS, SYSTEM, SYSMAN, and DBSNMP, or provide one password for all.

FIGURE 1.6 The Specify Database Schema Passwords screen



Introducing Installation Enhancements

In addition to the new installation features, the Oracle 10*g* installer includes many performance and management enhancements over 9*i*. Oracle 10*g* groups the products into separate CDs so that you need to use only one CD at a time. The following are some of the CDs that ship with Oracle 10*g*; all these are included in one DVD:

- Oracle Database 10*g*
- Oracle Database 10*g* Companion CD
- Oracle Database 10*g* Client
- Oracle Cluster Ready Services
- Oracle Database Documentation Library

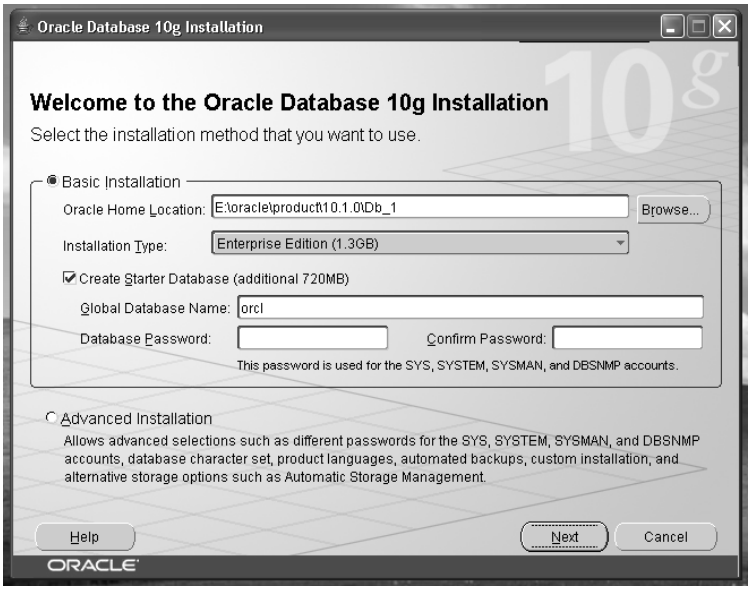
Oracle Enterprise Manager 10*g* Grid Control is shipped separately in one DVD or three CDs.

The installation completes in about 20 minutes and requires only one CD. The EM Webstage and Apache, which were installed with Oracle 9*i*, are no longer installed with the Oracle 10*g* database.

Oracle 10*g* has a simplified software install and database creation; the disk requirement for software is now less. The following are some of the install enhancements:

Simplified install The Oracle 10*g* installer can install the software and create a database with default settings from one screen. This simplifies the install actions required and is really useful for a new user. Figure 1.7 shows the install screen from a Windows platform. The Advanced Installation option lets you choose location, type of software installation, and other options.

FIGURE 1.7 The Welcome to the Oracle Database 10g Installation screen



Memory and disk Oracle 10*g* requires a minimum of 512MB for an instance with the Database Control and a minimum of 256MB for an instance without the Database Control. The OUI automatically checks the disk space requirements. The minimum is 1GB swap space (or twice the RAM), between 500MB and 2.5GB of disk space depending on the options, and about 1200MB for the preconfigured database.

Administrative passwords In Oracle 9*i* Release 2, you were required to enter the passwords for SYS and SYSTEM twice—once during installation and once after the database creation. In Oracle 10*g*, this information is required only once during installation.

Clean removal The Oracle 10*g* OUI removes the Oracle software cleanly, meaning no files are left in the Oracle home directory; files outside the Oracle home directory related to the install are also removed. Software removal also shuts down any databases that are currently using the Oracle home directory.

The silent install of Oracle using a reponse file in Unix is truly silent; you have no need to set up a DISPLAY variable. The response file records only the values used in dialog boxes needing user inputs.

Though most of the features used by the Oracle database can be installed from one CD, you may want to install a few products from the Oracle Database 10*g* Companion CD. The Oracle 10*g* Companion CD includes the following two main product options:

Oracle 10*g* products These products must be installed to an existing Oracle 10*g* home directory:

Oracle database examples Database examples are product demonstrations to learn the product features. These mostly use the sample schema data to demonstrate features.

JPublisher JPublisher is a Java utility that generates Java classes to represent the user-defined database entities in a Java program. JPublisher enables you to specify and customize the mapping of SQL object types, object reference types, and collection types (VARRAYs or nested tables) to Java classes in a strongly typed paradigm.

Legato Single Server Version Legato Single Server Version (LSSV) is a backup and recovery application that is developed by Legato Systems Inc. LSSV software includes a media management layer. Oracle RMAN requires this layer when using tape storage for database backups and restoration. LSSV manages the backup schedule and communicates with Oracle Recovery Manager (RMAN) to copy the Oracle data to tape.

Natively compiled Java libraries The CD includes JAccelerator and Oracle interMedia Image Accelerator, which contain the natively compiled Java libraries (NCOMPs) for Oracle JVM and Oracle interMedia. These libraries improve the performance of the Oracle JVM and Oracle interMedia.

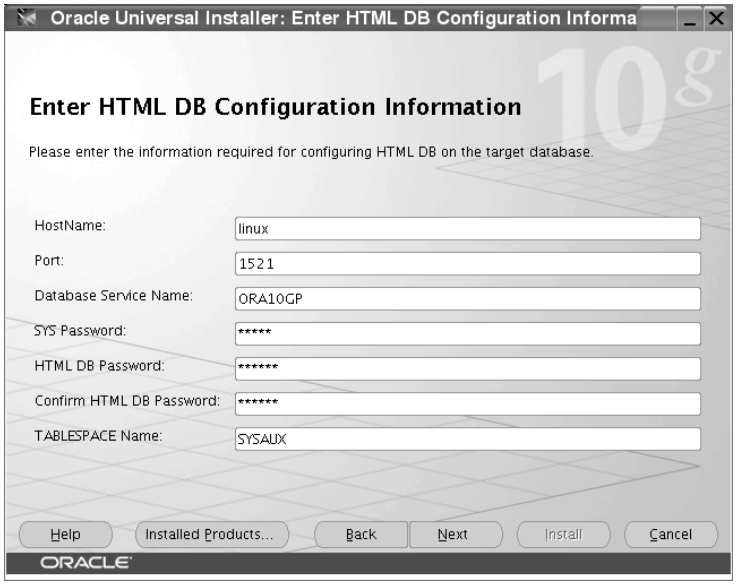
Oracle text-supplied Knowledge Bases An Oracle Text Knowledge Base is a hierarchical tree of concepts used for indexing themes, performing ABOUT queries, and deriving themes for document services.

Oracle 10*g* companion products These products must not be installed to the Oracle 10*g* database Oracle home directory; they must be installed to a separate Oracle home directory.

Oracle HTTP server *Oracle 10g HTTP Server (OHS)* is based on the Apache web server 1.3.28 and is designed to take advantage of the latest optimizations and security features. OHS includes SSL session renegotiation and death detection and the restart of failed processes.

Oracle HTML DB *HTML DB* is new in Oracle 10*g*. HTML DB is a Rapid Application Development (RAD) tool for the Oracle database, and it has many built-in themes and features. Using only a web browser, developers can build web applications faster. Before installing HTML DB, an Oracle 10*g* database must be configured and should be able to connect using SQLNet. Also, OHS and HTML DB must be installed in the same Oracle home directory. Figure 1.8 shows the HTML configuration screen of the OUI.

FIGURE 1.8 HTML DB configuration options



In earlier releases of Oracle, the client software was part of the database install CD. In Oracle 10*g*, the client is installed from the Oracle Database 10*g* CD when installing the database software. To install the Oracle client software alone, you need to use the Oracle Database 10*g* Client CD.

Configuring Oracle 10*g*

Oracle 10*g* provides several configuration enhancements over 9*i*. Most of the tasks are completed automatically, thus reducing manual intervention and errors. The architectural enhancements include a new SYSAUX tablespace to store all auxiliary metadata (discussed in Chapter 4, "General Storage Enhancements"), store workload information, and collect statistics to optimize performance. In addition, the DBCA is enhanced in Oracle 10*g* to include all these architectural changes.

You invoke the DBCA on Unix platforms using the `dbca` executable. On Windows, choose Database Configuration Assistant from the Configuration and Migration Tools folder.

In the following sections, we will discuss the enhancements to DBCA, how you can set up the database using simplified initialization parameters, and how to verify the database feature and high-watermark usage.

Examining DBCA Enhancements

The DBCA is a GUI tool for database creation and configuration changes. The DBCA can create a stand-alone database, a Real Application Cluster (RAC) database, or a standby database. A database created using the DBCA is fully set up and ready to use.

When creating a database, the DBCA can configure the following new features of Oracle 10*g*:

- Automatically create the `SYSAUX` tablespace to store auxiliary metadata information.
- Implement backup and recovery procedures and set up flash recovery area.
- Create management repository and services. The Enterprise Manager repository, jobs, and event subsystems are configured automatically.
- Automatically register LDAP (if available), which eliminates the need for manual `LDAP.ORA` configuration.
- Simplify the creation of a seed database, which is powerful and makes use of all the Oracle 10*g* features.
- Make the database ready for management using Enterprise Manager. The database can be centrally managed using EM Grid control. DBCA can set this up.
- Configure ASM storage options, and if an ASM instance is not already installed, create an ASM instance.
- Specify initialization parameters as typical, where you need to provide only minimal information. Choosing Custom enables you to configure parameters.
- Create sample schemas.
- Create a database as a clone of an existing database. The DBCA can clone the database entirely or just the structure.

In addition, when a database is deleted using the DBCA, the DBCA deletes all the files associated with the database and, on Windows, also removes the services.

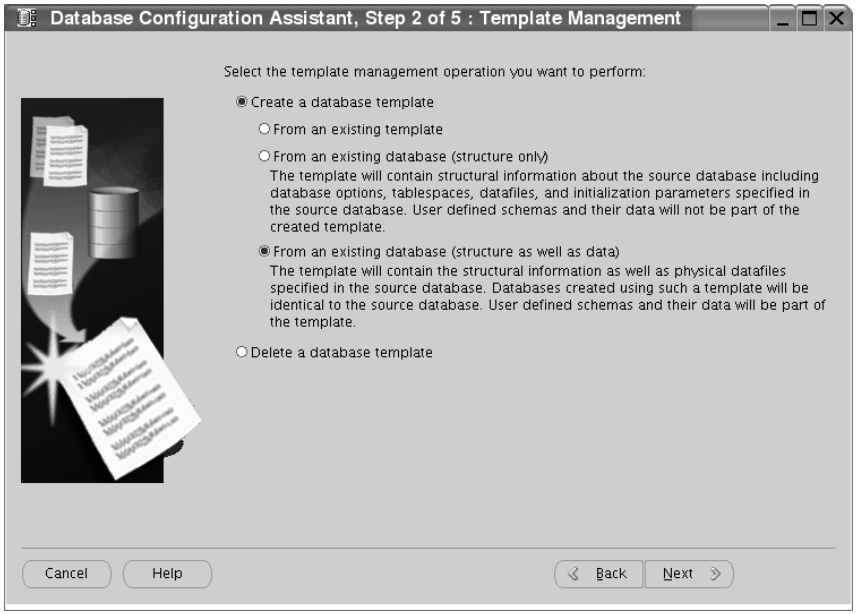
You can also change many options using the DBCA utility at a later time, if you decide to do so. Choose the Configure Database option from the main screen of the DBCA.

Using the DBCA to Clone a Database

The DBCA can create a database, configure database options, delete a database, or manage templates. These are the four options you see when you start the DBCA. Managing the templates clones the database. Figure 1.9 shows the Template Management screen of the DBCA.

DBCA templates are XML files that contain information required to create a database—new databases or clones of existing databases. The information in the templates includes database options, initialization parameters, and storage attributes (for data files, tablespaces, control files, and redo logs).

FIGURE 1.9 The DBCA: Template Management screen



Cloning a database using templates saves time in database creation, because copying an already created seed database's files to the correct locations takes less time than creating them as new. Templates are stored in the `$ORACLE_HOME/assistants/dbca/templates` directory. Templates are easy to share and can be copied from one machine to another.

Two types of templates exist: seed and nonseed. *Seed templates* have the extension `.dbc` and include the data files of an existing database. When creating a database using DBCA, if you choose seed template, the database creation is faster because the physical files and schema of the database have already been created. Your database starts as a copy of the seed database, rather than having to be built. DBCA copies the data files to the location you specify and creates a control file and opens the database with RESETLOGS option.

A nonseed template has the extension `.dbt` and does not include data files. If you choose a nonseed template while creating the database, the database creation assistant builds a fresh database and runs all the scripts on the database. Nonseed database templates have more flexibility in customizing database creation.

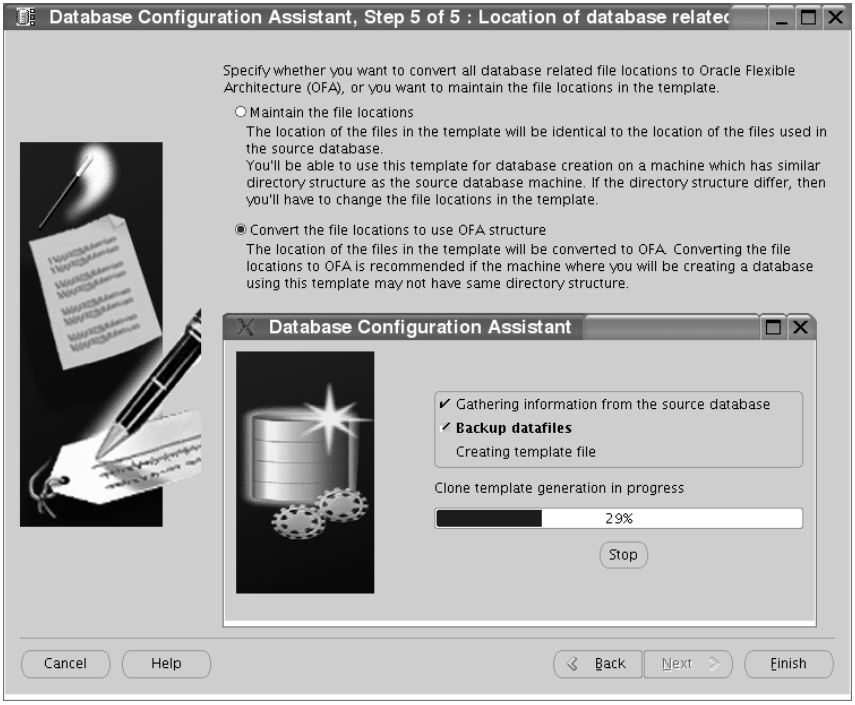
For seed database templates, you can change only the following:

- Name of the database
- Destination of the data files
- Number of control files
- Number of redo log groups
- Initialization parameters

Templates can be created from an existing template or an existing database. Cloning of database is performed when you create a template using the From an Existing Database (Structure As Well As Data) option, as shown in Figure 1.9.

Choose the database you want to clone. The database file locations can be maintained or the files can be converted to an OFA structure. See Figure 1.10, which shows this option. When you click Finish, the confirmation window pops up and the template creation is started.

FIGURE 1.10 Location of database related files



DBCA will shut down the database and start in the mount state to create the template. If the database is already shut down, the DBCA will start it in mount state. At mount state, the data files are copied to the XML file template. When the template creation is completed, two files will exist for seed database templates: the template with a `.dbc` extension and another file with a `.dfb` extension that contains all the database files. The template files are by default stored under the `$ORACLE_HOME/assistants/dbca/templates` directory.

Copy these two files to another host or to a different Oracle home directory if you want to clone the database at a different host or location. To clone the database, start the DBCA, and choose the Create Database option. You will see that the new template you just created is listed along with other Oracle supplied templates. To summarize, the following are the steps needed in cloning a database using DBCA.

1. Start DBCA and choose Manage Templates.

2. Choose the From an Existing Database (Structure As Well As Data) option.
3. Choose the database to be cloned.
4. If the database is cloned on a different server, copy the `.dbc` and `.dfb` file to the remote server.
5. Start DBCA on the destination server and choose the Create Database option.
6. Choose the template you just copied.

Oracle supplies four templates: General Purpose, Transaction Processing, Data Warehouse, and Custom Database. Except for Custom Database, the other three are seed templates (they include data files).

Once you have created the template to clone the database, you can remove it from the templates using the Manage Template screen of the DBCA.

Simplifying Instance Configuration

In Oracle 10*g*, the instance parameters (also known as *initialization parameters*) are categorized into two groups: basic and advanced. You can achieve most of the database setup and simple tuning with the basic parameters. The following are the basic parameters:

CLUSTER_DATABASE
COMPATIBLE
CONTROL_FILES
DB_BLOCK_SIZE
DB_CREATE_FILE_DEST
DB_CREATE_ONLINE_LOG_DEST_n
DB_DOMAIN
DB_NAME
DB_RECOVERY_FILE_DEST
DB_RECOVERY_FILE_DEST_SIZE
DB_UNIQUE_NAME
INSTANCE_NUMBER
JOB_QUEUE_PROCESSES
LOG_ARCHIVE_DEST_n
LOG_ARCHIVE_DEST_STATE_n
NLS_LANGUAGE
NLS_TERRITORY
OPEN_CURSORS
PGA_AGGREGATE_TARGET
PROCESSES
REMOTE_LISTENER
REMOTE_LOGIN_PASSWORDFILE
ROLLBACK_SEGMENTS
SESSIONS
SGA_TARGET
SHARED_SERVERS
STAR_TRANSFORMATION_ENABLED
UNDO_MANAGEMENT
UNDO_TABLESPACE

Oracle recommends you set up the database using these basic parameters and use the advanced parameters on an as-needed basis.

You can view/modify the initialization parameters used for the database through the EM Database Control page. A check mark in the Basic column indicates the parameter is basic. A blank in the Dynamic column indicates the parameter is static, meaning you are required to restart a database for the changes to take effect.

The `COMPATIBLE` parameter in Oracle 10*g* is irreversible; once you set it, you cannot change its value to one that is less than a previous value. To lower the value, you need to perform a point-in-time recovery of the database.

Using the Enterprise Manager

Oracle Enterprise Manager (EM) in Oracle 10*g* is completely revamped, includes many new features, and is very DBA friendly. Unlike the Java-based Oracle 9*i* EM, the HTML-based 10*g* EM can be accessed from any computer on the network using a web browser and can be used to manage all databases in your enterprise. EM can have two types of installations: Database Control and Grid Control.

The Oracle Management Repository stores host configurations and database configurations that are collected by the Oracle Management Agent on the hosts. The set of all host configurations and database configurations stored in a Management Repository is known as the *enterprise configuration*.

When you are using Enterprise Manager Database Control, the enterprise configuration includes the host configuration for a single host and the database configuration for the databases installed on that host. When you are using Enterprise Manager Grid Control, the enterprise configuration includes all the host configurations collected and all the database configurations collected by the Oracle management agent on each host.

Every 12 hours, the Oracle Management Agent on the host communicates the database configuration information over HTTPS to the Oracle Management Service, which loads the information to the Oracle Management Repository. The database configuration information you see on the EM is the information from the Oracle Management Repository. The database configuration information collected by the EM includes the following:

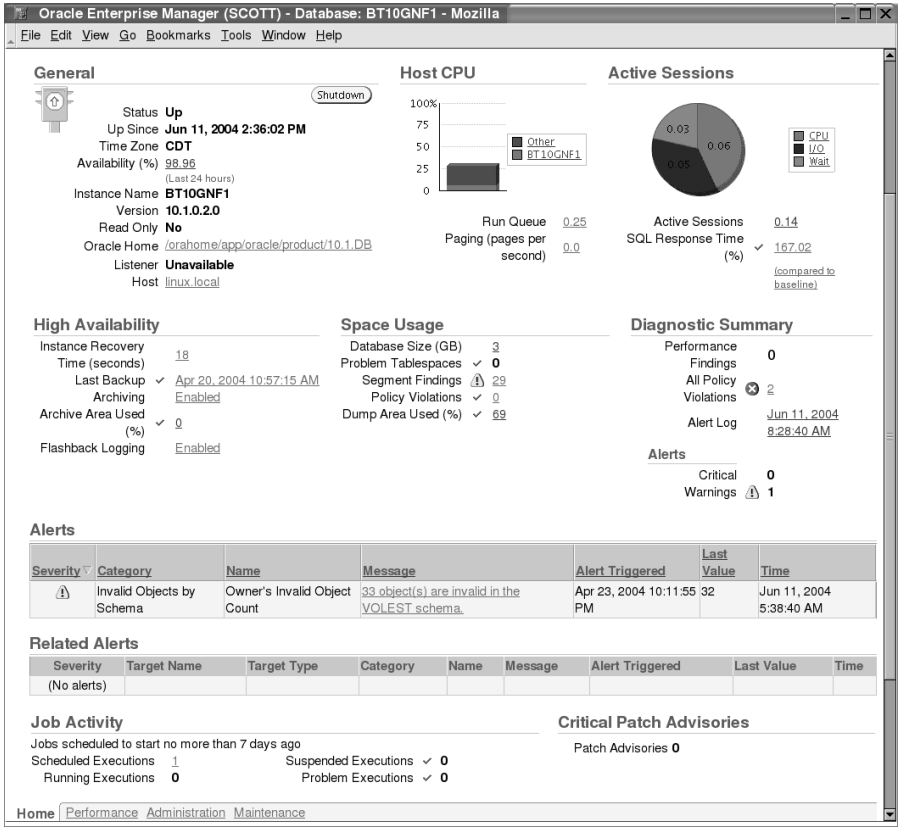
- Database and instance names
- Whether the database is running in ARCHIVELOG mode
- Initialization parameter and System Global Area values
- Information on tablespaces and rollback segments
- Attributes of data files, control files, and redo logs
- License and high-availability information

The Oracle Management Agent sends the host configuration information to the Management Repository every 24 hours. The host configuration information collected by the EM includes the following:

- Hardware information
- Operating system information, including patches
- Installed Oracle software, its patch level, and all product information
- Oracle patches installed by the OPatch utility
- Operating system–registered software

The EM Database Control is installed by default when you create a database using the DBCA utility (refer to Figure 1.3). By default, the Database control can be accessed from any web browser using port 5500 of your host. Figure 1.11 shows Enterprise Manager Database Control main page.

FIGURE 1.11 Enterprise Manager Database Control

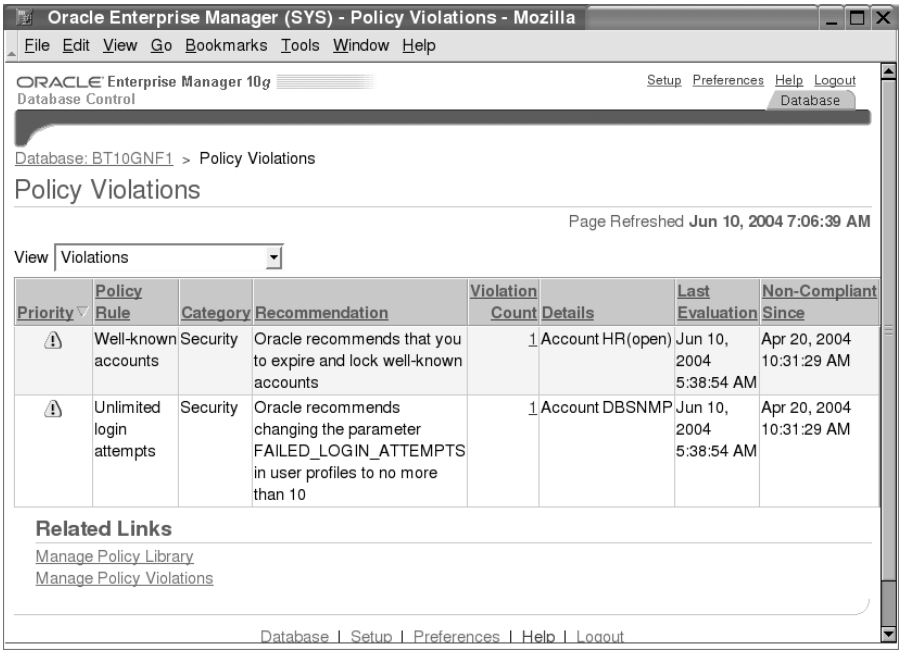


Many organizations have rules to manage the IT infrastructure, which translate into policies for the database administrator. In the next section, we will discuss the policies defined and monitored by EM. We will also discuss how you can use Enterprise Manager to clone Oracle home directories.

Configuring a Database Policy

Oracle 10*g* Enterprise Manager includes several out-of-the-box policies that are based on the best practices followed in the industry. The policies are categorized into configuration, security, and storage. The policy rules are given different priorities, such as High, Medium, and Informational. Enterprise Manager compares each host and database in the enterprise with the policy rules and identifies the policy violations for each host and database. The main page of the Database Control shows the number of policy violations for the database. When you click the Policy Violations count, all policy violations display, as shown in Figure 1.12.

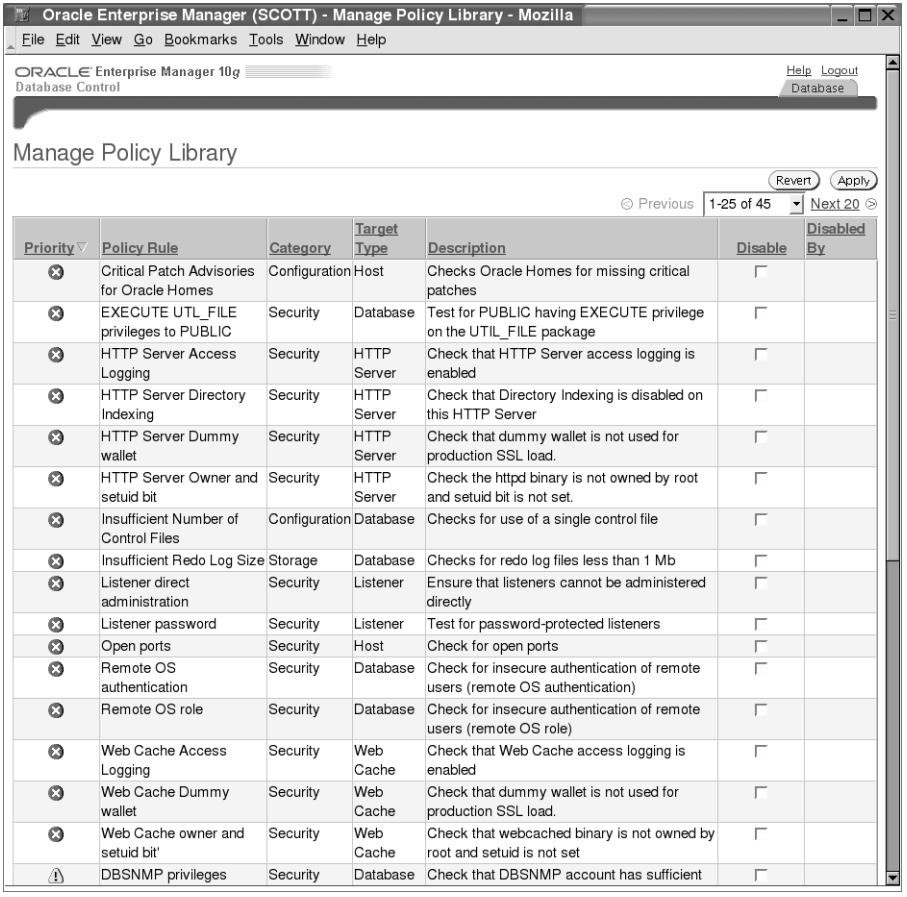
FIGURE 1.12 Policy violations



Click the Manage Policy Library link, and you will see all the policies defined for the enterprise. On this page, you can view the priority, category, and description of each policy rule. The Target Type column tells you which infrastructure component the policy is evaluated against; examples are Host, Database, Listener, HTTP Server, and so on. You can disable certain policies if they are not applicable to you or if the policy violation is to be ignored. The Disabled By

column shows the user who disabled the policy rule. Figure 1.13 shows the Manage Policy Library screen.

FIGURE 1.13 Manage Policy Library



Priority	Policy Rule	Category	Target Type	Description	Disable	Disabled By
⊗	Critical Patch Advisories for Oracle Homes	Configuration	Host	Checks Oracle Homes for missing critical patches	☐	
⊗	EXECUTE UTL_FILE privileges to PUBLIC	Security	Database	Test for PUBLIC having EXECUTE privilege on the UTIL_FILE package	☐	
⊗	HTTP Server Access Logging	Security	HTTP Server	Check that HTTP Server access logging is enabled	☐	
⊗	HTTP Server Directory Indexing	Security	HTTP Server	Check that Directory Indexing is disabled on this HTTP Server	☐	
⊗	HTTP Server Dummy wallet	Security	HTTP Server	Check that dummy wallet is not used for production SSL load.	☐	
⊗	HTTP Server Owner and setuid bit	Security	HTTP Server	Check the httpd binary is not owned by root and setuid bit is not set.	☐	
⊗	Insufficient Number of Control Files	Configuration	Database	Checks for use of a single control file	☐	
⊗	Insufficient Redo Log Size	Storage	Database	Checks for redo log files less than 1 Mb	☐	
⊗	Listener direct administration	Security	Listener	Ensure that listeners cannot be administered directly	☐	
⊗	Listener password	Security	Listener	Test for password-protected listeners	☐	
⊗	Open ports	Security	Host	Check for open ports	☐	
⊗	Remote OS authentication	Security	Database	Check for insecure authentication of remote users (remote OS authentication)	☐	
⊗	Remote OS role	Security	Database	Check for insecure authentication of remote users (remote OS role)	☐	
⊗	Web Cache Access Logging	Security	Web Cache	Check that Web Cache access logging is enabled	☐	
⊗	Web Cache Dummy wallet	Security	Web Cache	Check that dummy wallet is not used for production SSL load.	☐	
⊗	Web Cache owner and setuid bit'	Security	Web Cache	Check that webcached binary is not owned by root and setuid is not set	☐	
⚠	DBSNMP privileges	Security	Database	Check that DBSNMP account has sufficient	☐	

When you disable a particular rule, you also delete any violations from the Management Repository that were previously detected for the rule.

Enterprise Manager considers Oracle-critical patches that are not applied to appropriate Oracle software installations (`ORACLE_HOME`) as policy violations. From the main page of the Database Control, you can see if any such critical patches are to be applied. Enterprise Manager logs into Oracle's support site (Metalink) with the credentials provided by you to check for the critical patch availability. By default this patch search job is set to run once daily.

The jobs Enterprise Manager uses to verify the policy violations and to check for critical patches are maintained by the job system inside Enterprise Manager. You can create, edit, and manage jobs by clicking the Jobs link on the Database Control main page. For more information about Enterprise Manager jobs, click the Help link found on the top-right corner of the page.

Cloning the Oracle Home and Database

You can use the EM to clone Oracle software installations on the same server or different servers. This ensures that all patches and settings in the source and destination are the same. Cloning is faster than installing new software and applying the patches; also it is less error prone.

EM cloning uses the Enterprise Manager job system, which allows you to clone an Oracle home directory to multiple hosts and multiple Oracle home directories in a single cloning job. Enterprise Manager clones only the Oracle home directories that are clonable. An Oracle home directory is clonable when it was installed from an OUI that has built-in cloning support (for example, the Oracle 10*g* OUI).

From the Database Control main page, navigate to the Maintenance tab. Under Deployments, click the Clone Oracle Home link. Choose the Oracle home directory that you need to clone. In the six steps to set up a cloning job, you specify the source, destination, and when to clone.

Enterprise Manager can also clone a database. The Clone Database link is available under the Deployments The Clone Database tool clones a database instance to an existing Oracle home directory. If you want to create a new Oracle home directory to clone the instance to, use the Clone Oracle Home tool to create a new Oracle home directory and then use the Clone Database tool to clone the instance to that home directory.

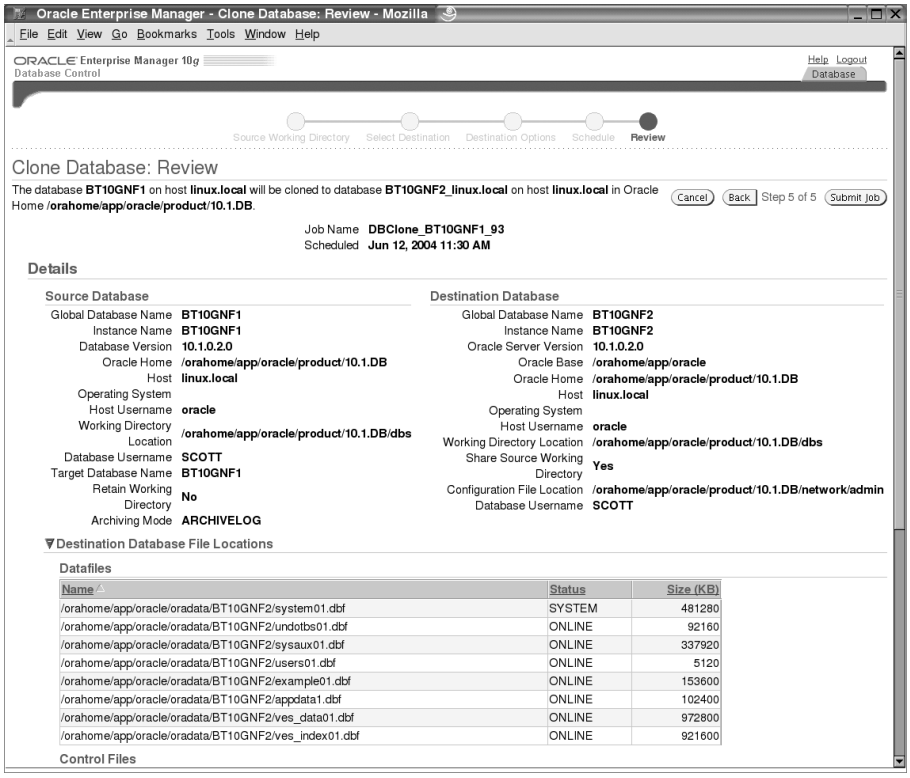
Figure 1.14 shows the Review screen of the Clone Database operation. You must follow five steps to set up the clone job. In step 3, you can specify destination file locations. The clone job can be executed immediately or can be set for a future time.

Cloning a database has several advantages. It saves time compared to creating a new database and populating it. The database can be cloned while it is up; the clone tool uses the RMAN to perform the cloning and then applies the archive logs to make it consistent. Note that DBCA cloning does not use RMAN, it copies the template and data files to XML files. EM Clone Database uses RMAN and performs the following operations:

- Backs up each database file and stores it in a working directory
- Transfers each backup file from source to the destination host
- Restores each backup file to the existing destination Oracle home directory
- Recovers the cloned database with saved archived logs
- Opens the cloned database with RESETLOGS

If the source database is in ARCHIVELOG mode, the source database is kept up and running while the cloning operation is performed.

FIGURE 1.14 Clone Database: Review



Viewing Database Usage

Oracle 10*g* keeps track of how the database is being used. The information is collected by the MMON process and is recorded in the Automatic Workload Repository (AWR). AWR is a new feature of Oracle 10*g* database and is discussed in Chapter 3, " Automating Management." AWR collects the following two types of database usage metrics:

- Database feature usage
- High watermark (HWM) of database attributes

Introducing Database Feature Usage

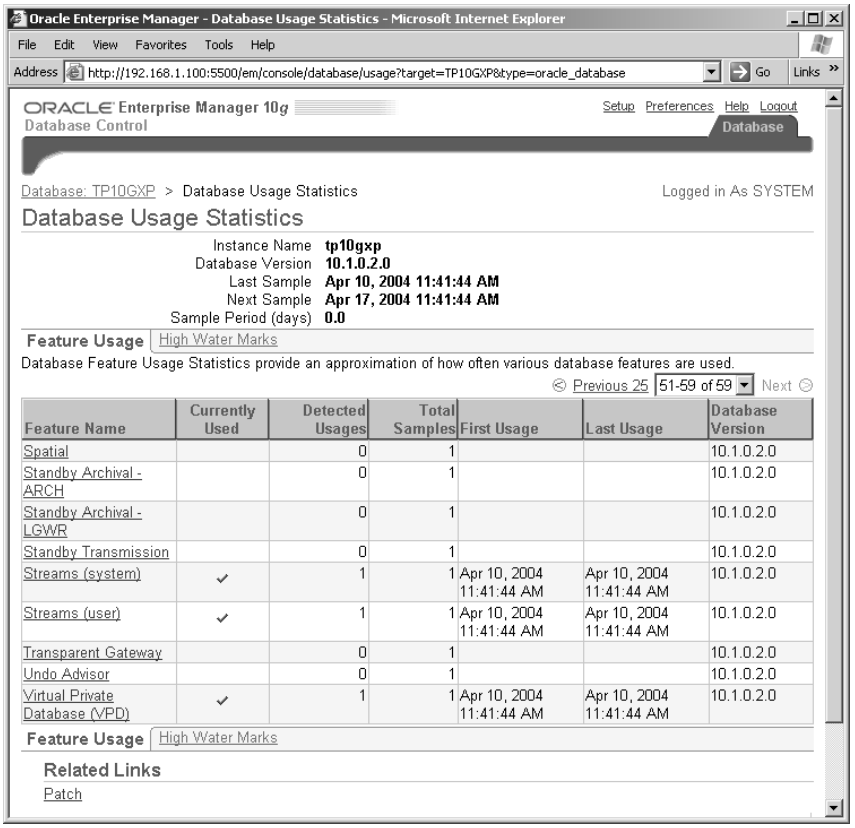
Database Feature usage of EM shows the usage statistics of various database features such as audit options, data mining, flashback database, MTTR advisor, and so on. You can determine what feature of the database is used how often. You can query the usage information using the DBA_FEATURE_USAGE_STATISTICS view. The NAME column identifies the feature, and the DESCRIPTION column provides a description on what/how the feature is monitored.

Here is a sample query from the DBA_FEATURE_USAGE_STATISTICS view:

```
SQL> SELECT name, detected_usages DU, last_usage_date
  2  FROM dba_feature_usage_statistics
  3  WHERE currently_used = 'TRUE'
SQL> /

NAME                                          DU LAST_USAG
--------------------------------------------- -- ---------
Automatic Segment Space Management (system)    7 06-JUN-04
Automatic Segment Space Management (user)      7 06-JUN-04
Automatic SQL Execution Memory                 7 06-JUN-04
Automatic Undo Management                      7 06-JUN-04
Locally Managed Tablespaces (system)           7 06-JUN-04
Locally Managed Tablespaces (user)             7 06-JUN-04
MTTR Advisor                                   6 06-JUN-04
Partitioning (system)                          7 06-JUN-04
Protection Mode - Maximum Performance          7 06-JUN-04
Recovery Area                                  7 06-JUN-04
Recovery Manager (RMAN)                        6 06-JUN-04
RMAN - Disk Backup                             6 06-JUN-04
SQL Access Advisor                             3 06-JUN-04
Streams (system)                               7 06-JUN-04
Streams (user)                                 7 06-JUN-04
Virtual Private Database (VPD)                 7 06-JUN-04

16 rows selected.

SQL>
```

You may use EM to get the database feature usage. From the EM Database Control page, navigate to the Administration tab, then navigate to Configuration Management, and next click Database Usage Statistics. Click the Feature Usage tab. Figure 1.15 shows the EM screen on the Database Usage Statistics.

FIGURE 1.15 The Database Usage Statistics screen



Introducing the HWM of Database Attributes

The Oracle 10*g* database keeps the usage statistics of various database attributes at its highest usage point. Information includes the size of the largest segment, the number of tables, the number of indexes, the maximum number of partitions per table/index, and the maximum concurrent sessions. You can query the information using the `DBA_HIGH_WATER_MARK_STATISTICS` view. The `NAME` column shows the name of the statistic, and the `DESCRIPTION` column provides a short explanation.

If the high-water statistics and database feature usage statistics are not populated, you can perform `execute dbms_stats.gather_database_stats` to collect the statistics.

Here is a sample query from the DBA_HIGH_WATER_MARK_STATISTICS view:

```
SQL> SELECT name, highwater, last_value
2    FROM dba_high_water_mark_statistics;

NAME                  HIGHWATER LAST_VALUE
-------------------- ---------- ----------
USER_TABLES                 764        764
SEGMENT_SIZE          158334976  158334976
PART_TABLES                   0          0
PART_INDEXES                  0          0
USER_INDEXES               1400       1400
SESSIONS                      3          3
DB_SIZE              1553203200 1553203200
DATAFILES                    10         10
TABLESPACES                  11         11
CPU_COUNT                     1          1
QUERY_LENGTH                 87         87
SERVICES                      4          4
```

You may use the EM to get the high-watermark information. In the Database Usage Statistics page, click the High Water Marks link.

Upgrading the Database

You can upgrade your database from one release to a higher release to use the new features and to be in a supported database version. Oracle typically announces the "de-support" date for a database version several months ahead so that you can plan and test the database migration.

Follow the database upgrade process when you're ready to transform your pre–Oracle 10*g* database to Oracle 10*g*. Before upgrading the production database, make sure you upgrade the test database and thoroughly check all the application features.

Oracle 10*g* has several upgrade options.

- Direct upgrade to Oracle 10*g* using *Database Upgrade Utility (DBUA)*. The DBUA is a GUI tool to upgrade an existing database to Oracle 10*g*. Using the DBUA is Oracle's preferred method.
- Direct upgrade to Oracle 10*g* by running scripts (this is a manual upgrade).
- Export/import utilities to copy data to a new Oracle 10*g* database.
- Copy data to a new Oracle 10*g* database using SQL tools.

Upgrading a database to Oracle 10*g* typically involves these tasks:

- Identify the supported upgrade options for the database.
- Decide on the method to be used to upgrade the database.
- Verify if the database is ready for direct upgrade.
- Upgrade the database.

In the following sections, we will discuss the supported releases for direct upgrade to Oracle 10*g*, the preupgrade checks provided by Oracle for a smooth trouble-free upgrade, and how to upgrade an Oracle database to Oracle 10*g* using the DBUA (GUI and command line) and using scripts.

Before upgrading the database to Oracle 10g, check with the application vendor to verify that the application is certified on Oracle 10g database and/or if the vendor has an upgraded application that works with Oracle 10g.

Introducing Upgrade-Supported Releases

Oracle 10*g* supports the direct upgrade of database from the following releases:

- Oracle 8 Release 8.0.6
- Oracle 8*i* Release 8.1.7
- Oracle 9*i* Release 1 – 9.0.1
- Oracle 9*i* Release 2 – 9.2.0

For all other database releases, you must upgrade the database to an upgrade-supported release using the methods suggested in that release before using the direct upgrade method. You have some restrictions, though. To upgrade any database prior to release 8.0.6, you must upgrade the database to 8.0.6 first and then use the DBUA utility (or manual upgrade) to upgrade to Oracle 10*g*. To upgrade an 8.1.5 or 8.1.6 database to Oracle 10*g*, you must first upgrade the database to Oracle 8*i* 8.1.7. To upgrade a 7.3.4 database, first upgrade to 9.2.0 and then to Oracle 10*g*.

The upgrade path you choose and the steps involved depend on the release of the database you are upgrading. For smaller databases in non-upgrade-supported releases (older than 8.0.6, or 8.1.5, or 8.1.6), it may be faster to perform an export/import rather than going through two upgrade processes.

Upgrading a database using the export/import method has the following advantages and disadvantages:

- How long the upgrade process takes depends on the size of the database.
- A new database for Oracle 10*g* needs to be created, which makes the current database a backup archive. Therefore, you need to double the amount of disk space required.
- The import process can defragment data that would improve performance. It also gives you an opportunity to create tablespaces using the new features of Oracle 10*g* database.

When installing Oracle 10*g* software, the OUI provides an option to invoke the DBUA if it finds any existing Oracle database in `/var/opt/oracle/oratab`, in `/etc/oratab`, or in the Windows Registry. The DBUA also can be invoked as a stand-alone tool.

After upgrading a database, its Oracle home directory changes to the new Oracle 10*g* home directory. DBUA automatically updates the `oratab` file with the right Oracle home directory. You must use the new Oracle home directory to start and stop the database.

Validating the Database Before Upgrade

Oracle 10*g* provides a utility script—`utlu101i.sql`—to perform preupgrade validation on the database to be upgraded. The DBUA automatically runs this tool (and takes corrective action) as part of the upgrade process. You can find the SQL script in the administration scripts directory (`$ORACLE_HOME/rdbms/admin`).

The `utlu101i.sql` script needs to be run as SYSDBA before you plan on performing a manual upgrade. It is preferred to copy this script to a temporary folder and run it after spooling the output to a file. You must run this script on the database to be upgraded. The script performs the following tasks:

- Checks database compatibility (the `COMPATIBLE` parameter must be set to 9.2.0 before upgrade)
- Verifies the redo log file size is at least 4MB
- Estimates time for upgrade
- Looks for obsolete, renamed, and special parameters
- Applies new values for certain upgrade parameters
- Finds all the components installed
- Finds the default tablespace for each database component schema
- Finds tablespace size estimates
- If the `SYSAUX` tablespace already exists, warns the user the properties may not be right and displays the required properties of the `SYSAUX` tablespace SYSAUX tablespace is covered in depth in Chapter 4.
- Checks the installed database options
- Checks the database character set and national character set are supported in Oracle 10*g*.

If the database version is not one that supports a direct upgrade, an error displays and the script terminates.

The following output shows the result of executing the `utlu101i.sql` script on an Oracle 9*i* Release 2 database under Linux; the installation home for `ora0109` database is `/orahome/app/oracle/product/9.2.0`:

```
linux:oracle>pwd
/home/oracle/temp
linux:oracle>echo $ORACLE_HOME
/orahome/app/oracle/product/9.2.0
linux:oracle>echo $ORACLE_SID
ora0109
linux:oracle>sqlplus '/ as sysdba'

SQL*Plus: Release 9.2.0.1.0 - Production on Fri Mar 19Copyright (c) 1982, 2002,
Oracle Corporation.
All rights reserved.
Connected to:
Oracle9i Enterprise Edition Release 9.2.0.1.0 - Production
With the Partitioning and Oracle Data Mining options
JServer Release 9.2.0.1.0 - Production

sys@ORA0109> spool ora0109upgcheck.lst
sys@ORA0109> @utlu101i.sql
Oracle Database 10.1 Upgrade Information Tool.
**********************************************************
Database:
---------
--> name: ORA0109
--> version: 9.2.0.1.0
--> compatibility: 9.2.0.0.0
.
**********************************************************
Logfiles: [make adjustments in the current environment]
--------------------------------------------------
-- The existing log files are adequate.
   No changes are required.
.
**********************************************************
Tablespaces: [make adjustments in the current environment]
--------------------------------------------------------
--> SYSTEM tablespace is adequate for the upgrade.
.... owner: SYS
.... minimum required size: 501 MB
--> DRSYS tablespace is adequate for the upgrade.
```

```
.... owner: CTXSYS
.... minimum required size: 10 MB
--> ODM tablespace is adequate for the upgrade.
.... owner: ODM
.... minimum required size: 9 MB
--> XDB tablespace is adequate for the upgrade.
.... owner: XDB
.... minimum required size: 48 MB
.
**************************************************************Options: [present in
existing database]
-------------------------------------
--> Partitioning
--> Spatial
--> Oracle Data Mining
WARNING: Listed option(s) must be installed with
         Oracle Database 10.1
.
**************************************************************Update Parameters:
[Update Oracle Database 10.1 init.ora or spfile]
-----------------------------------------------------------WARNING: --> "shared_
pool_size" needs to be increased to
   at least "150944944"
WARNING: --> "pga_aggregate_target" needs to be increased
   to at least "25165824"
--> "large_pool_size" is already at "16777216" calculated
   new value is"16777216"
--> "java_pool_size" is already at "83886080" calculated
 new value is "83886080"
.
**************************************************************Deprecated Parameters:
[Update Oracle Database 10.1 init.ora or spfile]
------------------------------------------------------------ No deprecated
parameters found. No changes required.
.
**************************************************************Obsolete Parameters:
[Update Oracle Database 10.1 init.ora or spfile]
-------------------------------------------------------------> "hash_join_enabled"
.
**************************************************************Components: [The
following database components will be
upgraded or installed]
```

```
------------------------------------------------------------> Oracle Catalog
Views         [upgrade]  VALID
--> Oracle Packages and Types    [upgrade]  VALID
--> JServer JAVA Virtual Machine [upgrade]  VALID
...The 'JServer JAVA Virtual Machine' JAccelerator(NCOMP)
...is required to be installed from the 10g Companion CD.
...
--> Oracle XDK for Java          [upgrade]  VALID
--> Oracle Java Packages         [upgrade]  VALID
--> Oracle XML Database          [upgrade]  VALID
--> Oracle Workspace Manager     [upgrade]  VALID
--> Oracle Data Mining           [upgrade]
--> Oracle interMedia            [upgrade]
...The 'Oracle interMedia Image Accelerator' is
...required to be installed from the 10g Companion CD.
...
--> Spatial                      [upgrade]
--> Oracle Text                  [upgrade]  VALID
--> Oracle Ultra Search          [upgrade]  VALID
--> Oracle Label Security        [upgrade]  VALID
.
************************************************************SYSAUX Tablespace:
[Create tablespace in Oracle
Database 10.1 environment]
------------------------------------------------------------> New "SYSAUX"
tablespace
.... minimum required size for database upgrade: 500 MB
Please create the new SYSAUX Tablespace AFTER the Oracle
 Database  10.1 server is started and BEFORE you invoke
the upgrade script.
.
************************************************************Oracle Database 10g:
Changes in Default Behavior
-----------------------------------------------
This page describes some of the changes in the behavior
of Oracle Database 10g from that of previous releases.
In some cases the default values of some parameters have
changed.  In other cases new behaviors/requirements have
been introduced that may affect current scripts or
applications. More detailed information is in the
documentation.
```

```
SQL OPTIMIZER
The Cost Based Optimizer (CBO) is now enabled by default.
* Rule-based optimization is not supported in 10g (setting
OPTIMIZER_MODE to RULE or CHOOSE is not supported).  See Chapter
12, "Introduction to the Optimizer," in Oracle Database
Performance Tuning Guide.
* Collection of optimizer statistics is now performed by
default, automatically for all schemas (including SYS),
for pre-existing databases upgraded to 10g, and for newly
created 10g databases.
Gathering optimizer statistics on stale objects is
scheduled by default to occur daily during the maintenance
window.  See Chapter 15, "Managing Optimizer Statistics"
in Oracle Performance Tuning Guide.
* See the Oracle Database Upgrade Guide for changes in
behavior for the COMPUTE STATISTICS clause of
CREATE INDEX, and for behavior changes in
SKIP_UNUSABLE_INDEXES.

UPGRADE/DOWNGRADE
* After upgrading to 10g, the minimum supported release
to downgrade to is Oracle 9i R2 release 9.2.0.3 (or later)
and the minimum value for COMPATIBLE is 9.2.0.  The only
supported downgrade path is for those users who have kept
COMPATIBLE=9.2.0 and have an installed 9i R2 (release
9.2.0.3 or later) executable.  Users upgrading to 10g from
prior releases (such as Oracle 8, Oracle 8i or 9iR1)
cannot downgrade to 9i R2 unless they first install 9i R2.
When upgrading to10g, by default the database will remain
at 9i R2 file format compatibility, so the on disk
structures that 10g writes are compatible with 9i R2
structures; this makes it possible to downgrade to
9i R2. Once file format compatibility has been explicitly
advanced to 10g (using COMPATIBLE=10.x.x), it is no longer
possible to downgrade.
See the Oracle Database Upgrade Guide.
* A SYSAUX tablespace is created upon upgrade to 10g.
The SYSAUX tablespace serves as an auxiliary tablespace
to the SYSTEM tablespace. Because it is the default
```

```
tablespace for many Oracle features and products that
previously required their own tablespaces, it reduces
the number of tablespaces required by Oracle that you,
as a DBA, must maintain.

MANAGEABILITY
* Database performance statistics are now collected by the
Automatic Workload Repository (AWR) database component,
automatically upon upgrade to 10g and also for newly
created 10g databases.  This data is stored in the SYSAUX
tablespace, and is used by the database for automatic
generation of performance recommendations. See Chapter 5,
"Automatic Performance Statistics" in the Oracle Database
Performance Tuning Guide.
* If you currently use Statspack for performance data
gathering, see section 1. of the Statspack readme
(spdoc.txt in the RDBMS ADMIN directory) for directions
on using Statspack in 10g to avoid conflict with the AWR.

MEMORY
* Automatic PGA Memory Management is now enabled by
default (unless PGA_AGGREGATE_TARGET is explicitly set
to 0 or WORKAREA_SIZE_POLICY is explicitly set to MANUAL).
PGA_AGGREGATE_TARGET is defaulted to 20% of the SGA size,
Unless explicitly set.  Oracle recommends tuning the value
of PGA_AGGREGATE_TARGET after upgrading.  See Chapter 14
of the Oracle Database Performance Tuning Guide.
* Previously, the number of SQL cursors cached by PL/SQL
was determined by OPEN_CURSORS.  In 10g, the number of
cursors cached is determined by SESSION_CACHED_CURSORS.
See the Oracle Database Reference manual.
* SHARED_POOL_SIZE must increase to include the space
needed for shared pool overhead.
* The default value of DB_BLOCK_SIZE is operating system
specific, but is typically 8KB (was typically 2KB in
previous releases).

TRANSACTION/SPACE
* Dropped objects are now moved to the recycle bin, where
```

```
the space is only reused when it is needed. This allows
'undropping' a table using the FLASHBACK DROP feature.
See Chapter 14 of the Oracle Database Administrator's
Guide.
* Auto tuning undo retention is on by default. For more
information, see Chapter 10, "Managing the Undo
Tablespace," in the Oracle Database Administrator's Guide.

CREATE DATABASE
* In addition to the SYSTEM tablespace, a SYSAUX
tablespace is always created at database creation, and
upon upgrade to 10g. The SYSAUX tablespace serves as an
auxiliary tablespace to the SYSTEM tablespace. Because it
is the default tablespace for many Oracle features and
products that previously required their own tablespaces,
it reduces the number of tablespaces required by
Oracle that you, as a DBA, must maintain. See Chapter 2,
"Creating a Database," in the Oracle Database
Administrator's Guide.
* In 10g, by default all new databases are created with
10g file format compatibility. This means you can
immediately use all the 10g features.  Once a database
uses 10g compatible file formats, it is not possible to
downgrade this database to prior releases. Minimum and
default logfile sizes are larger. Minimum is now 4 MB,
default is 50MB, unless you are using Oracle Managed
Files (OMF) when it is 100 MB.

PL/SQL procedure successfully completed.

sys@ORA0109> spool off
```

We showed the result in its entirety because of the useful tips that follow the checks and warnings. Please read them. We copied the `utlu101i.sql` script from the Oracle 10*g* `$ORACLE_HOME/rdbms/admin` directory to the `/home/oracle/temp` directory.

Before upgrading the database, make sure you have a good backup. You have the option to back up the database while using the DBUA.

Performing the Upgrade

You can perform a direct upgrade of an Oracle database to Oracle 10*g* by using Oracle's GUI interface, the DBUA, or by running scripts using the command-line SQL*Plus. Oracle 10*g* has a simplified upgrade procedure. In the earlier releases, you were supposed to run different scripts based on the database options. In Oracle 10*g*, the components to be upgraded are determined automatically and are executed in the correct dependency order. Oracle 10*g* has one script upgrade, which upgrades all the database components.

Oracle uses the `DBMS_REGISTRY` package to determine the objects to be upgraded. In Oracle 10*g*, the database and all the components have been integrated into the `cmpdbmig.sql` script. The `cmpdbmig.sql` script determines which components are in the database by performing specific callouts to the component `REGISTRY`.

The versions of Oracle prior to Oracle 9*i* Release 2 do not have a component `REGISTRY`. When upgrading from the older versions of Oracle, the upgrade automatically creates and populates the component `REGISTRY`. You can query the components using the `DBA_REGISTRY` view.

The following components are identified automatically by the upgrade process and are upgraded or installed (if a required component):

- Oracle Database Catalog Views
- Oracle Database Packages and Types
- JServer Java Virtual Machine
- Oracle Database Java Packages
- Oracle XDK
- Oracle Real Application Clusters
- Oracle Workspace Manager
- Oracle interMedia
- Oracle XML Database
- OLAP Analytic Workspace
- Oracle OLAP API
- OLAP Catalog
- Oracle Text
- Spatial
- Oracle Data Mining
- Oracle Label Security
- Messaging Gateway

The next section describes the direct database upgrade performed by using the DBUA.

Using the DBUA

The DBUA will be invoked by the OUI if you choose the Upgrade Database option when first installing the Oracle 10*g* software. On Unix platforms, you can invoke the DBUA by using the command `dbua`. On Windows platforms, you can invoke the DBUA by choosing Start ➢ Program Files ➢ Oracle Configuration and Migration Tools ➢ Database Upgrade Assistant.

The upgrade process is automated by DBUA, including the preupgrade steps. The following are some of the DBUA features and their advantages:

- Proceeds with upgrade only if the selected database release is supported for direct upgrade.
- Runs the preupgrade validation and identifies the options to be upgraded. It performs the necessary adjustments.
- Checks for disk space and tablespace requirements.
- Updates obsolete initialization parameters.
- Includes an option to back up the database prior to upgrade.
- Shows upgrade progress and writes detailed traces and log files.
- Disables archiving of the database during upgrade.
- Includes an option to configure the database with the EM.
- Includes an option to recompile invalid objects after upgrade; on multiCPU systems, the recompilation happens in parallel.
- Shows summary page prior to upgrade and after the upgrade.
- Includes an HTML report of upgrade summary.
- Able to upgrade all nodes of a database in RAC.
- Supports silent mode upgrade with a single command line.

To upgrade the database with the DBUA, follow these steps:

1. Choose the database to be upgraded from the list. You can choose only one database for upgrade at one time, and the database must be running.
2. The `SYSAUX` tablespace will be created in the database. Specify the file location and size of this tablespace. The minimum recommended size is 500MB. You cannot change other properties of the `SYSAUX` tablespace.
3. Choose if you would like to recompile all the invalid objects at the end of upgrade. During the upgrade, it is common that many of the objects will become invalid. By selecting this option, the DBUA runs the `utlrp.sql` script. If there are multiple CPUs on the server, an additional screen displays to change the degree of parallelism during recompile. This can speed up the recompilation time.
4. Choose the option to back up the database. If the backup is performed by the DBUA, it writes the backup files to a directory on the server, uncompressed. The DBUA also creates

a script to restore the database. The script is named <*dbname*>BACK.BAT on Windows and <*dbname*>back.sh on Unix.

5. Chose the option to configure the database with the EM and schedule daily backups.
6. Specify a location and size of the flash recovery area. This screen displays only if you choose to back up the database using the EM in the previous screen.
7. Specify passwords for the EM administrative accounts: SYSMAN and DBSNMP.
8. The summary of the upgrade displays (see Figure 1.16). Verify all the information, especially the database name, Oracle home directories (source and target), and version. The summary page also shows the components to be upgraded, the parameter changes, and the estimated upgrade time (excluding recompiling objects). The upgrade starts as soon as you click the Finish button. No one should connect to the database until the upgrade is completed.

Figure 1.17 shows the DBUA Progress screen. You can stop the upgrade at any time, but you may have to restore the database from the backup.

FIGURE 1.16 The DBUA: Summary screen

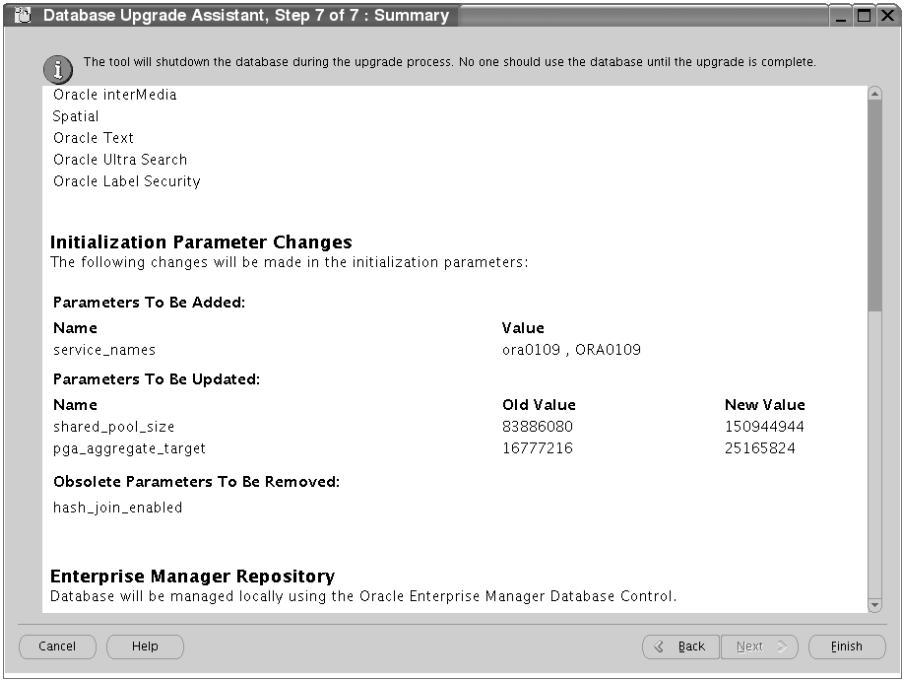
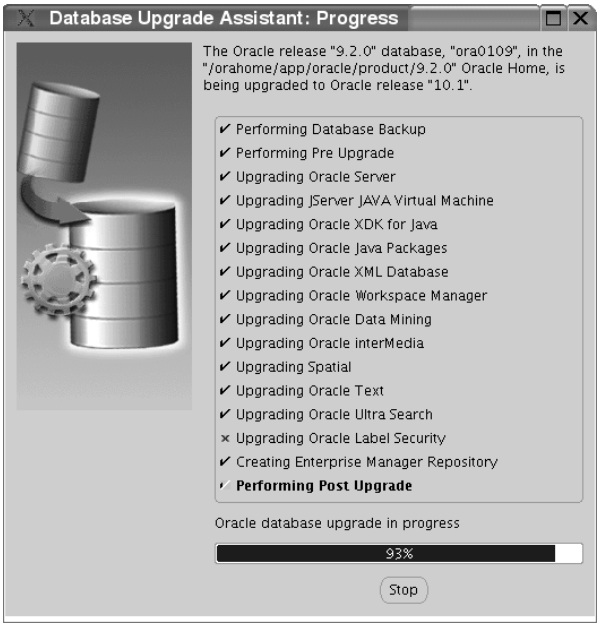


FIGURE 1.17 The DBUA: Progress screen

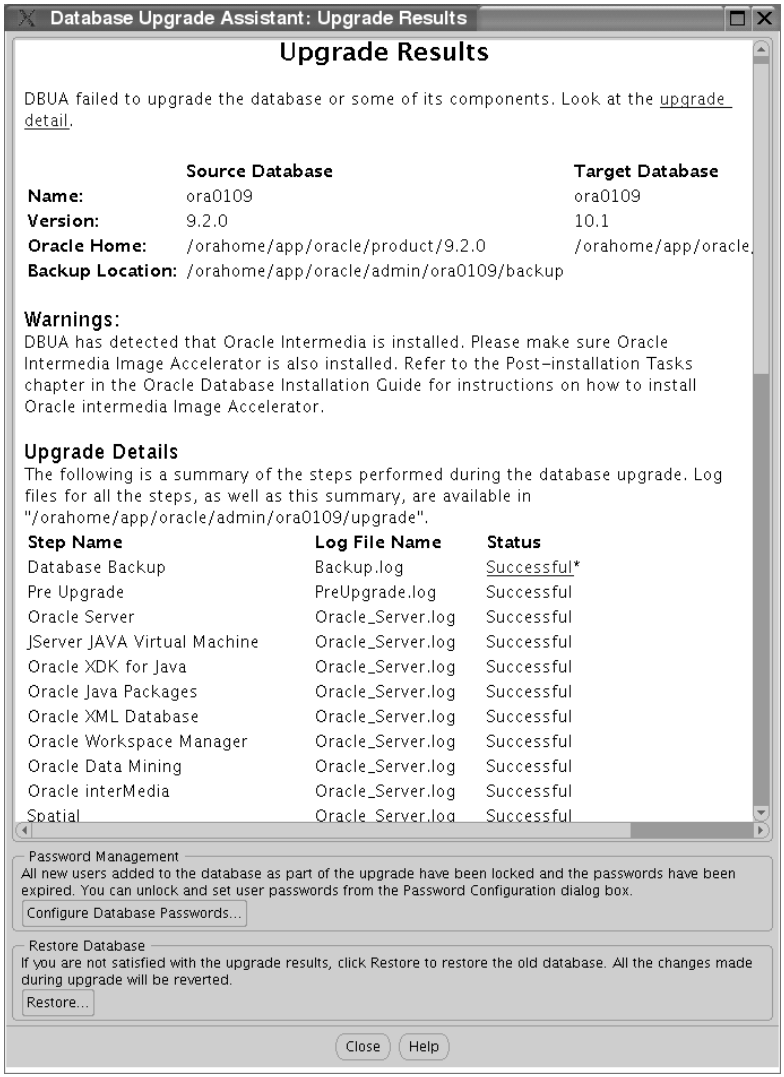


After the upgrade is completed, the upgrade results display on the DBUA Upgrade Results screen (see Figure 1.18). You are also given the option to change passwords and to restore the database. All the user accounts created by the upgrade process are locked for security reasons. Click the Configure Database Parameters button to assign new password and to unlock the accounts. If the DBUA is used to back up the database, restoring will put back the original database and the parameters. If you used other tools to back up the database, the DBUA restores only the original database settings (parameters) without the data files.

DBUA removes the database entry from the `listener.ora` file of the old database and adds it to the `listener.ora` file of the new database. Both listeners are reloaded automatically. If you have only the Oracle 10*g* listener, the Oracle home value is adjusted to reflect the upgrade.

Oracle 10*g* collects optimizer statistics for all the dictionary tables that lack statistics during upgrade. You can minimize the database upgrade downtime if you collect statistics on tables owned by SYS, SYSTEM, DBSNMP, and OUTLN and all other system schema using `exec dbms_stats.gather_schema_stats('<schema>', method_opt => 'FOR ALL COLUMNS SIZE AUTO', cascade => TRUE)` prior to the upgrade.

FIGURE 1.18 The DBUA: Upgrade Results screen



Using the DBUA Command Line

You can invoke the DBUA in command-line mode. You can specify several parameters with the command line `dbua`. The command line is invoked if you specify any parameter with the command `dbua`. `dbua -h` shows the help information.

Table 1.1 lists the command-line dbua parameters and their purpose.

TABLE 1.1 DBUA Command-Line Parameters

Parameter	Purpose
`-dbName`	Name of the database to be upgraded. This is the only mandatory argument.
`-silent`	Performs the upgrade in silent mode.
`-disableUpgradeScriptLogging`	Use this parameter to disable logging during upgrading.
`-backupLocation`	Name of the directory where the database should be backed up before upgrading.
`-postUpgradeScripts`	Comma-separated names of files that need to run after the upgrade. Specify full path along with file names.
`-initParam`	Specify comma-separated values of parameters to start up the database for upgrade.
`-emConfiguration`	Specify how you want the database to be managed: database configuration or grid configuration. Use `dbua -h` to see the other `-emConfiguration` arguments such as passwords.

For example,

```
dbua -silent -dbName ORA9
```

will upgrade the ORA9 database to Oracle 10*g*, detailed logging information will be written to log files, the database will not be backed up by DBUA, and the database will be configured to use the Enterprise Manager locally.

Upgrading the Database Manually

You can manually upgrade the database by running scripts using the SQL*Plus utility. Though manual upgrade provides you with more control, the process is error prone, involves more work, and could take more time.

To manually upgrade the database, follow these steps:

1. Connect to the database to be upgraded and run `utlu101i.sql` to determine the preupgrade tasks to be completed.

2. Resize the redo log files if they are smaller than 4 MB.
3. Adjust the size of the tablespaces where the dictionary objects are stored.
4. Perform a cold backup of the database.
5. Shut down the database (do not perform a `SHUTDOWN ABORT`; perform only `SHUTDOWN IMMEDIATE` or `SHUTDOWN NORMAL`). On Windows you will have to do `NET STOP`, `ORADIM -DELETE` from the old Oracle home directory and `ORADIM -NEW` from the new Oracle 10*g* home directory.
6. Copy the parameter file (`initDB.ora` or `spfileDB.ora`) and password file from the old Oracle home directory to the Oracle 10*g* Oracle home directory. The default location for parameter file is `$ORACLE_HOME/dbs` on Unix platforms and `ORACLE_HOME\database` on Windows. Adjust the following parameters:
   - Adjust the `COMPATIBLE` parameter; the minimum value required is 9.2.0 for the upgrade. If you set this to 10.0, you will never be able to downgrade the database to 9*i*.
   - Update the initialization parameters. You must remove obsolete parameters.
   - Set the `DB_DOMAIN` parameter properly.
   - Make sure memory parameters have at least the minimum size required for upgrade: `SHARED_POOL_SIZE` (96MB for 32-bit platforms, 144MB for 64-bit), `PGA_AGGREGATE_TARGET` (24MB), `JAVA_POOL_SIZE` (48MB), and `LARGE_POOL_SIZE` (8MB). Use the sizes recommended by the preinstall verification utility.
7. Make sure all the environment variables are set to correctly reference the Oracle 10*g* Oracle home. On Unix, verify `ORACLE_HOME`, `PATH`, `ORA_NLS33`, and `LD_LIBRARY_PATH`.
8. Use SQL*Plus, and connect to the database using the `SYSDBA` privilege. Start the instance by using the `STARTUP UPGRADE` mode.
9. Create the `SYSAUX` tablespace with the following attributes:
   - `online`
   - `permanent`
   - `read write`
   - `extent management local`
   - `segment space management auto`

   The syntax could be as follows:

```
CREATE TALESPACE sysaux
DATAFILE '/ora01/oradata/OR0109/sysaux.dbf' SIZE 500M
EXTENT MANAGEMENT LOCAL
SEGMENT SPACE MANAGEMENT AUTO;
```

10. Run the upgrade script from the `$ORACLE_HOME/rdbms/admin` directory. Based on the version of the old database, the name of the upgrade script varies. The following lists the old release and the upgrade script name:

Database Version	Script to Run
8.0.6	`u0800060.sql`
8.1.7	`u0801070.sql`
9.0.1	`u0900010.sql`
9.2.0	`u0902000.sql`

For example, to upgrade an Oracle 8.1.7 database to Oracle 10*g*, you must run `u0801070.sql`.

```
SQL> spool ora8i7upg.log
SQL> @?/rdbms/admin/u0801070.sql
SQL> spool off
```

If you get any errors during the upgrade script execution, reexecute the script after fixing the error. The postupgrade status utility—`utlu101s.sql`—gives the name of specific script to run to fix the failed component.

11. Run the `utlu101s.sql` utility with the `TEXT` option. It queries the `DBA_SERVER_REGISTRY` to determine upgrade status and provides information about invalid or incorrect component upgrades. It also provides names of scripts to rerun to fix the errors.

Here is an example (output truncated to fit in single line):

```
sys@ORA0109> @?/rdbms/admin/utlu101s.sql TEXT

PL/SQL procedure successfully completed.

Oracle Database 10.1 Upgrade Status Tool 19-MAR-2004
--> Oracle Database Catalog Views       Normal successful
--> Oracle Database Packages and Types  Normal successful
--> JServer JAVA Virtual Machine        Normal successful
--> Oracle XDK                          Normal successful
--> Oracle Database Java Packages       Normal successful
--> Oracle XML Database                 Normal successful
--> Oracle Workspace Manager            Normal successful
--> Oracle Data Mining                  Normal successful
--> Oracle interMedia                   Normal successful
--> Spatial                             Normal successful
```

```
--> Oracle Text                          Normal successful
--> Oracle Ultra Search                  Normal successful
--> Oracle Label Security                Problem detected
WARNING:----> required option not installed
----> component not upgraded

PL/SQL procedure successfully completed.

sys@ORA0109>
```

12. Shut down and restart the instance to reinitialize the system parameters for normal operation. The restart also performs Oracle 10*g* database initialization for JServer Java Virtual Machine and other components. Perform a clean shutdown (`SHUTDOWN IMMEDIATE`); starting the instance flushes all caches, clears buffers, and performs other housekeeping activities. This is an important step to ensure the integrity and consistency of the upgraded database.
13. Run the `utlrp.sql` script to recompile all invalid objects.
14. Update the `listener.ora` file with the new database information.
15. Back up the database.

On Unix environments, to connect to the database as SYSDBA, the single quotes are no longer required in Oracle 10*g*. In the prior releases you had to specify `sqlplus '/ as sysdba'` whereas in Oracle 10*g* `sqlplus / as sysdba` will work.

Using the *STARTUP UPGRADE* Option

To upgrade the database to Oracle 10*g*, you must start the instance with the `STARTUP UPGRADE` option (introduced in Oracle 9*i* Release 2). If you try to start the database in any other mode, you will get an error. This mode automatically handles certain system parameter values for the upgrade. Also, this option suppresses the `ORA-00942` error for the `DROP TABLE` statements in the upgrade script. So when reviewing for errors, you will see only genuine errors in the log file. For successful upgrade, you should not see any ORA- or PLS- errors in the log file. Here is an example of logging into the database using SQL*Plus with the SYSDBA privilege and starting up using the `STARTUP UPGRADE` method:

```
linux:oracle>sqlplus / as sysdba
SQL*Plus: Release 10.1.0.2.0 - Production on Fri Jun 11 Copyright (c) 1982,
2004, Oracle.  All rights reserved.
Connected to an idle instance.
```

```
SQL> startup upgrade
ORACLE instance started.

Total System Global Area  197132288 bytes
Fixed Size                   778076 bytes
Variable Size             162537636 bytes
Database Buffers           33554432 bytes
Redo Buffers                 262144 bytes
Database mounted.
Database opened.
SQL>
```

Downgrading Your Database

Sometimes it may be necessary to downgrade a database to its previous release because of issues with an application in the new database. Though the safe method is to restore from the backup taken prior to the upgrade, Oracle provides an option to downgrade the database to Oracle 9*i* Release 2. After upgrading the database to Oracle 10*g* release 1, the only supported downgrade option is downgrading to Oracle 9*i* Release 2. If you have set the `COMPATIBLE` parameter to 10.0 or higher, you will not be able to downgrade the database.

To downgrade the database, follow these steps:

1. Run `d0902000.sql` script from the Oracle 10*g* Oracle home directory after starting the instance using the `STARTUP DOWNGRADE` option.
2. Shut down the database, and start it from the Oracle 9*i* Release 2 home directory after adjusting the system parameters.
3. Connect to the database as SYSDBA, and start using the `STARTUP MIGRATE` option. Run `catrelod.sql` to reinstall the Oracle 9*i* Release 2 dictionary objects.
4. Perform a `SHUTDOWN IMMEDIATE`, and start the database in normal mode.

Real World Scenario

Upgrading Oracle 8*i* Database to Oracle 10*g*

We have an Oracle 8.1.7 database that is couple of terabytes big. Since the database is still in 8.1.7 and its support ends by the end of 2004, we have to upgrade the database to a higher release. We chose to upgrade to 10*g*, skipping 9*i* to avoid another major upgrade and the time spent on testing. Since the application is homegrown, we have to perform thorough testing.

The only practical upgrade option for this database to upgrade to Oracle 10*g* is to use the direct method. The other option—export/import—would require several days and is prone to errors when dealing with a database of this size.

Since we have decided on the upgrade path, the first step is to run the `utlu101i.sql` script to see what items should be fixed in the database for a successful upgrade. The following is the advice from the preupgrade check utility where changes need to be made:

```
Database:
---------
--> name: DBNAME
--> version: 8.1.7.4.0
--> compatibility: 8.1.7
WARNING: Database compatibility must be set to 9.2.0 prior to
 upgrade.
.
**************************************************************
Options: [present in existing database]
---------------------------------------
--> Partitioning
WARNING: Listed option(s) must be installed with Oracle
 Database 10.1
.
**************************************************************
Update Parameters: [Update Oracle Database 10.1 init.ora or
spfile]
-----------------------------------------------------------------WARNING: -->
"shared_pool_size" needs to be increased to at
          least "440688496"
WARNING: --> "pga_aggregate_target" is not currently defined
          and needs a value of at least "25165824"
--> "large_pool_size" is already at "104857600" calculated
          new value is "104857600"
WARNING: --> "java_pool_size" needs to be increased to at
          least "50331648"
**************************************************************
Obsolete Parameters: [Update Oracle Database 10.1 init.ora or
spfile]
------------------------------------------------------------------>
"db_block_lru_latches"
--> "max_rollback_segments"
--> "job_queue_interval"
--> "optimizer_max_permutations"
--> "fast_start_io_target"
--> "max_enabled_roles"
```

```
--> "log_archive_start"
.
****************************************************************Components: [The fol-
lowing database components will be
 upgraded or installed]
----------------------------------------------------------------> Oracle Catalog
Views         [upgrade]
--> Oracle Packages and Types    [upgrade]
--> JServer JAVA Virtual Machine [upgrade]
...The 'JServer JAVA Virtual Machine' JAccelerator (NCOMP)
...is required to be installed from the 10g Companion CD.
...
--> Oracle XDK for Java          [upgrade]
--> Oracle Java Packages         [install]
.
************************************************************
```

The first warning is the compatibility, which we can fix only during the upgrade. In fact, we let the DBUA fix all the parameter changes required in the upgraded Oracle 10*g* database. Since the tablespace sizes are adequate, the item we need to be working on is to install the JServer Java Virtual Machine from the companion CD.

We performed a backup and initiated the DBUA utility to upgrade the database after installing the JServer JVM component. This upgrade was tested successfully in the test database. Now the developers and users are testing the application. Our testing typically takes three months, so we hope we will be upgrading the production database to Oracle 10*g* soon.

Summary

The Oracle Universal Installer (OUI) is enhanced to include the entire new Oracle 10*g* database feature install. You perform the installation of the Oracle database software and the most common components from one CD. The companion CD includes HTTP Server and HTML DB along with other database products. The Oracle client is shipped in a separate CD.

For creating preconfigured database during software install, the OUI invokes the DBCA in a noninteractive mode. For custom databases, the DBCA is invoked interactively. The OUI and the DBCA include several options to capture user input for all the new features of the Oracle 10*g* database. You can also configure the database management using the Database Control (local) or Grid Control (centralized management).

The OUI and the DBCA have screens to capture the installation options for the new Oracle 10*g* features. The database data files can be using file system, raw devices, or ASM storage. Also, you can set up database management locally or using central management.

You can use the DBCA to clone a database. You do this by creating a template with structure and data. Enterprise Manager has several new features and has a new look in Oracle 10*g*. EM comes with several out-of-the-box policy rules for monitoring the enterprise. You can see the policy violations from the Database Control main page.

Oracle 10*g* keeps track of the database feature usage and database high-watermark usage. You can query the information from the data dictionary or using EM. The `COMPATIBLE` database parameter is irreversible in Oracle 10*g*; it cannot be set to a value less than a previous value. The minimum value is 9.2.0.

Upgrading a database to Oracle 10*g* is simplified by using the DBUA. DBUA does the preinstall tasks, backs up the database, adjusts parameters, upgrades the database, does the postupgrade status, and recompiles all the invalid objects. Directly upgrading the database is possible from the 9.2.0, 9.0.1, 8.1.7, and 8.0.6 databases. For other releases, you must first upgrade to an intermediate release and then upgrade to Oracle 10*g* or use other methods of the upgrade such as export/import.

Manually upgrading the database is made simple by using the one-script upgrade method. The database identifies all the components to be upgraded and performs the upgrade. The postupgrade status utility gives the status of all the components of the database and, if any component is invalid, provides the name of the script to run to fix the component.

The `SYSAUX` tablespace is mandatory in all Oracle 10*g* databases. The DBUA creates this as part of the upgrade. If you are performing a manual upgrade, you must create this tablespace. You must start the database in the `STARTUP UPGRADE` mode to begin the database upgrade.

Once the database is upgraded to Oracle 10*g*, it can be downgraded only to Oracle 9*i* Release 2. If the `COMPATIBLE` parameter was set to 10.0 or higher, a database downgrade is not possible.

Exam Essentials

Understand the new features of Oracle 10*g* database supported by the Oracle Universal Installer. Be familiar with the performance enhancements and preinstallation checks.

Understand the features of the Database Configuration Assistant. Learn to install the sample schema, when and how the DBCA is invoked by the OUI, and how to invoke the DBCA in stand-alone mode.

Familiarize with the Database Control main pages Know where to get the database feature usage and high-watermark usage.

Understand the policy violations pages Know the major links and their purpose on the Database Control Administration, Maintenance and Performance pages.

Learn which versions of Oracle can be upgraded directly to Oracle 10*g*, and learn the upgrade path for other versions. Oracle supports direct upgrade of the database to the Oracle 10*g* from 8.0.6, 8.1.7, 9.0.1, and 9.2.0 versions. For other database versions, you need to first upgrade to one of these releases before upgrading to Oracle 10*g*.

Remember the scripts to perform preupgrade check and postupgrade validation. Know the script to run on pre–Oracle 10*g* databases to check what needs be done before upgrade. Understand the results of the postupgrade utility script. Remember the script names.

Understand the advantages of using the Database Upgrade Assistant to upgrade a database rather than performing a manual upgrade. Using the DBUA automates the upgrade process. The DBUA can back up the database, perform the preupgrade checks and make changes, and upgrade the database with detailed log files.

Familiarize yourself with the steps involved in upgrading a database to Oracle 10*g* manually. Learn the scripts to perform the database checks (preupgrade and postupgrade), and learn the script to perform the upgrade based on the version of the database.

Understand cloning a database using DBCA Know the steps involved in cloning a database using DBCA and how to create templates.

Review Questions

1. On most platforms, to install Oracle 9*i* software, you needed three installation CDs. How many CDs are required for Oracle 10*g* installation?
   - **A.** 4
   - **B.** 3
   - **C.** 2
   - **D.** 1
2. Of the following options, which is not true when installing Oracle 10*g*?
   - **A.** The operating system must be certified.
   - **B.** A product key must be entered and activated.
   - **C.** 512MB RAM is required for each database instance with Database Control
   - **D.** Enough swap space available
3. Which component can be installed from the Oracle 10*g* database installation CD?
   - **A.** Legato Single Server Version
   - **B.** Database examples
   - **C.** Oracle Enterprise Manager Database Control
   - **D.** Oracle Database Client
4. When using the DBCA GUI tool to create a database, which feature is supported?
   - **A.** Databases that use ASM storage
   - **B.** Databases that need to be controlled using the Enterprise Manager Central Management Control
   - **C.** Real Application Cluster database
   - **D.** All of the above
5. Identify the statement that is true regarding cloning a database using DBCA.
   - **A.** When cloning a database, the source database must not be started.
   - **B.** When cloning a database, the source database must be started.
   - **C.** Cloning using the DBCA creates a copy of the database data files under templates and can be used for creating any number of cloned databases at any time.
   - **D.** When cloning a database to more than one destination, the source database must remain in the mount state until all cloning operations are completed.

6. When upgrading a database to Oracle 10*g*, which of the following options are true?
   - **A.** Any version of Oracle 8, Oracle 8*i*, or Oracle 9*i* database can be upgraded to Oracle 10*g* using the DBUA.
   - **B.** Only the versions 8.0.6, 8.1.7, 9.0.1, and 9.2.0 can be upgraded to Oracle 10*g*.
   - **C.** Once upgraded to Oracle 10*g*, the database can be downgraded only to Oracle 9*i* 9.2.0.
   - **D.** The upgraded database can be downgraded to its original version by using the DBUA if no Oracle 10*g*–related feature is implemented in the database.

7. Which option in the database is used to monitor the database feature usage?
   - **A.** Automatic Workload Repository
   - **B.** Enterprise Manager Database Control
   - **C.** Database monitoring feature
   - **D.** The `SYSAUX` tablespace

8. Which is the best option to upgrade an Oracle 8*i*, 8.1.7 database to Oracle 10*g*?
   - **A.** Use the export utility from Oracle 8*i* and import utility from Oracle 10*g*.
   - **B.** Perform a direct upgrade using DBUA.
   - **C.** Upgrade to Oracle 9*i* 9.2.0 using the Oracle 9*i* DBUA and then upgrade the database to Oracle 10*g* using the Oracle 10*g* DBUA.
   - **D.** Run `u0801070.sql` script on an Oracle 8*i* instance and then start the instance in Oracle 10*g*.

9. When upgrading a database using the DBUA to Oracle 10*g*, which activity is not performed by the DBUA?
   - **A.** Perform preupgrade steps.
   - **B.** Create the `SYSAUX` tablespace.
   - **C.** Change the `listener.ora` file to enter new Oracle home directory information.
   - **D.** Back up the database after upgradDisable archiving during upgrade.
   - **E.** Lock new user accounts created.
   - **F.** Adjust initialization parameter values.
   - **G.** Remove deprecated initialization parameters.
   - **H.** Recompile invalid objects.

10. When performing a manual upgrade to Oracle 10*g*, in what order are the following steps performed? (Note: Some steps may be missing.)
    1. Run `utlu101s.sql`.
    2. Run `utlu101i.sql`.
    3. Run `utlrp.sql`.
    4. Create the `SYSAUX` tablespace.

5 Start the database using the STARTUP UPGRADE option.

A. 1, 2, 3, 4, 5.

B. 2, 5, 4, 1, 3.

C. 5, 4, 2, 1, 3.

D. 5, 2, 4, 1, 3.

11. When using the DBCA to create a database, which types of file storage cannot be chosen for the database?

A. Raw device

B. ASM storage

C. File system

D. Oracle Managed Files (OMF)

E. None of the above

12. Which of the following actions are performed by the preupgrade utility `utlu101i.sql`?

A. Resize redo log files to 4MB if they are smaller.

B. Create the SYSAUX tablespace.

C. Resize the SYSTEM tablespace.

D. Suggest the size for the PGA_AGGREGATE_TARGET parameter.

13. Which two options are not true with the STARTUP UPGRADE mode instance startup?

A. Prepares the database for upgrade; no need to run any special script.

B. Suppresses spurious and unnecessary error messages, especially the ORA-00942.

C. Handles certain system startup parameters that could interfere with the upgrade.

D. This option is more of a documentation purpose when the database is started for upgrade; its functionality is no different from the default STARTUP option.

14. When you click the Restore button on the Upgrade Results page, which options must be true to perform a complete restore?

A. The database upgraded from 9.2.0 to Oracle 10*g*.

B. The database must be backed up using the DBUA.

C. The COMPATIBLE parameter value must be 9.2.0.

D. You must have backed up the database prior to upgrading.

15. Which product option installed from the Oracle 10*g* Companion CD must be installed in an Oracle home directory with database software installation?

A. JPublisher

B. HTML DB

C. HTTP Server

D. None

16. Which of the following database options must be upgraded after upgrading the database to Oracle 10*g*?

A. JServer Java Virtual Machine

B. Oracle Real Application Clusters

C. Oracle XML Database

D. All of the above

E. None of the above

17. When creating a database to Oracle 10*g*, what is the minimum size for the redo log files?

A. 40KB

B. 4MB

C. 50MB

D. 100MB

18. Which component is used by Oracle to identify the options that need to be upgraded while upgrading a database to Oracle 10*g*?

A. `V$OPTION`

B. `V$LICENSE`

C. `DBMS_REGISTRY`

D. `DBMS_OPTIONS`

19. When you choose to create a Transaction Processing database while installing Oracle software, which of the following statements is most appropriate?

A. The OUI will invoke the DBCA in an interactive mode, where you enter more information about the database and data files.

B. The OUI will not invoke the DBCA; the OUI collects all the information to create the database and creates the database.

C. The OUI will invoke DBCA in a noninteractive mode to create the database.

D. Irrespective of the type of database, the OUI always invokes DBCA in noninteractive mode.

20. Before manually upgrading an Oracle 8*i* 8.1.7 database, which of the following would be the appropriate value of `COMPATIBLE` parameter? (Choose two.)

A. 8.1.7.

B. 9.2.0.

C. Any value between 8.1.7 and 10.1.0.

D. Leave the `COMPATIBLE` parameter's default value.

Answers to Review Questions

1. D. Oracle has made several enhancements to Oracle 10*g* installation. Oracle 10*g* can be installed with just one CD. You can also install a preconfigured database or a custom database with the software install. Oracle achieved this by removing all duplicate files and having only one database template. The Oracle database examples are installed from the companion CD.

2. B. You do not need to provide or activate any product key to install the Oracle1Oracle 10*g* software.

3. C. The EM Database Control is installed by default for Enterprise Edition or Standard Edition; for custom install you can optionally not install this. Legato and database examples are installed from the companion CD. (Remember, database examples are not the same as sample schema; sample schema can be installed along with the database creation.) Beginning with Oracle 10*g*, the client software can be installed only from database client installation media.

4. D. The DBCA supports RAC, ASM, backup and recovery options, administrative passwords, and so on. The DBCA supports all the new features of Oracle 10*g* database including database management control using Enterprise Manager. You can also use the DBCA to clone an existing database.

5. C. Database cloning using DBCA is accomplished by creating a template with structure and data option. Once the template is created, it can be used to create any number of similar (cloned) databases. The source database will be in the mount state when creating the template. The state of the source database does not matter when creating the clones using the template.

6. C. The Oracle 10*g* database provides the provision to downgrade the database to Oracle 9*i* Release 2, provided the `COMPATIBLE` parameter is still set to 9.2.0. Not all versions of the database can be upgraded to Oracle 10*g* using the DBUA; only 8.0.6, 8.1.7, 9.0.1, and 9.2.0 databases can be directly upgraded to Oracle 10*g*. The DBUA supports only direct upgrade. Any version of Oracle database can be upgraded to Oracle 10*g* either using the direct upgrade method, first upgrading to a version supported by direct upgrade, or by using export/import method.

7. A. The AWR is used to monitor the database feature usage. The MMON process collects information on database feature usage (can be queried from `DBA_FEATURE_USAGE_STATISTICS` view) and database high-watermark statistics (can be queried from `DBA_HIGH_WATER_MARK_STATISTICS` view).

8. B. Oracle 10*g* supports direct upgrade from 8.0.6, 8.1.7, 9.0.1, and 9.2.0 databases.

9. D. The DBUA has an option to back up the database prior to upgrade. It's up to you to back up the database after the upgrade is completed.

10. B. The first step is to run the preupgrade information utility `utlu101i.sql`. Fix all the discrepancies listed in this result, and shut down the database. Start the Oracle 10*g* instance after adjusting any initialization parameters using `STARTUP UPGRADE`. Create the `SYSAUX` tablespace and then run the upgrade script based on the release of the database from which you're upgrading. After the upgrade, verify the status of upgrade using `utlu101s.sql`. Shut down and start up the database, and recompile any invalid objects using `utlrp.sql` script.

11. E. DBCA in Oracle 10*g* provides provisions to create the database with any of the storage options. OMF is a subcategory of file system storage.

12. D. The preupgrade information utility—`utlu101i.sql`—does not make any database changes; it advises you on what parameters need to be changed and tablespaces that need more space for a successful database upgrade. This utility is run on the database environment that needs the upgrade. When upgrading the database manually, you must perform all the suggestion by the `utlu101i.sql` before performing the upgrade. If you're using DBUA to upgrade, it will take care of all these changes.

13. A, D. `STARTUP UPGRADE` is the only way you can bring up an instance of Oracle 10*g* database prior to upgrading a database. You still need to upgrade the database using the upgrade scripts after creating the `SYSAUX` tablespace. Though the `STARTUP UPGRADE` option prepares the database for upgrade, you still need to run the database upgrade script based on the release of the database. This option suppresses ORA-00942 error messages and disables certain startup parameters.

14. B. DBUA performs a restore from the backup it created prior to upgrade, and it restores the database files and configuration files from the backup location. If the backup is performed by you, the DBUA only restores the database settings—data files are not restored.

15. A. JPublisher, was well as Legato Single Server Version, Java libraries, and other products, must be installed in the same Oracle home directory as the database software. HTTP Server must be installed in a separate Oracle home directory, and HTML DB must be installed in the same Oracle home directory as HTTP Server.

16. E. Oracle 10*g* has a very simplified upgrade process, which determines all the components of the database to be upgraded and automatically upgrades them. Oracle uses `DBMS_REGISTRY` to identify the components to be upgraded.

17. B. The minimum size of redo log file in Oracle 10*g* is 4MB. When creating a new database, the default is 50MB. If you're using OMF, the default is 100MB.

18. C. Oracle uses `DBMS_REGISTRY` to keep the status of components loaded to the database. You can query `DBA_REGISTRY` to see all the components and their status. It also provides the schema owner of the component and the script to run if a component is invalid.

19. C. When installing database software, you are given choice to create four types of databases: General Purpose, Data Warehouse, Transaction Processing, and Advanced. If you choose Advanced, the OUI invokes the DBCA in an interactive mode, where more information about the database is obtained by the DBCA. For the other three choices, OUI invokes DBCA in noninteractive mode to create the database; OUI gets the necessary information for database creation.

20. B, D. The minimum `COMPATIBLE` value for Oracle 10*g* database is 9.2.0. You can set this value to 9.2.0 or 10.0.0 prior to upgrading the database (that is, prior to starting the instance in Oracle 10*g*). The default value of `COMPATIBLE` parameter in 10*g* is 10.0.0.

Chapter 2

Moving Data and Managing the Scheduler

ORACLE DATABASE 10*g* NEW FEATURES FOR ADMINISTRATORS EXAM OBJECTIVES OFFERED IN THIS CHAPTER:

- ✓ **Load and Unload Data**
  - Transport tablespaces across different platforms
  - Explain Data Pump architecture
  - Monitor a Data Pump job
  - Use Data Pump export and import
  - Create external tables for data population
  - Define your external table properties
- ✓ **Automating Tasks with the Scheduler**
  - Simplify management tasks by using the Scheduler
  - Create a job, program, schedule and window
  - Reuse scheduler components for similar tasks
  - View information about job executions and job instances

Exam objectives are subject to change at any time without prior notice and at Oracle's sole discretion. Please visit Oracle's training and certification website (`http://www.oracle.com/education/certification/`) for the most current exam objectives listing.

Oracle Database 10*g* (Oracle 10*g*) has several enhancements and new utilities to move data across Oracle databases. The major enhancement is the introduction of Data Pump, a new server-based utility, to unload and load data. Data Pump can move data as well as metadata. Data Pump is an enhanced version of the old export/import utilities. The Enterprise Edition of Oracle includes parallelism for Data Pump.

External table was introduced in Oracle 9*i* mainly to help load jobs for data warehouse-like environments. In Oracle 10*g*, you can populate data to an external table, which is unloading data to a file (proprietary format—direct path API).

In Oracle 10*g*, the transportable tablespace feature supports across platforms. This, with the multiple block size introduced in Oracle 9*i*, will help a great deal in moving data between OLTP systems and data warehouses. The job scheduling features have a new set of programs that enable you to manage jobs, schedules, and programs. You can schedule regular database maintenance, application logic, and backups through the database. The new package `DBMS_SCHEDULER` is available in Oracle 10*g* to schedule and manage jobs.

In this chapter you will learn more about all these new features.

Introducing Data Pump

Moving data across databases is an integral part of enterprise architecture. You need to move data from a production database to test databases for realistic testing, move data from OLTP databases to data warehouse databases, send data from one location to another for trouble-shooting, and at times recover or restore data using these methods. Oracle 10*g* introduces new utilities to make the data movement operation simple and fast.

Data Pump is a new feature of Oracle 10*g* database that provides fast parallel bulk data and metadata movement between Oracle databases. Data Pump is fully integrated with the Oracle database and is installed automatically during database creation or database upgrade. Data Pump is available in Oracle the Enterprise, Standard, and Personal Editions, but the parallel capability is only available in the Enterprise Edition.

With the direct path method and parallel execution, Data Pump loads/unloads are several times faster than the traditional export/import methods. Data Pump also supports restarting jobs, monitoring progress, and adjusting the degree of parallelism on the fly.

Data Pump is an excellent choice for large export and import jobs. When compared to the `exp/imp` utilities, the startup time is longer for Data Pump, because it has to set up the jobs, queues, and master table. Also, at the end of the export operation the master table data is written to the dump file set, and at the beginning of the import job the master table is located and loaded in the schema of the user.

Data Pump is a major step forward for Oracle in loading and unloading data as well as copying data from one database to another.

In the following sections, we will discuss the architecture of Data Pump and the new Data Pump export and import utilities.

Introducing the Architecture of Data Pump

In Oracle 10*g* Data Pump, the database does all the work. This is a major deviation from the earlier architecture of export/import utilities, which ran as clients and did the major part of the work. The dump files for export/import were stored at the client whereas the Data Pump files are stored at the server. Figure 2.1 shows the Data Pump architecture. Data Pump consists of the following components:

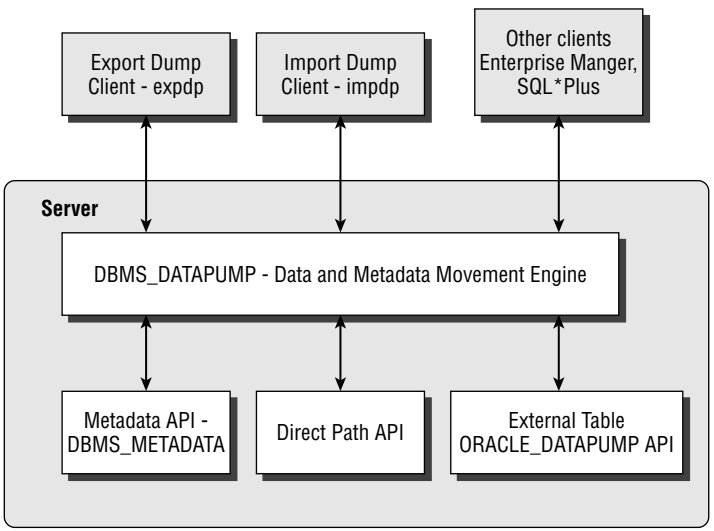
Data Pump API `DBMS_DATAPUMP` is the PL/SQL API for Data Pump, which is the engine. Data Pump jobs are created and monitored using this API.

Metadata API The `DBMS_METADATA` API provides the database object definition to the Data Pump processes.

Client tools The Data Pump client tools `expdp` and `impdp` use the procedures provided by the `DBMS_DATAPUMP` package. These tools make calls to the Data Pump API to initiate and monitor Data Pump operations.

Data movement APIs Data Pump uses the direct path API (DPAPI) to move data. Certain circumstances do not allow the use of DPAPI; in such cases, the Oracle external table with `ORACLE_DATADUMP` access driver API is used.

FIGURE 2.1 Data Pump architecture



Oracle Data Pump jobs, once started, are performed by various processes on the database server. The following are the processes involved in the Data Pump operation:

Client process This process is initiated by the client utility: `expdp`, `impdp`, or other clients to make calls to the Data Pump API. Since the Data Pump is completely integrated to the database, once the Data Pump job is initiated, this process is not necessary for the progress of the job.

Shadow process When a client logs into the Oracle database, a foreground process is created (a standard feature of Oracle). This shadow process services the client data dump API requests. This process creates the master table and creates Advanced Queuing (AQ) queues used for communication. Once the client process is ended, the shadow process also goes away.

Master control process (MCP) *Master control process* controls the execution of the Data Pump job; there is one MCP per job. MCP divides the Data Pump job into various metadata and data load or unload jobs and hands them over to the worker processes. The MCP has a process name of the format *ORACLE_SID*_DMnn_*PROCESS_ID*. It maintains the job state, job description, restart, and file information in the master table.

Worker process The MCP creates the worker processes based on the value of the `PARALLEL` parameter. The worker process performs the tasks requested by MCP, mainly loading or unloading data and metadata. The worker processes have the format *ORACLE_SID*_DWnn_*PROCESS_ID*. The worker processes maintain the current status in the master table that can be used to restart a failed job.

Parallel Query (PQ) processes The worker processes can initiate parallel query processes if external table is used as the data access method for loading or unloading. These are standard parallel query slaves of the parallel execution architecture.

Oracle Data Pump cannot be used to load data into a database from data exported using the exp utility.

Let's consider the example of an export Data Pump operation and see all the activities and processes involved. User A invokes the `expdp` client, which initiates the shadow process. The client calls the `DBMS_DATAPUMP.OPEN` procedure to establish the kind of export to be performed. The `OPEN` call starts the MCP process and creates two AQ queues.

The first queue is the status queue, used to send status of the job, which includes logging information and errors. Clients interested in the status of the job can query this queue. This is strictly a unidirectional queue—MCP posts the information to the queue, and the clients consume the information. The second queue is the command and control queue, which is used to control the worker processes established by the MCP and to perform API commands and file requests. This is a bidirectional queue where the MCP listens and writes. The commands are sent to this queue by the `DBMS_DATAPUMP` methods or by using the parameters of `expdp` client.

Once all the components (parameters and filters) of the job are defined, the client (`expdp`) invokes `DBMS_DATAPUMP.START_JOB`. Based on the number of parallel processes requested, MCP starts the worker processes. MCP directs one of the worker processes to do the metadata extraction using the `DBMS_METADATA` API.

During the operation, a master table is maintained in the schema of the user who initiated the Data Pump export. The master table has the same name as the name of the Data Pump job. This table maintains one row per object with status information. In the event of a failure, Data Pump uses the information in this table to restart the job. The master table is the heart of every Data Pump operation; it maintains all the information about the job. Data Pump uses the master table to restart a failed or suspended job. The master table is dropped (by default) when the Data Pump job finishes successfully.

The master table is written to the dump file set as the last step of the export dump operation and is removed from the user's schema. For the import dump operation, the master table is loaded from the dump file set to the user's schema as the first step and is used to sequence the objects being imported.

While the export job is underway, the original client who invoked the export job can detach from the job without aborting the job. This is especially useful when performing long-running data export jobs. Users can attach the job any time using the `DBMS_DATAPUMP` methods and query the status or change the parallelism of the job.

Since the master table is created in the Data Pump user's schema as a table, if there is an existing table in the schema with the Data Pump job name, the job fails. The user must have appropriate privileges to create the table and must have appropriate tablespace quotas.

Introducing Data Access Methods

Data Pump chooses the most appropriate data access method. Two methods are supported: direct path access and external table access.

Direct path export has been supported since Oracle 7.3 and therefore will not be discussed here.

External tables were introduced in Oracle 9*i*, and Oracle 10*g* supports writing to external tables. Data Pump provides an external table access driver (`ORACLE_DATAPUMP`) that can be used to read and write files. The format of the file is the same as the direct path methods; hence, this makes it possible to load data that is unloaded in another method. Data Pump uses the direct load API whenever possible. The following are the exceptions when the direct load API cannot be used and the external tables method will be used instead:

- Tables with fine-grained access control enabled in `INSERT` and `SELECT` operations.
- A domain index exists for a LOB column.
- A global index on multipartition table exists during a single-partition load.
- Tables in a cluster or if the table has an active trigger during import.
- Table contains `BFILE` columns.
- A referential integrity constraint is present during import.

- Table contains a VARRAY column with an embedded opaque type.
- Loading and unloading very large tables and partitions, where the PARALLEL SQL clause can be used to advantage.
- Loading tables that are partitioned different at load time and unload time.

Exploring the Advantages of Data Pump

Prior to Oracle 10*g*, the only export/import utility available with Oracle databases was the `exp`/`imp` tools. The Data Pump has the following advantages over the traditional `exp`and `imp` tools:

- Data access methods are decided automatically. For circumstances where direct path cannot be used, the external method is used.
- Can perform export in parallel. It can also write to multiple files on different disks. (Specify parameters `PARALLEL=2` and the two directory names with file specification `DUMPFILE=DDIR1:/file1.dmp,DDIR2:/file2.dmp`.)
- Has the ability to attach and detach from a job gives the DBA opportunity to monitor job progress remotely and make adjustments to the job as needed.
- Has the ability to restart a failed job from where it failed.
- Has more options to filter metadata objects. The `INCLUDE` and `EXCLUDE` options of the `expdp` and `impdp` utilities—which are described in the following section—make it possible to extract metadata with several possible combinations.

See the section "Using Data and Metadata Filters" later in this chapter for more information.

- Has the option to filter data rows during import.
- The `ESTIMATE_ONLY` option can be used to estimate disk space requirements before actually performing the job.
- Data can be exported from a remote database and imported to a remote database using a database link.
- Its job status can be queried from the database directly or by using the Enterprise Manager.
- Jobs can be allocated resources dynamically based on the workload.
- Explicit database version can be specified, so only supported object types are exported.
- Its operations can be performed from one database to another without writing to a dump file, using the network method.
- During import, you can change target file names, schema, and tablespaces.

Using Data Pump Clients

Oracle 10*g* comes with the `expdp` utility to invoke Data Pump for export and `impdp` for import. The `expdp` utility can unload data and metadata to a set of operating system files called *dump files*. The `impdp` utility loads data and metadata stored in an export dump file to a target database. The `expdp` and `impdp` utilities accept parameters that are then passed to the `DBMS_DATAPUMP` program. The command-line executable name for Data Pump Export is `expdp`, and for Data Pump Import is `impdp` on Windows as well as Unix platforms.

For a user to invoke `expdp`/`impdp`, you as the DBA need to set up a directory where the dump files will be stored, and the user must have appropriate privileges to perform Data Pump export/import.

In the next section, we will discuss setting up the export dump location.

Setting Up a Dump Location

Since the Data Pump is server based, directory objects must be created in the database where the Data Pump files will be stored. The user executing Data Pump must have been granted permissions on the directory. `READ` permission is required to perform import, and `WRITE` permission is required to perform export and to create log files or SQL files.

The following code creates a directory in the database and also grants privileges on the directory to the user SCOTT:

```
SQL> CREATE DIRECTORY dumplocation
     AS '/oradata/dumpfiles';

Directory created.

SQL> GRANT READ, WRITE ON DIRECTORY dumplocation TO scott;

Grant succeeded.

SQL>
```

Note that the user (who owns the software installation and database files) must have `READ` and `WRITE` operating system privileges on the directory. The user SCOTT does not need any operating system privileges on the directory for Data Pump to succeed.

A default directory can be created for Data Pump operations in the database. Once this directory is created, privileged users (with the `EXP_FULL_DATABASE` or `IMP_FULL_DATABASE` privilege) do not need to specify a directory object name when performing the Data Pump operation. The name of the default directory must be `DATA_PUMP_DIR`. Also, the privileged users do not need to have explicit `READ` or `WRITE` permissions on `DATA_PUMP_DIR`.

Here is an example of creating the default DATA_PUMP_DIR:

```
SQL> create directory DATA_PUMP_DIR
     AS '/oradata/defaultdatadumps';

Directory created.

SQL>
```

Data Pump may write three types of files to the operating system directory defined in the database.

Remember, absolute paths are not supported; Data Pump can write only to a directory defined by a directory database object.

The file types are as follows:

Dump files These contain data and metadata information.

Log files These record the standard output to a file and contain job progress and status information.

SQL files These files contain the SQL statements extracted from the dump files using the `impdp` utility. Data Dump Import can extract the metadata information from a dump file and write them to a SQL script, which can be used to create database objects without using the Data Pump import utility.

You can specify the location of the files to the Data Pump clients using the following three methods (given in the order of precedence):

- Prefix the file name with the directory name separated by a colon, as shown in this example:

  ```
  DUMPFILE=dumplocation:myfile.dmp
  ```

- Use the `DIRECTORY` parameter.
- Define the `DATA_DUMP_DIR` directory in the database for privileged users.

Performing an export and import using the `expdp` and `impdp` tools can have different modes based on your requirement. The next section will discuss this.

Specifying Export and Import Modes

Export and import using the Data Pump clients can be performed in five different modes to unload or load different portions of the database. When performing the dump file import, specifying the mode is optional; when no mode is specified, the entire dump file is loaded with the mode automatically set to the one used for export. Table 2.1 describes the modes.

TABLE 2.1 Export and Import Modes

Mode	Export	Import
Database. Performed by specifying the FULL=Y parameter.	Export user requires the EXP_FULL_DATABASE role.	Import user requires the IMP_FULL_DATABASE role.
Tablespace. Performed by specifying the TABLESPACES parameter.	Data and metadata for only objects contained in the specified tablespaces are unloaded. Export user requires the EXP_FULL_DATABASE role.	All objects contained in the specified tablespaces are loaded. Import user requires IMP_FULL_DATABASE privilege. The source dump file can be exported in database, tablespace, schema, or table mode.
Schema. Performed by specifying the SCHEMAS parameter. This is the default mode.	Only objects belonging to specified schema are unloaded.	All objects belonging to the specified schema are loaded. The source can be a database or schema mode export. The IMP_FULL_DATABASE role is required to specify list of schema.
	The EXP_FULL_DATABASE role is required to specify list of schema.	
Table. Performed by specifying the TABLES parameter.	Only the specified table, its partitions, and its dependent objects are unloaded. Export user must have SELECT privilege on the tables.	Only the specified table, its partitions, and its dependent objects are loaded. Requires the IMP_FULL_DATABASE role to specify tables belonging to a different user.
Transport tablespace. Performed by specifying the TRANSPORT_TABLESPACES parameter.	Only metadata for tables and their dependent objects within the specified set of tablespaces are unloaded. Use this mode to transport tablespaces from one database to another.	Metadata from a transport tablespace export is loaded.

In the next sections we will discuss using the expdp (Data Pump export utility) and impdp (Data Pump import utility).

Using *expdp*

The *expdp* utility performs Data Pump exports. Any user can export objects or complete schema owned by the user without any additional privileges. Nonprivileged users must have `WRITE` permission on the directory object and must specify the `DIRECTORY` parameter or specify the directory object name along with the dump filename.

Here is an example to perform an export by the user SCOTT (since Scott is not a privileged user, he must specify the `DIRECTORY` object name as in the first part of the example).

```
linux:oracle>expdp scott/tiger

Export: Release 10.1.0.2.0 - Production on Tuesday,
20 April,   2004 18:03

Copyright (c) 2003, Oracle.  All rights reserved.

Connected to: Oracle Database 10g Enterprise Edition
    Release 10.1.0.2.0   - Production
With the Partitioning, OLAP and Data Mining options
ORA-39002: invalid operation
ORA-39070: Unable to open the log file.
ORA-39145: directory object parameter must be specified
           and non-null

linux:oracle>
linux:oracle>expdp directory=dumplocation

Export: Release 10.1.0.2.0 - Production on Tuesday,
 20 April, 2004  14:48

Copyright (c) 2003, Oracle.  All rights reserved.

Username: scott/tiger

Connected to: Oracle Database 10g Enterprise
Edition Release  10.1.0.2.0 - Production
```

```
With the Partitioning, OLAP and Data Mining options
FLASHBACK automatically enabled to preserve database
integrity.
Starting "SCOTT"."SYS_EXPORT_SCHEMA_01":  scott/********
  directory=dumplocation
Estimate in progress using BLOCKS method...
Processing object type SCHEMA_EXPORT/TABLE/TABLE_DATA
Total estimation using BLOCKS method: 192 KB
Processing object type
  SCHEMA_EXPORT/SE_PRE_SCHEMA_PROCOBJACT/PROCACT_SCHEMA
Processing object type SCHEMA_EXPORT/TABLE/TABLE
Processing object type SCHEMA_EXPORT/TABLE/INDEX/INDEX
Processing object type
              SCHEMA_EXPORT/TABLE/CONSTRAINT/CONSTRAINT
Processing object type
  SCHEMA_EXPORT/TABLE/INDEX/STATISTICS/INDEX_STATISTICS
Processing object type
          SCHEMA_EXPORT/TABLE/STATISTICS/TABLE_STATISTIC
Processing object type SCHEMA_EXPORT/TABLE/COMMENT
Processing object type
            SCHEMA_EXPORT/TABLE/CONSTRAINT/REF_CONSTRAINT
. . exported "SCOTT"."DEPT"          5.656 KB
    4 rows
. . exported "SCOTT"."EMP"           7.820 KB
   14 rows
. . exported "SCOTT"."SALGRADE"      5.585 KB
    5 rows
. . exported "SCOTT"."BONUS"             0 KB
    0 rows
Master table "SCOTT"."SYS_EXPORT_SCHEMA_01" successfully
    loaded/unloaded
******************************************************
Dump file set for SCOTT.SYS_EXPORT_SCHEMA_01 is:
  /oradata/dumpfiles/expdat.dmp
Job "SCOTT"."SYS_EXPORT_SCHEMA_01" successfully
  completed at 14:49
linux:oracle>
```

Since we did not specify any other parameters, the expdp used default values for the filenames (expdat.dmp, export.log), did schema-level export (login schema), calculated job estimation using blocks method, used a default job name (SYS_EXPORT_SCHEMA_01), and exported both data and metadata.

The next section discusses parameters.

This output looks similar to the exp utility. Though most of the parameters of exp and expdp are similar, they both are different products. We will compare these two products in the next section. While comparing, we will examine the new parameters available for expdp.

Comparing *exp* and *expdp*

The exp utility is still available in Oracle 10*g*; expdp is an advanced version of exp. Many parameters are common to both utilities. Table 2.2 lists the parameters that are common to both exp and expdp, and their behavior is same.

TABLE 2.2 *exp* and *expdp* Common Parameters

Parameter Name	Purpose
FILESIZE	Specifies maximum size for each dump file. Default is 0 (unlimited). The size can be specified in bytes (the default), kilobytes, megabytes, and gigabytes.
FLASHBACK_SCN	Specifies the System Change Number (SCN). Export will be performed with data that is consistent as of this SCN.
FLASHBACK_TIME	The SCN that closely matches the specified time is found and export is performed with data that is consistent of that time.
FULL	When Y is specified, does a complete database export.
HELP	Displays a help screen with the parameters and their purpose.
PARFILE	Specifies name of a file with parameter values.
QUERY	When specified, a WHERE clause is added to the table export to filter data.

TABLE 2.2 *exp* and *expdp* Common Parameters *(continued)*

Parameter Name	Purpose
TABLES	Lists the table names for table mode export.
TABLESPACES	Lists the tablespaces to be exported in tablespace mode.
TRANSPORT_TABLESPACES	When Y is specified, transportable tablespace mode export is performed.

FLASHBACK_SCN and FLASHBACK_TIME are mutually exclusive parameters.

A few parameters have a new name in the expdp, but their behavior is similar to their counterpart in exp. Table 2.3 lists such parameters.

TABLE 2.3 Comparing *exp* and *expdp* Parameters

Exp Parameter	Expdp Parameter	Purpose
FEEDBACK	STATUS	Displays detailed status of current operation. The integer for STATUS specifies the frequency in seconds; for FEEDBACK, it is the number of rows exported.
FILE	DUMPFILE	Specifies the name of the file to store the export information. DUMPFILE can accept multiple filenames or substitution variable %U. The %U will be expanded to 01 through 99 during export.
LOG	LOGFILE	Specifies the name of the file to save the log information.
OWNER	SCHEMAS	Specifies the name of the users/schema to export.
TTS_FULL_CHECK	TRANSPORT_FULL_CHECK	When Y is specified, checks for dependencies for those objects in the transportable set and those outside the transportable set.

Several parameters are specific to the expdp utility command line. Table 2.4 lists such parameters.

TABLE 2.4 *expdp* Command-Line parameters

Parameter	Purpose
ATTACH	Attaches a client session to an existing Data Pump job and automatically places you in the interactive command mode.
CONTENT	Specifies what to export. The default is ALL. DATA_ONLY unloads only table row data. METADATA_ONLY unloads only database object definitions.
DIRECTORY	Specifies the name of the database directory object. The dump file will be written to this location on the server. Privileged users can use DATA_DUMP_DIR without specifying this parameter.
ESTIMATE	Specifies the method (BLOCKS or STATISTICS) to estimate how much disk space each table in the export job will consume. Estimate does not include metadata!
ESTIMATE_ONLY	Estimates the space required for the export but does not perform the export job. You should not specify the DUMPFILE parameter with ESTIMATE_ONLY=Y.
EXCLUDE	Lists the metadata object types to be excluded from the export. For more information, see the "Data and Metadata Filters" section.
INCLUDE	List the metadata object types to be included in the export. See the "Using Data and Metadata Filters" section.
JOB_NAME	Specifies a name for the export job. The default is SYS_operation_mode_NN. The master table will be created in the schema of the user with the job name.
KEEP_MASTER	Specify Y not to drop the master table after the export job completes. This could be useful for debugging or reporting.
NETWORK_LINK	Specifies name of a database link to perform network export. The local database that runs the expdp, contacts the remote database through the db link to retrieve data, and writes the data to the dump file.
NOLOGFILE	Specify Y if you do not want to create a log file.
PARALLEL	Specifies the maximum number of threads for the export job.
VERSION	Specifies version of database. Database objects that are incompatible with the specified version will not be exported.

The DUMPFILE parameter can specify more than one file. The filenames can be comma separated, or you can use the %U substitution variable. If you specify %U in the DUMPFILE filename, the number of files initially created is based on the value of the PARALLEL parameter. Preexisting files that match the name of the files generated are not overwritten; an error is flagged. The FILESIZE parameter determines the size of each file. Table 2.5 shows some examples.

TABLE 2.5 File Name and File Size Examples

Parameter Examples	File Characteristics
`DUMPFILE=exp%U.dmp FILESIZE=200M`	Initially, the `exp01.dmp` file will be created; once the file is 200MB, the next file, called `exp02.dmp`, will be created.
`DUMPFILE=exp%U_%U.dmp PARALLEL=3`	Initially three files will be created—`exp01_01.dmp`, `exp02_02.dmp`, and `exp03_03.dmp`. Notice that every occurrence of the substitution variable is incremented each time. Since there is no FILESIZE parameter, no more files will be created.
`DUMPFILE=DMPDIR1:exp%U.dmp, DMPDIR2:exp%U.dmp FILESIZE=100M`	The dump files are stored in directories defined by DMPDIR1 and DMPDIR2. This method is especially useful if you do not have enough space in one directory to perform the complete export job.

You can specify all the parameters in a file and specify the filename with the PARFILE parameter. The only exception is the PARFILE parameter inside the parameter file. Recursive PARFILE is not supported.

In the next section, we will discuss the impdp utility, which does the import from a dump file created using expdp.

Using *impdp*

The impdp utility can read and apply the dump file created by the expdp utility. The directory permission and privileges for using impdp are similar to that of expdp.

Let's try importing the export dump file created using the following parameters of the expdp:

```
expdp dumpfile=quotes.dmp logfile=quotes.log
      schemas=quotes
```

For the import, you do not specify any other parameters except the dump filename. The user QUOTES does not exist in the target database, and will be created as part of the import.

Here is an example:

```
linux:oracle>impdp dumpfile=quotes.dmp

Import: Release 10.1.0.2.0 - Production on Wednesday,
 21 April, 2004  7:09

Copyright (c) 2003, Oracle.  All rights reserved.

Username: bill/billthedba

Connected to: Oracle Database 10g Enterprise Edition
   Release 10.1.0.2.0 - Production
With the Partitioning, OLAP and Data Mining options
Master table "BILL"."SYS_IMPORT_FULL_01"
   successfully loaded/unloaded
Starting "BILL"."SYS_IMPORT_FULL_01":
   bill/******** dumpfile=quotes.dmp
Processing object type SCHEMA_EXPORT/USER
Processing object type SCHEMA_EXPORT/SYSTEM_GRANT
Processing object type SCHEMA_EXPORT/ROLE_GRANT
Processing object type SCHEMA_EXPORT/DEFAULT_ROLE
Processing object type SCHEMA_EXPORT/TABLESPACE_QUOTA
Processing object type
   SCHEMA_EXPORT/SE_PRE_SCHEMA_PROCOBJACT/PROCACT_SCHEMA
Processing object type SCHEMA_EXPORT/TABLE/TABLE
Processing object type SCHEMA_EXPORT/TABLE/TABLE_DATA
. . imported "QUOTES"."SEC_FILINGS"
                                  124.3 KB     382 rows
. . imported "QUOTES"."ALERT"
                                  5.531 KB       6 rows
. . imported "QUOTES"."ANALYST"
                                  7.671 KB      36 rows
. . imported "QUOTES"."CAN_QUOTE"
                                  7.117 KB       1 rows
. . imported "QUOTES"."CHART"
                                  7.242 KB      67 rows
. . imported "QUOTES"."EVENT"
                                  12.34 KB      49 rows
. . imported "QUOTES"."NEWS_RELEASE"
                                  11.96 KB      49 rows
```

```
. . imported "QUOTES"."EARNINGS_ESTIMATE"
                                    9.812 KB      11 rows
. . imported "QUOTES"."QUOTE"
                                    7.117 KB       1 rows
. . imported "QUOTES"."SYNC_CONTROL"
                                     5.75 KB       9 rows
. . imported "QUOTES"."URLS"
                                    5.375 KB       2 rows
. . imported "QUOTES"."ITEM"
                                        0 KB       0 rows
. . imported "QUOTES"."ITEM_INDEX"
                                        0 KB       0 rows
Processing object type SCHEMA_EXPORT/TABLE/INDEX/INDEX
Processing object type
              SCHEMA_EXPORT/TABLE/CONSTRAINT/CONSTRAINT
Processing object type
SCHEMA_EXPORT/TABLE/INDEX/STATISTICS/INDEX_STATISTICS
Processing object type
SCHEMA_EXPORT/TABLE/STATISTICS/TABLE_STATISTICS
Processing object type SCHEMA_EXPORT/TABLE/COMMENT
Processing object type SCHEMA_EXPORT/FUNCTION/FUNCTION
Processing object type
                  SCHEMA_EXPORT/FUNCTION/ALTER_FUNCTION
Job "BILL"."SYS_IMPORT_FULL_01" successfully
   completed at 07:09
linux:oracle>
```

Many parameters in `impdp` are similar to the `imp` utility. We will discuss and compare the parameters in next section.

Comparing *imp* and *impdmp*

`impdp` is advanced and has several new features when compared to the `imp` utility. Many parameters are common to both `imp` and `impdp`, with the same behavior, as described in Table 2.6.

TABLE 2.6 *imp* and *impdp* Common Parameters

Parameter	Purpose
FULL	Specify Y for full database import.
HELP	Shows a help screen with all the parameters.
PARFILE	Names the file that has all the parameters to be used for the import.

TABLE 2.6 *imp* and *impdp* Common Parameters *(continued)*

Parameter	Purpose
QUERY	Restricts the rows imported based on the condition specified in this parameter.
SKIP_UNUSABLE_INDEXES	If set to Y, does not load the tables with unusable indexes, and the job continues without error.
TABLES	Lists the tables to be imported.
TABLESPACES	Loads Objects that belong to the specified tablespaces.
TRANSPORT_TABLESPACES	Specifies the tablespaces that are imported using the transport tablespace method.

A few parameters have a new name in the `impdp` utility, but their behavior is similar to their counterpart in `imp`. Table 2.7 describes such parameters.

TABLE 2.7 Comparing *imp* and *impdp* Parameters

Imp Parameter	Impdp Parameter	Purpose
DATAFILES	TRANSPORT_DATAFILES	Specifies the list of datafiles to be imported using the transport tablespace method.
DESTROY	REUSE_DATAFILES	When creating tablespace during full import, specifies whether to overwrite existing datafiles.
FEEDBACK	STATUS	Displays detailed status of current operation.
FILE	DUMPFILE	Names the export dump file to import.
FROMUSER	SCHEMAS and REMAP_SCHEMAS	SCHEMAS can be used to import a schema, where the source and target are the same. REMAP_SCHEMA can be used to import to a different target schema. For more information, see the section "Using Import Transformations."
IGNORE	TABLE_EXISTS_ACTION	IGNORE can ignore the create error and continue with import. The TABLE_EXISTS_ACTION has more options: SKIP, APPEND, TRUNCATE, or REPLACE.

TABLE 2.7 Comparing *imp* and *impdp* Parameters *(continued)*

Imp Parameter	Impdp Parameter	Purpose
INDEXFILE SHOW	SQLFILE	Writes the metadata SQL statements to a file specified in this parameter. The SQL is not executed and the target system remains unchanged.
LOG	LOGFILE	Lists the filename where the status of the import will be written.
TOUSER	REMAP_SCHEMA	Specifies a username to import the objects into. See the section "Using Import Transformations" for more information.

Several parameters are specific to the `impdp` utility command line. Table 2.8 describes such parameters.

TABLE 2.8 *impdp* Command-line Parameters

Parameter	Purpose
FLASHBACK_SCN	Performs import operation that is consistent with the SCN specified from the source database. Valid only when the NETWORK_LINK parameter is used.
FLASHBACK_TIME	Similar to FLASHBACK_SCN, but Oracle finds the SCN close to the time specified.
NETWORK_LINK	Performs import directly from a source database using database link name specified in the parameter.
REMAP_DATAFILE	Changes name of the source datafile to a different name in the target. See the "Using Import Transformations" section for more information.
REMAP_SCHEMA	Loads objects to a different target schema name. See the "Using Import Transformations" section for more information.
REMAP_TABLESPACE	Changes name of the source tablespace to a different name in the target. See the "Using Import Transformations" section for more information.
TRANSFORM	Enables to change certain attributes of object creation DDL. See the "Using Import Transformations" section for more information.

You can use the CONTENT, INCLUDE, and EXCLUDE parameters in the impdp utility to filter the metadata objects. Their behavior is the same as in the expdp utility. The "Using Data and Metadata Filters" section will discuss this in detail.

In the next section, we will discuss methods to use a different target for tablespaces, schema, and datafiles.

When using the schema-level import with the SCHEMAS parameter, if the schema does not exist in the target database, the import operation creates it with same attributes from the source. The schema created by the import operation will need to have the password reset.

Using Import Transformations

While performing the import, you can specify a different target name for datafiles, tablespaces, or schema. These transformations are possible because the object metadata is stored in the dump file as XML. You use the REMAP_ parameters to specify this. When any of the three REMAP_ parameters are used, Data Pump makes transformations to the metadata DDL during import. The IMP_FULL_DATABASE role is required to use these parameters. You may use these parameters multiple times, if there is more than one transformation to be made, but the same source cannot be repeated more than once.

The REMAP_ parameters are as follows:

REMAP_DATAFILES Using this parameter, you can specify a different name for the datafile. The filename referenced could be in a CREATE TABLESPACE, CREATE LIBRARY, or CREATE DIRECTORY statement. REMAP_DATAFILES is especially useful when performing a full database import, when the tablespaces are being created by the impdp, and when the source directories do not exist in the target database server or the source and target platforms are different (VMS, Windows, Unix). The syntax is as follows:

```
REMAP_DATAFILE=source_datafile:target_datafile
```

The following example shows the parameters used to perform a full import on a Unix system from an export taken from Windows system.

```
impdp directory=mydumpdir dumpfile=winexp.dmp
    remap_datafile='D:/ORADATA/MYDB/userdata01.dbf': ➥
'/orad01/oradata/mydb/userdata01.dbf'
```

REMAP_SCHEMA Using this parameter, you can load all the objects belonging to the source schema to a target schema. Multiple source schemas can map to the same target schema. If the target schema specified does not exist, the import operation creates the schema and performs the load. The syntax is as follows:

```
REMAP_SCHEMA=source_schema:target_schema
```

The following example shows copying objects from the SCOTT schema of the source database to the BILL schema in the target database. If the BILL schema does not exist, it will be created.

```
impdp directory=mydumpdir dumpfile=scott.dmp
    remap_schema=SCOTT:BILL
```

REMAP_TABLESPACE Using this parameter, you can create the objects that belong to a tablespace in the source to another in the target. The syntax is as follows:

```
REMAP_TABLESPACE=source_tablespace:target_tablespace
```

The following example shows copying objects from the SCOTT schema of the source database to the BILL schema in the target database. The objects owned by SCOTT are stored in the SCOTT_DATA tablespace, we want to import these objects to the BILL_DATA tablespace.

```
impdp directory=mydumpdir dumpfile=scott.dmp
    remap_schema=SCOTT:BILL
    remap_tablespace=SCOTT_DATA:BILL_DATA
```

TRANSFORM Using the TRANSFORM parameter, you can specify that the storage clause should not be generated in the DDL for import. This is useful if the storage characteristics of the source and target databases are different. TRANSFORM has the following syntax:

```
TRANSFORM=name:boolean_value[:object_type]
```

The name of the transform can be either SEGMENT_ATTRIBUTES or STORAGE. STORAGE removes the STORAGE clause from the CREATE statement DDL whereas SEGMENT_ATTRIBUTES removes physical attributes, tablespaces, logging, and storage attributes. The *boolean_value* can be Y or N; the default is Y. The type of object is optional; the valid values are TABLE and INDEX.

For example, if you want to ignore the storage characteristics during the import, and use the defaults for the tablespace, you may do:

```
impdp dumpfile=scott.dmp  transform=storage:N:table ➥
exclude=indexes
```

The next example will remove all the segment attributes, and the import will use the user's default tablespace and its default storage characteristics.

```
impdp dumpfile=scott.dmp  transform=segment_attributes:N
```

In the next section, we will discuss how data can be copied from one database to another without using a dump file.

Real World Scenario

Using Network Mode to Refresh Test Data from Production

We periodically refresh the test database with production data. Since we have to preserve all the grants on the test schema, we perform the following steps in an Oracle 8*i* database to perform the data refresh:

- Disable all foreign keys.
- Disable all primary keys.
- Drop indexes so that the import goes faster.
- Truncate tables.
- Export data from the production database.
- Import data to the test database using the following parameters.

```
COMMIT=Y
BUFFERS=10485760
FROMUSER=SCHEMAPROD
TOUSER=SCHEMATEST
IGNORE=Y
GRANTS=N
```

After upgrading the test and production databases to Oracle 10*g*, we perform the import in just one step using the following `impdp` parameters:

```
SCHEMAS=SCHEMAPROD
NETWORK_LINK=TEST_SCHEMA
REMAP_SCHEMA=SCHEMAPROD:SCHEMATEST
TABLE_EXISTS_ACTION=REPLACE
EXCLUDE=OBJECT_GRANT
```

Specifying Network Mode Import

The `NETWORK_LINK` enables the network mode import using a database link. The database link must be created before the export is started. The export is performed on the source database based on the various parameters; the data and metadata are passed to the source database using the database link and loaded. To get a consistent export from the source database, you can use the `FLASHBACK_SCN` or `FLASHBACK_TIME` parameter.

Using FLASHBACK_SCN, FLASHBACK_TIME, ESTIMATE, or TRANSPORT_TABLESPACES requires you also specify the NETWORK_LINK parameter.

The following is an example of copying the SCOTT schema in the source (remote) database to LARRY in the target (local) database. Scott's objects are stored in the USERS tablespace; in the target we will create Larry's objects in the EXAMPLE tablespace. The database link name is NEW_DB.

```
impdp schemas=scott network_link=new_db
➥remap_schema=scott:larry
➥remap_tablespace=users:example
```

The network mode import is different from using SQL*Net to perform the import: impdp username/*password@database*.

Using Data and Metadata Filters

Data Pump provides fine-grained object selection to filter the metadata objects during exporting and importing. You can specify the EXCLUDE and INCLUDE parameters with expdp and impdp clients to filter metadata objects. You can use the CONTENT parameter to specify whether you need to export/import just data, just metadata, or both. You can use the QUERY parameter to filter data rows.

The EXCLUDE and INCLUDE parameters are mutually exclusive. Also, when you specify either parameter, you cannot specify the CONTENT parameter with DATA_ONLY value. The QUERY, EXCLUDE and INCLUDE parameters have the following syntax:

```
QUERY=[schema.][table_name:]"query clause"
EXCLUDE=object_type[:"object names"]
INCLUDE=object_type[:"object names"]]
```

Table 2.9 shows examples of data and metadata filter usage. Though the explanation says *unloaded*, it is applicable to loading also.

TABLE 2.9 Data Pump Filter Examples

Parameter Examples	Accomplishes
`schemas=traing` `content=metadata_only`	Unloads the metadata information for all objects owned by the TRAING schema. No data row will be unloaded.

`content=data_only`
`schemas=traing`
`query=traing.student:"where ee_dept = 'IST'"`
	No metadata will be unloaded; only data rows will be unloaded. All data rows will be unloaded for all tables owned by TRAING, except STUDENT table, where only the rows that belong to the IST department is unloaded.

TABLE 2.9 Data Pump Filter Examples *(continued)*

Parameter Examples	Accomplishes

`content=data_only`
`tables=traing.student`
`query="where ee_dept = 'IST'"`
	Only rows in the STUDENT table that belong to the IST department are unloaded.

`schemas=traing`
`exclude=view,package,procedure,`
`function,grant,trigger`
`exclude=index:"like 'S%'"`
	Table rows will be unloaded. Metadata definition for view, trigger, procedure, function, grants, packages, and indexes that begin with S are not unloaded.

`Content=data_only`
`schemas=hr`
`include=table:"in`
`('EMPLOYEES','DEPARTMENTS')"`
`query="where DEPARTMENT_ID = 10"`
	Only rows belonging to department 10 are unloaded from the EMPLOYEES and DEPARTMENTS tables.

You can obtain the parameter values for INCLUDE and EXCLUDE by querying the OBJECT_PATH column from the following data dictionary views:

- DATABASE_EXPORT_OBJECTS for full database export parameters
- SCHEMA_EXPORT_OBJECTS for schema-level export parameters
- TABLE_EXPORT_OBJECTS for table-level export parameters

The following query shows the values that can be used with INCLUDE/EXCLUDE parameters when performing a schema level export that is related to packages:

```
SQL> select object_path, comments
  2  from schema_export_objects
  3  where object_path like '%PACKAGE%'
SQL> /

OBJECT_PATH        COMMENTS
------------------ -----------------------------------
ALTER_PACKAGE_SPEC Recompile package specifications in
                   the selected  schemas
PACKAGE            Packages (both specification and body)
                   in  selected schemas and their
                   dependent grants and audits
```

```
PACKAGE_BODY        Package bodies in the selected schemas
PACKAGE_SPEC        Package specifications in the selected
                    schemas

SQL>
```

Data Pump has the ability to monitor the jobs and make adjustments to the jobs. You can monitor and modify the jobs initiated by `impdp` and `expdp` by using the same clients. In the next section, we will discuss managing the jobs by using `expdp` and `impdp`.

Managing Data Pump Jobs

The Data Pump clients `expdp` and `impdp` provide an interactive command interface. Since each export and import operation has a job name, you can attach to that job from any computer and monitor the job or make adjustments to the job. Table 2.10 lists the parameters that can be used interactively.

TABLE 2.10 Data Pump Interactive Commands

Parameter	Purpose
`ADD_FILE`	Adds another file or a file set to the `DUMPFILE` set.
`CONTINUE_CLIENT`	Changes mode from interactive client to logging mode.
`EXIT_CLIENT`	Leaves the client session and discontinues logging but leaves the current job running.
`KILL_JOB`	Detaches all currently attached client sessions and terminates the job.
`PARALLEL`	Increases or decreases the number of threads.
`START_JOB`	Starts (or restarts) a job that is not currently running. The `SKIP_CURRENT` option can skip the recent failed DDL statement that caused the job to stop.
`STOP_JOB`	Stops the current job; the job can be restarted later.
`STATUS`	Displays detailed status of the job; the refresh interval can be specified in seconds. The detailed status is displayed to the output screen but not written to the log file.

The data dictionary view DBA_DATAPUMP_JOBS shows the active job information along with its current state, the number of threads, and the number of client sessions attached. You can join this view with DBA_DATAPUMP_SESSIONS to get the SADDR column of the sessions attached and can join the SADDR column with V$SESSION to get more information. The V$SESSION_LONGOPS view also has info onthe progress of the job. Use the SID and SERIAL# columns from V$SESSION to query V$SESSION_LONGOPS.

The following example should help you understand the parameters more clearly. We have an export dump job to be performed. The DBA starts the job with the following parameters in a parameter file:

```
DIRECTORY=DUMPLOCATION
DUMPFILE=volest.dmp
LOGFILE=volest.exp.log
SCHEMAS=volest
JOB_NAME=VOLEST_EXP_TEST
```

A table with name VOLEST_EXP_TEST is created in the DBA's schema. This is the master control table. Querying the DBA_DATAPUMP_JOBS view will show the status of the jobs running.

```
SQL> SELECT job_name, state
  2  FROM dba_datapump_jobs;

JOB_NAME                       STATE
------------------------------ ----------------
VOLEST_EXP_TEST                EXECUTING

SQL>
```

By pressing **Ctrl+C**, you can stop the logging screen, and you can enter the interactive mode. The DBA finds that the job is halfway through and is consuming resources on the server, so the DBA will suspend the job and restart it later when the server is less busy.

```
Export> stop_job
Are you sure you wish to stop this job ([y]/n): y
oracle@linux>
```

From home the DBA logs in to see the status of the job, and the job is in suspended mode. Now, the DBA wants to use the more processing power available in the server. So the first step is to attach to the job, like so:

```
oracle@linux:> expdp bill/thedba attach=VOLEST_EXP_TEST
```

```
Export: Release 10.1.0.2.0 - Production on
Friday, 23 April, 2004
Copyright (c) 2003, Oracle.  All rights reserved.
Connected to: Oracle Database 10g Enterprise
Edition Release 10.1.0.2.0 - Production
With the Partitioning, OLAP and Data Mining options

Job: VOLEST_EXP_TEST
  Owner: BILL
  Operation: EXPORT
  Creator Privs: FALSE
  GUID: D8C25554B641EF14E030007F0200562C
  Start Time: Friday, 23 April, 2004 15:16
  Mode: SCHEMA
  Instance: BT10GNF1
  Max Parallelism: 1
  EXPORT Job Parameters:
  Parameter Name      Parameter Value:
     CLIENT_COMMAND        bill/**** parfile=volest.par
     DATA_ACCESS_METHOD    AUTOMATIC
     ESTIMATE              BLOCKS
     INCLUDE_METADATA      1
     LOG_FILE_DIRECTORY    DUMPLOCATION
     LOG_FILE_NAME         volest.exp.log
     TABLE_CONSISTENCY     0
     USER_METADATA         1
  State: IDLING
  Bytes Processed: 730,622,512
  Percent Done: 69
  Current Parallelism: 1
  Job Error Count: 0
  Dump File: /oradata/dumpfiles/volest.dmp
    bytes written: 733,958,144

Worker 1 Status:
  State: UNDEFINED
```

```
Export> parallel=4

Export> status=60

Job: VOLEST_EXP_TEST
  Operation: EXPORT
  Mode: SCHEMA
  State: IDLING
  Bytes Processed: 730,622,512
  Percent Done: 69
  Current Parallelism: 4
  Job Error Count: 0
  Dump File: /oradata/dumpfiles/volest.dmp
    bytes written: 733,958,144

Worker 1 Status:
  State: UNDEFINED

Export> start_job

Export> continue_client
```

After attaching to the job, we increased the threads to four from one (`parallel=4`), set up to display detailed status to the screen every minute (`status=60`), restarted the job (`start_job`), and let the output display on the screen (`continue_client`).

Real World Scenario

Using Fine-Grained Object Selection

The fine-grained object selection in Oracle 10*g* for export came as a real boon for us. We perform daily exports on the OLTP database excluding certain large (maybe we should say *huge*) tables. In Oracle 8*i* and Oracle 9*i*, we had to re-create one of the dictionary views to exclude certain multimillion row transaction tables. Now in Oracle 10*g*, we simply use the `EXCLUDE=TABLESPACE:"like '%LARGE%'"`, which excludes all the objects created in the `%LARGE%` tablespaces.

Multiple clients (sessions) can attach to a job.

You can also use the Oracle Enterprise Manager (EM) Grid Control or the Database Control to perform the Data Pump export and import. The OEM can also do the job monitoring. The next section will discuss how to use the Data Pump wizard in the EM.

Using the Data Pump Wizard

You can use the EM Database Control to export and import data using Data Pump. From the Database Control home page, click the Maintenance tab. Under Utilities, you will see the following three links:

- Export To Files
- Import From File
- Import From Database

The export and import supports Database, Schema, and Table modes. The wizard accepts input for each option and shows the final review screen where you can see the actual DBMS_DATAPUMP calls. Figure 2.2 shows a screen where you would specify the export options.

While performing the import, options are available to transform the schema, tablespace, or datafiles. The jobs can be executed immediately or can be scheduled for a later time.

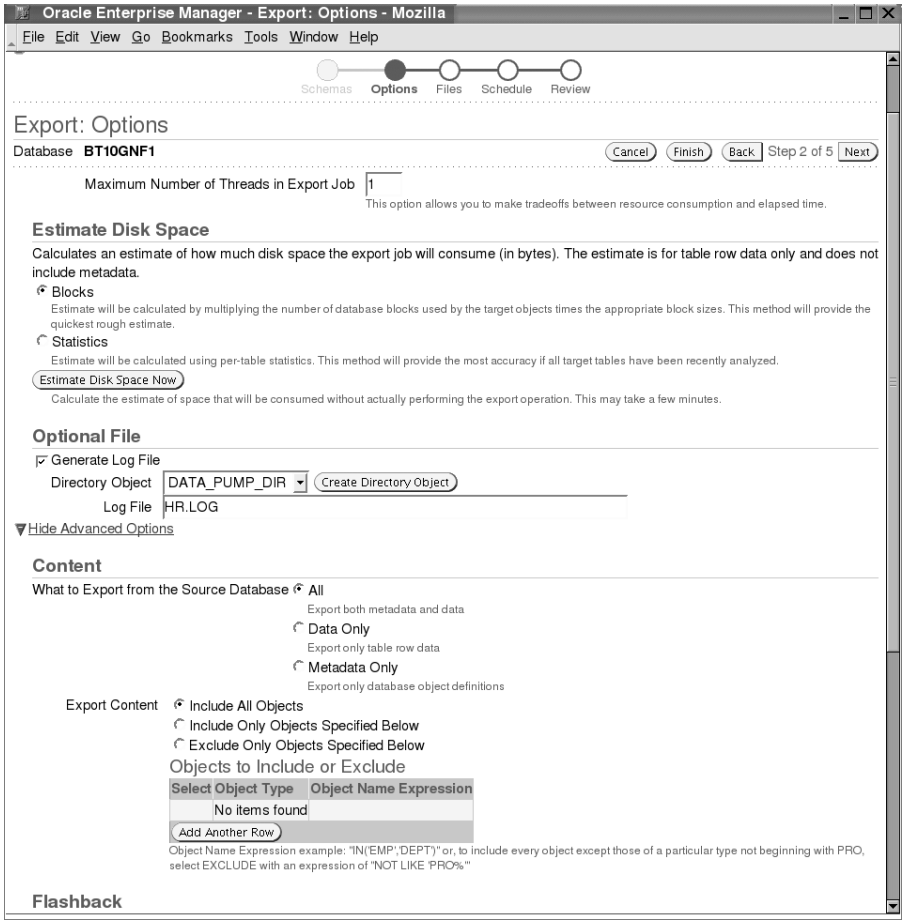
The following is a sample of the DBMS_DATAPUMP calls prepared by the EM wizard for a schema import (this PL/SQL block is available on the Review screen of the export/import):

```
declare
h1   NUMBER;
 begin
  begin
      h1 := dbms_datapump.open (
            operation => 'IMPORT',
            job_mode => 'FULL',
            job_name => 'IMPORT000028',
            version => 'COMPATIBLE');
  end;
  begin
     dbms_datapump.set_parallel(handle => h1,
                   degree => 1);
```

```
end;
begin
   dbms_datapump.add_file(handle => h1,
                  filename => 'IMPORT.LOG',
                  directory => 'DATA_PUMP_DIR',
                  filetype => 3);
end;
begin
   dbms_datapump.set_parameter(handle => h1,
                  name => 'KEEP_MASTER',
                  value => 0);
end;
begin
   dbms_datapump.add_file(handle => h1,
                  filename => 'volest.dmp',
                  directory => 'DUMPLOCATION',
                  filetype => 1);
end;
begin
   dbms_datapump.set_parameter(handle => h1,
                  name => 'DATA_ACCESS_METHOD',
                  value => 'AUTOMATIC');
end;
begin
   dbms_datapump.set_parameter(handle => h1,
                  name => 'INCLUDE_METADATA',
                  value => 1);
end;
begin
   dbms_datapump.set_parameter(handle => h1,
                  name => 'REUSE_DATAFILES',
                  value => 0);
end;
begin
   dbms_datapump.set_parameter(handle => h1,
                  name => 'SKIP_UNUSABLE_INDEXES',
                  value => 0);
end;
begin
```

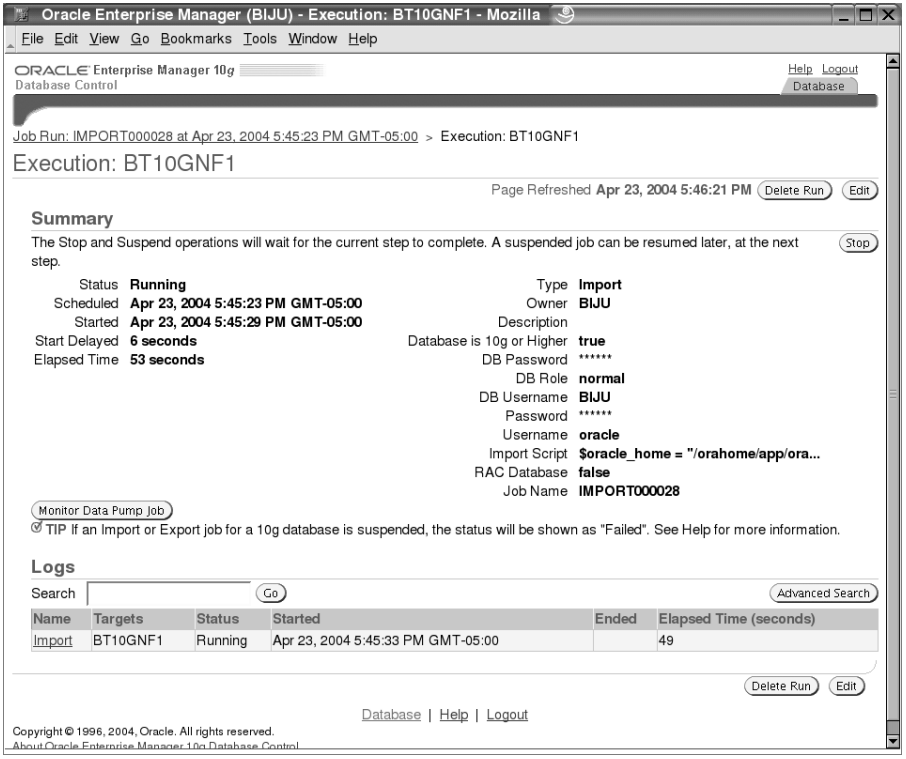
```
    dbms_datapump.start_job(handle => h1,
                skip_current => 0,
                abort_step => 0);
  end;
  begin
    dbms_datapump.detach(handle => h1);
  end;
end;
/
```

FIGURE 2.2 EM export options



Once the Data Pump job is submitted, you can view its progress by clicking the View Job button. A summary of job will be displayed, as shown in Figure 2.3.

FIGURE 2.3 Import job run status



The Monitor Data Pump Job button will take you to the details of the job. You can modify the parallelism or kill/stop the job. You may also use `impdp` client to monitor this job after attaching to the job.

Making Data Movement Enhancements

Apart from Data Pump, Oracle has improved the data movement capabilities of two other major components of Oracle 10*g*. Transportable tablespaces support cross-platform movement, and external tables support writing from the database (unloading). We will discuss these enhancements in the next two sections.

Using Cross-Platform Transportable Tablespaces

Oracle 8*i* introduced the transportable tablespace feature. Oracle 8*i* and Oracle 9*i* supported the transportable tablespaces feature when the Oracle databases were running on the same architecture and operating system. Oracle 10*g* supports moving datafiles across different platforms.

Each operating system supports either big- or little-Endian format to store numerical values. On platforms with big-Endian format, values are stored with the most significant bytes first in memory. On platforms with little-Endian format, values are stored with least significant bytes first.

When doing cross-platform transportable tablespaces, you can copy the datafiles directly if their Endian formats are the same. If the Endian formats are different, you must use RMAN to convert the datafiles before importing them to the target database. The V$TRANSPORATABLE_PLATFORM view shows Endian format for each platform.

```
SQL> select platform_id, platform_name, endian_format
  2  from   v$transportable_platform
  3  order by platform_name
SQL> /

PLATFORM_ID PLATFORM_NAME                         ENDIAN
----------- ------------------------------------ ----------
          6 AIX-Based Systems (64-bit)           Big
         16 Apple Mac OS                         Big
         15 HP Open VMS                          Little
          5 HP Tru64 UNIX                        Little
          3 HP-UX (64-bit)                       Big
          4 HP-UX IA (64-bit)                    Big
          9 IBM zSeries Based Linux              Big
         13 Linux 64-bit for AMD                 Little
         10 Linux IA (32-bit)                    Little
         11 Linux IA (64-bit)                    Little
         12 Microsoft Windows 64-bit for AMD     Little
          7 Microsoft Windows IA (32-bit)        Little
          8 Microsoft Windows IA (64-bit)        Little
          1 Solaris[tm] OE (32-bit)              Big
          2 Solaris[tm] OE (64-bit)              Big

15 rows selected.

SQL>
```

The V$DATABASE includes two new columns, PLATFORM_ID and PLATFORM_NAME.

With cross-platform tablespaces, data can be easily distributed across multiple platforms. Usually in data warehouse environments, the data marts are on smaller platforms, and the data warehouse is on a larger platform. It also allows database to be migrated from one platform to another by building the database and transporting application data tablespaces.

In the following sections, we will review the limitations of cross-platform transportable tablespaces and discuss the steps involved in using cross-platform transportable tablespaces.

Introducing the Limitations of Cross-Platform Transportable Tablespaces

For the cross-platform tablespace to work, you need to have the `COMPATIBLE` parameter set to 10.0.0 or higher on both databases. All the datafiles must be platform aware. When you first open the database with `COMPATIBLE` set to 10.0 or higher, all online read-write datafiles are made platform aware. So before transporting read-only tablespaces to another database, make sure to make the tablespaces read-write once at least with the `COMPATIBLE` parameter set to 10.0 or higher (applicable only to databases that are upgraded from earlier releases with read-only tablespaces).

The databases must use the same database character set and national character set. Character set conversion is not possible in transportable tablespaces.

A limitation exists on the `CLOB` datatype columns created prior to Oracle 10*g* (applicable only if the database was upgraded from an earlier release). RMAN does not convert the `CLOB` data; the application must take care of the conversion if any is required. Prior to Oracle 10*g*, `CLOB` datatype was represented as `UCS2`, which is Endian-dependent, and in Oracle 10*g* `CLOB` is represented as `AL16UTF16`, which is Endian-independent. The big-Endian `UCS2` is same as `AL16UTF16`, so no conversion is needed.

Introducing the Steps for Transporting Tablespaces Across Platforms

The steps involved in transporting tablespaces to another database within the same platform and across platforms are similar if the Endian formats of the platforms are the same. These are the steps involved:

1. Determine if the platforms use the same Endian format by querying the `V$TRANSPORTABLE_PLATFORM` in the source and target databases:

```
SQL> select a.platform_id, a.platform_name,
            endian_format
  2  from   v$transportable_platform a, v$database b
  3* where  a.platform_id = b.platform_id
SQL> /

PLATFORM_ID PLATFORM_NAME              ENDIAN_FOR
----------- -------------------------- ----------
         10 Linux IA (32-bit)          Little

SQL>
```

2. Ensure the tablespaces to be transported are self-contained. Use the DBMS_TTS.TRANSPORT_SET_CHECK procedure to determine this. For example:

```
SQL> EXEC DBMS_TTS.TRANSPORT_SET_CHECK( -
             'SALES_DATA,SALES_INDEX',TRUE);
```

3. Make the tablespaces to be transported read-only in the source database.

```
SQL> ALTER TABLESPACE SALES_DATA READ ONLY;
SQL> ALTER TABLESPACE SALES_INDEX READ ONLY;
```

4. Use the expdp utility to unload the metadata information for the tablespaces to be transported.

```
$ expdp system DUMPFILE=sales_tts.dmp
  LOGFILE=sales_tts.log
  DIRECTORY=dumplocation TRANSPORT_FULL_CHECK=Y
  TRANSPORT_TABLESPACES=SALES_DATA,SALES_INDEX
```

5. In step 1, if we have determined that the Endian formats are same for the platforms, you can skip this step and proceed to step 6. If the Endian formats are different, the datafiles need to be converted using RMAN.

   To convert the datafiles from the little-Endian format (Linux) to the big-Endian format (Sun Solaris), do the following:

```
$ rman target /
RMAN> CONVERT TABLESPACE 'sales_data, sales_index'
2> TO PLATFORM 'Solaris[tm] OE (64-bit)'
3> DB_FILE_NAME_CONVERT =
4> '/oradata/BT10GNF1/sales_data01.dbf',
5> '/tmp/sales_data01_sun.dbf',
6> '/oradata/BT10GNF1/sales_index01.dbf',
7> '/tmp/sales_index01_sun.dbf';
```

   If you decide to convert the datafiles at the target platform, you can do so—just replace line 2 with FROM_PLATFORM 'Linux IA (32-bit)'.

6. Use operating system utilities to copy the converted datafiles and the metadata dump file to the target server. Use the impdp utility on the target to import the metadata and plug-in the tablespaces. The target user must already exist in the target database, if not, you can make the objects owned by an existing user using the REMAP_SCHEMA parameter, as shown here:

```
$impdp system DUMPFILE=sales_tts.dmp
   LOGFILE=sales_tts_imp.log DIRECTORY=data_dump_dir
   TRANSPORT_DATAFILES='/oradata/SL10H/sales_data01.dbf',
   '/oradata/SL10H/sales_index01.dbf'
```

7. Make the new tablespaces read-write in the target database, like so:

```
SQL> ALTER TABLESPACE SALES_DATA READ WRITE;
SQL> ALTER TABLESPACE SALES_INDEX READ WRITE;
```

Writing and Projecting External Tables

Oracle 9*i* introduced external tables and were read-only from the Oracle database. In Oracle 10*g*, you can write to external tables. The external table enhancements in Oracle 10*g* also include the parallel populate operation and projected column feature. DML statements or index creation is still not permitted on external tables.

In Oracle9*i*, ORACLE_LOADER was the only access driver available for external tables. Oracle 10*g* has a new access driver called the ORACLE_DATAPUMP. Only tables created with ORACLE_DATAPUMP can be written to. The external tables that use ORACLE_LOADER access driver are still read-only—they read ASCII flat files from the operating system. Only the external tables created with ORACLE_DATAPUMP access driver can be written to. The resulting file is in proprietary format (Oracle native external representation, DPAPI), which only the Oracle Data Pump can read. You may use this file to load to another Oracle database.

You may wonder how this is beneficial. Why don't you use the Oracle Data Pump clients to generate the file? Well, though Oracle Data Pump client utilities (expdp and impdp) can handle a certain level of filtering, join operations with another table is not possible. Using the external table ORACLE_DATAPUMP access driver, you can unload data that is derived from complex queries. This is useful in loading data marts from data warehouse or similar applications.

In the following sections, we will discuss using the external tables for data loading and unloading.

Loading Using External Tables

The ORACLE_LOADER access driver loads data to an Oracle database from a flat file using the external table method. You can specify the PARALLEL clause when creating the table; ORACLE_LOADER access driver divides the large flat file into chunks that can be processed separately. Loading data in the context of external table means reading data from external table (flat file) and loading to a table in the database using a INSERT statement.

Let's create an external table using the ORACLE_LOADER access driver; the user already has privilege to read and write the directory WORK_DIR. The source datafile is employee.dat, which has fixed column data (name, title, salary). The following code shows the contents of the employee.dat file, creates the external table using the ORACLE_LOADER driver, and queries the external table:

```
linux:oracle>cat employee.dat
SMITH   CLERK    800
SCOTT   ANALYST  3000
ADAMS   CLERK    1100
MILLER  CLERK    1300
linux:oracle>
SQL> CREATE TABLE employees (
  2  ename  VARCHAR2 (10),
  3  title  VARCHAR2 (10),
  4  salary NUMBER (8))
```

```
  5  ORGANIZATION EXTERNAL (
  6  TYPE ORACLE_LOADER
  7  DEFAULT DIRECTORY WORK_DIR
  8  ACCESS PARAMETERS
     (RECORDS DELIMITED BY NEWLINE FIELDS (
  9  ename CHAR(10),
 10  title CHAR(10),
 11  salary CHAR(8)))
 12  LOCATION ('employee.dat'))
 13  PARALLEL
SQL> /

Table created.

SQL> SELECT * FROM employees;

ENAME      TITLE          SALARY
---------- ---------- ----------
SMITH      CLERK             800
SCOTT      ANALYST          3000
ADAMS      CLERK            1100
MILLER     CLERK            1300

SQL>
```

You can use the data from this external table to load other tables using INSERT statements. The characteristics shown in the example work the same on an Oracle *9i* database; the code is provided here for completeness of the loading and unloading discussion.

Only the SELECT statement is allowed on external tables; no INSERT/UPDATE/DELETE operation is permitted on external tables.

Unloading Using External Tables

The ORACLE_DATAPUMP access driver unloads data from an Oracle database to a flat file (DPAPI format) using the external table method. The external table must be created using the CREATE TABLE ... AS SELECT ... (CTAS) method. You can specify the PARALLEL clause when creating the table; ORACLE_DATAPUMP access driver unloads data into multiple flat files at the same time. One parallel execution server will write to only one file at a time. Unloading data in the context of external table means creating an external table (flat file) using CTAS method.

During the unload (or populate) operation, the data goes from the subquery to the SQL engine for the data to be processed and is extracted in the DPAPI format to write to the flat file. The external table to unload data can be created only using the CTAS method with the ORACLE_DATAPUMP access driver. The unload operation does not include the metadata for the tables. You can use the VERSION clause when unloading the data to make sure it loads correctly on the target database.

Let's demonstrate unloading data using the ORACLE_DATAPUMP access driver. We will join the EMPLOYEES and DEPARTMENTS tables of the HR schema to unload data. User SCOTT has write privilege on the directory WORK_DIR and has SELECT privilege on the tables in the subquery. The following statement creates the table in the database as well as creates two files—empl_comm1.dmp and empl_comm2.dmp—in the operating system.

```
SQL> CREATE TABLE empl_commission
  2  ORGANIZATION EXTERNAL (TYPE ORACLE_DATAPUMP
  3  DEFAULT DIRECTORY work_dir
  4  LOCATION ('empl_comm1.dmp','empl_comm2.dmp'))
  5  PARALLEL 2
  6  AS
  7  SELECT employee_id,
  8         first_name || ' ' || last_name employee_name,
  9         department_name,
 10         TO_CHAR(hire_date,'DD-MM-YYYY') hire_date,
 11         salary * NVL(commission_pct, 0.5) commission
 12  FROM hr.employees
 13       JOIN hr.departments
 14       USING (department_id)
 15  ORDER BY first_name || ' ' || last_name
SQL> /

Table created.

SQL> SELECT department_name, sum(commission) total_comm
  2  FROM   empl_commission
  3  GROUP BY department_name;

DEPARTMENT_NAME                TOTAL_COMM
------------------------------ ----------
Accounting                          10150
Finance                             25800
Human Resources                      3250
Marketing                            9500
Purchasing                          12450
```

```
Sales                              72640
Shipping                           78200
Administration                      2200
Executive                          29000
IT                                 14400
Public Relations                    5000

11 rows selected.

SQL>
```

Now you can copy the dump files to another Oracle 10*g* database and load it using the Data Pump utility or create an external table on these dump files and load from it. Let's create an external table using these dump files and query it:

```
SQL> CREATE TABLE new_empl_commission (
  2  employee_id  NUMBER (6),
  3  employee_name VARCHAR2 (40),
  4  department_name VARCHAR2 (30),
  5  hire_date VARCHAR2 (10),
  6  commission NUMBER)
  7  ORGANIZATION EXTERNAL (TYPE ORACLE_DATAPUMP
  8  DEFAULT DIRECTORY work_dir
  9  ACCESS PARAMETERS (
 10  LOGFILE 'new_empl_commission.log')
 11  LOCATION ('empl_comm1.dmp', 'expl_comm2.dmp'));

Table created.

SQL> SELECT department_name, sum(commission) total_comm
  2  FROM   new_empl_commission
  3  GROUP BY department_name;

DEPARTMENT_NAME                TOTAL_COMM
------------------------------ ----------
Accounting                          10150
Administration                       2200
Executive                           29000
Finance                             25800
Human Resources                      3250
IT                                  14400
Marketing                            9500
```

```
Public Relations                    5000
Purchasing                         12450
Sales                              72640
Shipping                           78200

11 rows selected.

SQL>
```

When dealing with external table files that contain rows of data that may be rejected, the projected column feature gets a consistent result set. The next section will discuss projected columns.

The data dictionary views DBA_EXTERNAL_TABLES and DBA_EXTERNAL_LOCATIONS can be queried to view the characteristics, location, and filenames of external tables.

Using Projected Columns

Since external tables are based on flat files, they could contain unclean or malformed data that may get rejected. For this reason, Oracle 10*g* processes all the columns of the external table even if they are not used in the SELECT statement every time you access the external table. If you know that the data is safe, you can improve performance by making Oracle process only the columns in the SELECT statement. You accomplish this by using the following:

```
ALTER TABLE external_table_name
PROJECT COLUMN REFERENCED;
```

PROJECT COLUMN ALL is the default for the external table.

Let's demonstrate using an example. Refer to the table EMPLOYEES created under the section "Loading Using External Tables." You are going to create a bad row in the employees.dat file (non-numeric value in the salary column for SCOTT). The REJECT LIMIT (number of bad rows allowed) is by default 0; you have to change it first to do this demonstration.

```
linux:oracle>cat employee.dat
SMITH     CLERK     800
SCOTT     ANALYST   3AAA
ADAMS     CLERK     1100
MILLER    CLERK     1300
linux:oracle>
SQL> ALTER TABLE employees REJECT LIMIT UNLIMITED;

Table altered.
```

```
SQL> SELECT COUNT(ename) FROM employees;

COUNT(ENAME)
------------
           3

SQL> SELECT COUNT(salary) FROM employees;

COUNT(SALARY)
-------------
            3

SQL> ALTER TABLE employees PROJECT COLUMN REFERENCED;

Table altered.

SQL> SELECT COUNT(ename) FROM employees;

COUNT(ENAME)
------------
           4

SQL> SELECT COUNT(salary) FROM employees;

COUNT(SALARY)
-------------
            3

SQL>
```

The PROPERTY column in DBA_EXTERNAL_TABLES shows you the projected column status of the table. The default is ALL in Oracle 10*g*; in Oracle 9*i* the only behavior available was REFERENCED.

Managing the Scheduler

Oracle 10*g* includes a very sophisticated scheduling mechanism to automate routine tasks. The scheduler offers you the ability to manage the Oracle database environment by breaking the tasks into manageable components. It is a collection of procedures and functions in the DBMS_SCHEDULER package. The earlier versions of Oracle included the DBMS_JOB program to schedule jobs; this utility is still available in Oracle 10*g*.

The main differences between DBMS_JOB and DBMS_SCHEDULER are

- DBMS_JOB can execute only stored programs or anonymous PL/SQL blocks. The new DBMS_SCHEDULER can execute stored programs, anonymous blocks and OS executables.
- There is only one component in DBMS_JOB, the job. The DBMS_SCHEDULER has several components that enhance the scheduling capabilities and works with the resource manager.
- The job or schedule intervals can be defined in a more complex and in natural language using DBMS_SCHEDULER. DBMS_JOB accepts only SQL date expressions.
- DBMS_SCHEDULER has a more detailed job run status and failure information that can be queried from the data dictionary.

You can manage the scheduler using the DBMS_SCHEDULER package programs or by using the Oracle Enterprise Manger. We will discuss both in this chapter.

The scheduler helps DBAs and developers to control when, where, and what various tasks take place. A typical example of using the scheduler is to automate database maintenance jobs such as performing database backups, loading data warehouse data, calculating statistics, refreshing materialized views, checking for audit violations, creating month-end reports, and so on.

In the following sections we discuss the concepts and components of the scheduler.

Understanding Scheduler Concepts

The scheduler is a set of programs in the DBMS_SCHEDULER package. They are callable from any PL/SQL program or by using the EM Database Control. The following are the basic components of the scheduler:

Program A *program* determines what task needs to be performed. The program is a collection of metadata information about the name of the program, its type, and its arguments. The program type could be an anonymous PL/SQL block, stored procedure, or operating system executable. You create programs in the scheduler using the DBMS_SCHEDULER.CREATE_PROGRAM procedure.

Schedule A *schedule* specifies when and how often a task (job) will be executed. You can schedule jobs to run immediately or at a later time. For jobs that repeat, you can also specify the frequency and end date. You create schedules in the scheduler using the DBMS_SCHEDULER.CREATE_SCHEDULE procedure.

Job *Job* specifies the program that needs to be executed and the schedule. A program and schedule can be shared in the database. Each user can have a job created using the program and schedule. A job instance represents a specific run of the job. You create jobs in the scheduler using the DBMS_SCHEDULER.CREATE_JOB procedure.

The scheduler also includes the following advanced components that can be used to prioritize jobs and to ensure resources are allocated appropriately:

Job class A *job class* defines a group of jobs that share the same characteristics and have common resource usage requirements. A job can belong to only one job class. A job class can be associated with a resource consumer group. The resource consumer group determines the resources that are allocated to the jobs in the job class. Within each job class, you can prioritize the jobs.

Window and window group A *window* can activate different resource plans at different times. The window represents an interval with a well-defined start and end time. A *window group* is a list of windows. A window or window group is also a valid schedule for a job; this ensures that a job runs only when a particular resource plan is active.

Each component of the scheduler is considered as a database object. You can manage privileges on these objects as you would on a table or procedure. When you try to drop an object or alter an object that does not exist in the scheduler, a PL/SQL exception is raised. If you try to enable or disable an object that is already enabled or disabled, no error is generated.

Creating Basic Scheduler Components

You should use the `DBMS_SCHEDULER` program to create the scheduler components using any PL/SQL interface. You can also create the components using the EM interface. From the database home page of EM, click the Administration tab to manage the components of the scheduler.

In the following sections, we will discuss how to create programs, jobs, and schedules.

Creating Programs

As stated earlier, a program is a collection of metadata about what is run by the scheduler. The `CREATE JOB` privilege is required for creating a job in the user's schema; `CREATE ANY JOB` privilege lets the user create the program in any schema. For another user to execute the programs created by you, you have to grant the `EXECUTE` privilege on the program to that user. The `DBMS_SCHEDULER.CREATE_PROGRAM` procedure has the following arguments:

PROGRAM_NAME Specifies the name of the program; must be unique in the SQL namespace. This parameter does not have a default value.

PROGRAM_TYPE Specifies the type of the program. Three types of programs exist: `plsql_block`, `stored_procedure`, and `executable`. This parameter does not have a default value.

PROGRAM_ACTION Specifies the PL/SQL code, name of the PL/SQL procedure, or name of the external executable including the full path name. This parameter does not have a default value.

NUMBER_OF_ARGUMENTS Specifies the number of arguments for an executable or stored procedure. The default is `0` (no arguments).

ENABLED Specifies if the program should be created and enabled. A program must be enabled before it can be used. The default is `FALSE`.

COMMENTS Specifies a comment for the program. The default is `NULL`.

Let's create a program using the scheduler. The task is to run a shell script executable. Here is the code to do this:

```
SQL> BEGIN
  2  DBMS_SCHEDULER.CREATE_PROGRAM(
  3  program_name=>'SCOTT.CHECK_ALERT_LOG_ERRORS',
  4  program_action=>'/dba_script/cron/check_alert.sh',
  5  program_type=>'EXECUTABLE',
  6  comments=>'Email DBA if errors in the alert file',
  7  enabled=>TRUE);
  8  END;
  9  /

PL/SQL procedure successfully completed.

SQL>
```

Here is another example where the program runs a stored procedure that takes two arguments:

```
SQL> BEGIN
  2  DBMS_SCHEDULER.CREATE_PROGRAM(
  3  program_name=>'SCP_PURGE_LOG_TABLE',
  4  program_action=>'SCOTT.PURGE_LOG_TABLE',
  5  program_type=>'STORED_PROCEDURE',
  6  number_of_arguments=>2,
  7  comments=>'Purge the Log tables');
  8  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

The arguments to the program are defined using the `DBMS_SCHEDULER.DEFINE_PROGRAM_ARGUMENT` procedure. You can define the arguments to a program irrespective of whether the program is enabled or disabled. The following are the parameters in the `DEFINE_PROGRAM_ARGUMENT` procedure:

PROGRAM_NAME Specifies the name of the program; the program must exist before you can define argument. This parameter does not have a default value.

ARGUMENT_NAME Specifies the name of the argument; this parameter is optional and defaults to NULL

ARGUMENT_POSITION Specifies the position of the argument when it is passed to the program. The valid values are from 1 to the *number_of_arguments* defined in the program specification. This parameter does not have a default value.

ARGUMENT_TYPE Specifies the datatype of the argument. This parameter does not have a default value.

DEFAULT_VALUE Specifies any default values to be used. This parameter does not have a default value.

OUT_ARGUMENT This must be set to FALSE; the parameter is reserved for future use. The default is FALSE.

Let's now define the arguments to the program defined earlier:

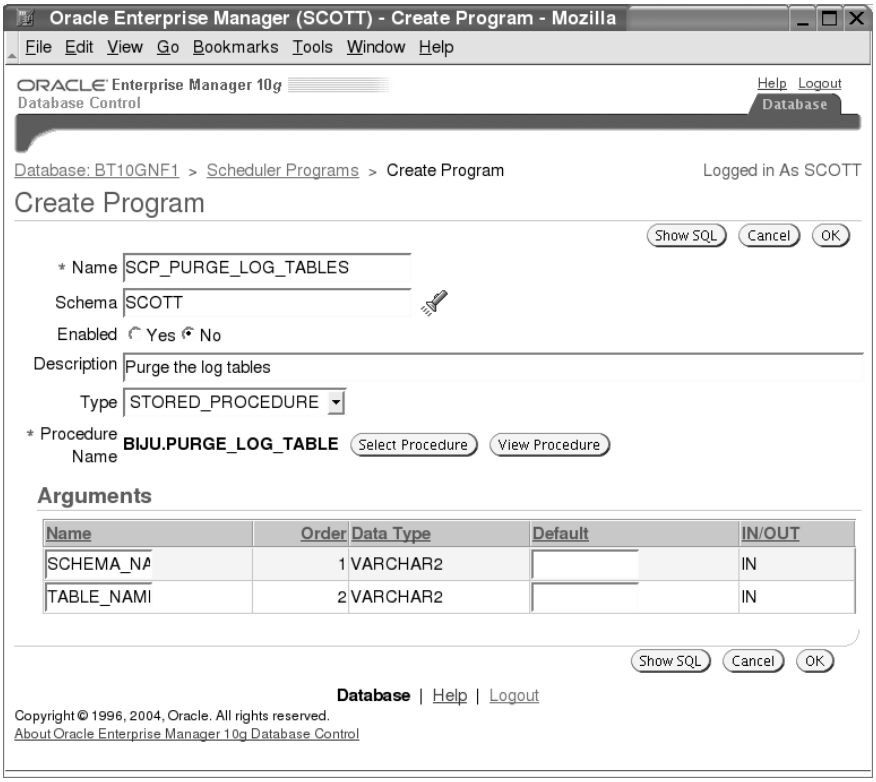
```
SQL> BEGIN
  2  DBMS_SCHEDULER.DEFINE_PROGRAM_ARGUMENT(
  3  program_name=>'SCOTT.SCP_PURGE_LOG_TABLE',
  4  argument_name=>'SCHEMA_NAME',
  5  argument_position=>1,
  6  argument_type=>'VARCHAR2',
  7  default_value=>'SCOTT',
  8  out_argument=>FALSE);
  9
 10  DBMS_SCHEDULER.DEFINE_PROGRAM_ARGUMENT(
 11  program_name=>'SCOTT.SCP_PURGE_LOG_TABLE',
 12  argument_position=>2,
 13  argument_type=>'VARCHAR2');
 14  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

Figure 2.4 shows the EM screen to create a program. You can also define the arguments to the program in the same screen.

Creating Schedules

As mentioned earlier, schedules define when a task needs to be run. The CREATE JOB privilege is required to create a schedule. The CREATE ANY JOB privilege lets you create the schedule in any schema in the database. You use the DBMS_SCHEDULER.CREATE_SCHEDULE procedure to create schedules.

FIGURE 2.4 EM Create Program screen



The following are the parameters to the CREATE_SCHEDULE procedure:

SCHEDULE_NAME Specifies name of the schedule. The name has to be unique in the SQL namespace. This parameter does not have a default value.

START_DATE Specifies the first date when the schedule becomes active. For repeating schedules, `start_date` determines the first instance of the schedule. The default value is `NULL`.

REPEAT_INTERVAL Specifies in calendar expression how often the job should repeat (see the section "Specifying Calendaring Expressions" for more information). SQL expressions such as `'TRUNC(SYSDATE)+28/24'` are not valid when defining named schedules. This parameter does not have a default value.

END_DATE Specifies the date after which the schedule becomes inactive. The `end_date` must be after the `start_date`. The default value is `NULL`.

COMMENTS Specifies and optional comments to the schedule. The default value is `NULL`.

The following example creates a schedule with the name SCS_TUES_AM in SCOTT's schema. The schedule runs every Tuesday at 8 a.m. with no end date and is valid from April 27.

```
SQL> BEGIN
  2  SYS.DBMS_SCHEDULER.CREATE_SCHEDULE(
  3  repeat_interval => 'FREQ=WEEKLY;BYDAY=TUE;BYHOUR=8;➥
  BYMINUTE=0;BYSECOND=0',
  4  start_date => to_timestamp_tz(➥
  '2004-04-27 US/Central', 'YYYY-MM-DD TZR'),
  5  comments => 'Tuesday AM Schedule',
  6  schedule_name => '"SCOTT"."SCS_TUES_AM"');
  7  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

Figure 2.5 shows the screen to create a schedule using the EM. The Repeat drop-down selection determines the columns and parameters for the interval. The Repeat drop-down list does not have seconds as an option for repeat interval, though the scheduler supports it.

You specify the start and end times to a schedule using the TIMESTAMP datatype. The precision is only up to a second.

Creating Jobs

As noted earlier, a job is a combination of the schedule and program. A job can use named schedules and named programs or define the schedule and program as part of the job definition. The job definition can be in any of the following combinations:

- Using a named program (a program defined using the CREATE_PROGRAM) and a named schedule (a schedule defined using CREATE_SCHEDULE)
- Using a named program and an inline schedule (a schedule defined as part of the job)
- Using an inline program (a program defined as part of the job) and named schedule

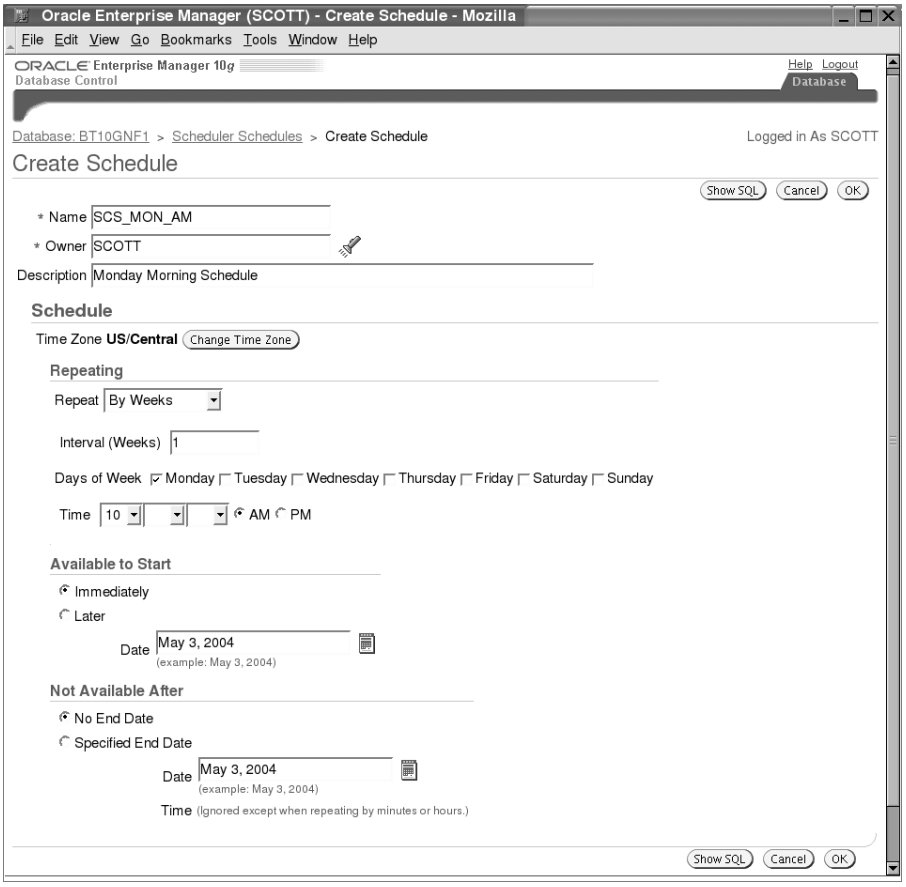
The DBMS_SCHEDULER.CREATE_JOB procedure has the following parameters:

JOB_NAME Specifies the name of the job. This parameter does not have a default value.

PROGRAM_NAME Specifies the name of the program to run. This parameter does not have a default value.

SCHEDULE_NAME Specifies the name of the schedule to use. This parameter does not have a default value.

FIGURE 2.5 EM Create Schedule screen



JOB_CLASS Specifies to which class the job belongs. If not specified, the job is assigned to the `DEFAULT_JOB_CLASS` job class.

ENABLED Specifies if the job is enabled. The default is `FALSE`. You have to enable a job before it can be used.

AUTO_DROP Specifies if the job should be automatically removed when its status is changed to `COMPLETED`. The default is `TRUE`, which means for one-time jobs, the job definition will be dropped as soon as the job completes; for repeating jobs, the definition will be removed when the end date of the schedule reached.

COMMENTS Specifies a description of the job. This parameter does not have a default value.

You can use the following parameters to replace the PROGRAM_NAME parameter (defining inline program):

JOB_TYPE Specifies type of the job, equivalent to PROGRAM_TYPE. Valid values are plsql_block, stored_procedure, and executable.

JOB_ACTION Specifies what needs to be executed; equivalent to PROGRAM_ACTION.

NUMBER_OF_ARGUMENTS Specifies the number of arguments to a stored procedure or executable. The default is 0.

You can use the following parameters to replace the SCHEDULE_NAME parameter (defining inline schedule):

START_DATE Specifies the date when the job becomes active. This parameter has a default value of NULL.

REPEAT_INTERVAL Specifies the frequency of the repeating jobs. You can specify this using the calendaring expressions or using PL/SQL expressions. If no repeat interval is specified, the job runs only once on the specified start date.

END_DATE Specifies the date when the job becomes inactive. Let's create a job that runs every week at 8 a.m. Though the calendaring expressions are easy and more readable, this example uses a SQL expression for the repeat interval (to demonstrate that it can be used when defining job schedule). The job does not use a named program or a named schedule. The schedule and program are defined with the job.

```
SQL> BEGIN
  2  SYS.DBMS_SCHEDULER.CREATE_JOB(
  3  job_name => 'SCOTT.SCJ_WEEKLY_DATA_CHECK',
  4  job_type => 'EXECUTABLE',
  5  job_action => '/scripts/app/weekly_data_check.sh',
  6  repeat_interval => 'TRUNC(SYSDATE)+176/24',
  7  start_date => TRUNC(SYSDATE)+8,
  8  comments => 'Check if data from Vendor loaded right',
  9  auto_drop => FALSE,
 10  enabled => TRUE);
 11  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

If you have a saved program and a saved schedule, the create job statement would be as follows:

```
SQL> BEGIN
  2  SYS.DBMS_SCHEDULER.CREATE_JOB(
  3  job_name => 'SCOTT.SCJ_TUE_PURGE',
  4  program_name => 'SCOTT.SCP_PURGE_LOG_TABLES',
  5  schedule_name => 'SCOTT.SCS_TUES_AM',
  6  comments => 'Purge Activity Logs on Tuesday',
  7  auto_drop => FALSE,
  8  enabled => TRUE);
  9  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

If multiple jobs need to be run at the same time, using saved schedules helps manage them better. If you want to change the time of the schedule, you need to change `repeat_interval` or `end_date` only once for the saved schedule, instead of changing each job. When a schedule is modified, each job using the schedule is automatically updated to use the new schedule.

Use the `DBMS_SCHEDULER.SET_JOB_ARGUMENT_VALUE` procedure to set parameter values for a job (similar to setting parameter values to a program). You can specify the parameter name using `argument_name` (only for saved programs) or `argument_position`.

Here is an example of setting up a job using a stored procedure that accepts two parameters, with a named schedule:

```
SQL> BEGIN
  2  SYS.DBMS_SCHEDULER.CREATE_JOB(
  3  job_name => 'SCOTT.SCJ_PURGE_DAILY_ACTIVTY',
  4  job_type => 'STORED_PROCEDURE',
  5  job_action => 'SCOTT.PURGE_LOG_TABLE',
  6  schedule_name => 'SCOTT.SCS_TUES_AM',
  7  comments => 'Named schedule inline procedure with
                 arguments',
  8  number_of_arguments => 2,
  9  enabled => FALSE);
 10  SYS.DBMS_SCHEDULER.SET_JOB_ARGUMENT_VALUE(
 11  job_name => 'SCOTT.SCJ_PURGE_DAILY_ACTIVTY',
 12  argument_position => 1,
 13  argument_value => 'HR');
 14  SYS.DBMS_SCHEDULER.SET_JOB_ARGUMENT_VALUE(
 15  job_name => 'SCOTT.SCJ_PURGE_DAILY_ACTIVTY',
```

```
 16  argument_position => 2,
 17  argument_value => 'DAILY_ACTIVITY');
 18  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

A job instance is a specific run of a job. For nonrepeating jobs, there will be only one instance. For jobs that repeat, there will be multiple instances.

Oracle *calendaring expressions* are used for the repeat interval of saved schedule; the repeat interval on a job could use either a calendaring expression or a SQL expression. In the next section, we will discuss how to use the calendaring expressions.

Specifying Calendaring Expressions

`repeat_interval` specifies how often a job or schedule repeats, using the calendaring expressions of Oracle. The calendaring expression has the following three parts:

- Frequency
- Interval
- Specifier

You specify the components using the keywords `FREQ=`, `INTERVAL=`, and *`specifier_name`*`=`. Semicolons separate each part and the components.

Frequency is the only mandatory part in the calendaring expression. You can specify frequency using any of the following types of recurrence:

```
YEARLY
MONTHLY
WEEKLY
DAILY
HOURLY
MINUTELY
SECONDLY
```

Interval is specified as a numeric integer; valid values are between 1 and 99.

The specifier provides detailed information about when the job should be run. Using *`specifier_name`*, you can determine which hours the job should be run or on what days the job should be run. The following are the available specifiers:

BYMONTH Specifies which month the job should be run. You can specify the month as `1` through `12` or `JAN` through `DEC`.

BYWEEKNO Specifies the week numbers of the year (follows ISO-8601 standard). The week number can be between 1 and 53. `BYWEEKNO` is valid only for `FREQ=YEARLY`.

BYYEARDAY Specifies the day of the year as a number. Must be careful with leap years when specifying BYYEARDAY. Valid values are between 1 and 366. You can specify negative numbers, which will evaluate to the same day irrespective of leap year. The number –17 will evaluate to December 15 always.

BYMONTHDAY Specifies day of the month (1 through 31). Negative values can be used. The number –1 means the last day of the month.

BYDAY Specifies the day of the week as a three-character abbreviation (MON, TUE, and so on).

BYHOUR Specifies the hour of the day. Values can range from 0 through 23.

BYMINUTE Specifies the minute of the hour. Values are from 0 through 59.

BYSECOND Specifies the second on the minute. Values are from 0 through 59.

Table 2.11 shows examples of using calendaring expressions.

Using the calendaring expressions, you can schedule jobs for every possible combination of run dates. You may use the DBMS_SCHEDULER.EVALUATE_CALENDAR_STRING procedure to verify the calendar syntax without running a real job.

TABLE 2.11 Calendaring Expression Examples

Calendaring Expression	Result
`FREQ=HOURLY;INTERVAL=4`	Every 4 hours
`FREQ=DAILY;INTERVAL=10;BYHOUR=8; BYMINUTE=0;BYSECOND=0`	Every 10 days at 8 a.m.
`FREQ=WEEKLY;INTERVAL=3;BYDAY=WED ,SAT;BYHOUR=6;BYMINUTE=30`	Every third Wednesday and Saturday at 6:30 a.m.
`FREQ=MONTHLY;INTERVAL=2; BYMONTHDAY=-1,15;BYHOUR=17`	Every other month, on the 15th and the last day of the month at 5 p.m.
`FREQ=YEARLY;BYYEARDAY=-276`	Every March 31st
`FREQ=YEALY;BYMONTH=MAR; BYMONTHDAY=31`	Every March 31st
`FREQ=YEARLY;BYWEEKNO=1;BYDAY=SAT`	First Saturday of the year
`FREQ=MONTHLY;BYDAY=-2FRI`	Second-to-last Friday of every month
`FREQ=HOURLY;BYMONTHDAY=1,-1`	Every hour on the first and last day of the month

Using the Scheduler

The scheduler objects (schedules, programs, jobs) are all treated as individual database objects, and they follow the same rules for privileges and naming other database objects. In the following sections, we will discuss the programs available for setting the scheduler environment and to administer the scheduler components.

To create a job, schedule, or program, you need the CREATE JOB privilege. To create a job, schedule, or program in another schema, you need the CREATE ANY JOB privilege. For a user to use a scheduler component created by you, the user must have the EXECUTE privilege on the object or the EXECUTE ANY PROGRAM privilege. When a named schedule is created, all users in the database (PUBLIC) have access to the schedule. The following are the privileges on individual scheduler objects:

```
EXECUTE ON program>
ALTER ON job, program or schedule
ALL ON job, program or schedule
```

The object privileges are granted using the regular SQL syntax of GRANT and REVOKE statements.

In the next section we will discuss enabling/disabling the job components and administering the scheduler components.

Administering Scheduler Components

You can modify and drop programs, schedules, and jobs once they are created. To modify or drop a component, you must be the owner of the component, have explicit ALTER/ALL privilege on the component, or have CREATE ANY JOB privilege.

You can enable a job or program using the DBMS_SCHEDULER.ENABLE procedure. You can disable a job or program using the DBMS_SCHEDULER.DISABLE procedure. ENABLE and DISABLE procedures have only one parameter, the program or job name.

The following example disables the SCJ_TUE_PURGE job and enables the SCP_PURGE_LOG_TABLES program:

```
SQL> BEGIN
  2  SYS.DBMS_SCHEDULER.DISABLE('SCOTT.SCJ_TUE_PURGE');
  3  SYS.DBMS_SCHEDULER.ENABLE
                        ('SCOTT.SCP_PURGE_LOG_TABLES');
  4  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

The ENABLE and DISABLE procedures can accept multiple jobs or programs as a comma-delimited list. Here is an example:

```
SQL> EXEC SYS,DBMS_SCHEDULER.ENABLE(  -
  'SCOTT.SCP_XR, HR.SCP_PAYROLL, VOLEST.SCJ_WEEKLY');
```

Let's discuss the administrative options available in each type of component.

Managing Jobs

Once a job is created and is enabled, you can run it using the DBMS_SCHEDULER.RUN_JOB procedure. The procedure accepts the job name as the parameter. If you want to run the job in the background, specify FALSE as the second parameter.

Many occurrences of the job can be running at the same time, if you run the job in the current session (second parameter TRUE). Here is an example to run the job SCJ_TUE_PURGE in the background:

```
SQL> EXEC DBMS_SCHEDULER.RUN_JOB('SCOTT.SCJ_TUE_PURGE',FALSE);
```

If a job is running currently and you want to stop it, use the DBMS_SCHEDULER.STOP_JOB procedure. *job_name* and force are the parameters to this procedure. If you set force to TRUE, the job slave process is terminated when the scheduler cannot stop the job gracefully using an interrupt mechanism. To force stop a job, you need the MANAGE SCHEDULER system privilege, which is not applicable to jobs of type EXECUTABLE. To stop multiple jobs, you can specify a comma-delimited list of jobs as the job name. Here is an example to stop the currently running SCJ_TUE_PURGE job. The second example shows force stopping the job.:

```
SQL> EXEC DBMS_SCHEDULER.STOP_JOB('SCOTT.SCJ_TUE_PURGE');
SQL> EXEC DBMS_SCHEDULER.STOP_JOB('SCOTT.SCJ_TUE_PURGE', TRUE);
```

To drop a job from the scheduler, use DBMS_SCHEDULER.DROP_JOB procedure. The job name can be a list of jobs and job classes. To drop a job that is currently running, specify TRUE as the second parameter (force). When the job is dropped, it arguments are also dropped. The following example drops two jobs:

```
SQL> EXEC DBMS_SCHEDULER.DROP_JOB('SCOTT.SCJ_DAILY1, -
  SCOTT.SCJ_DAILY2');
```

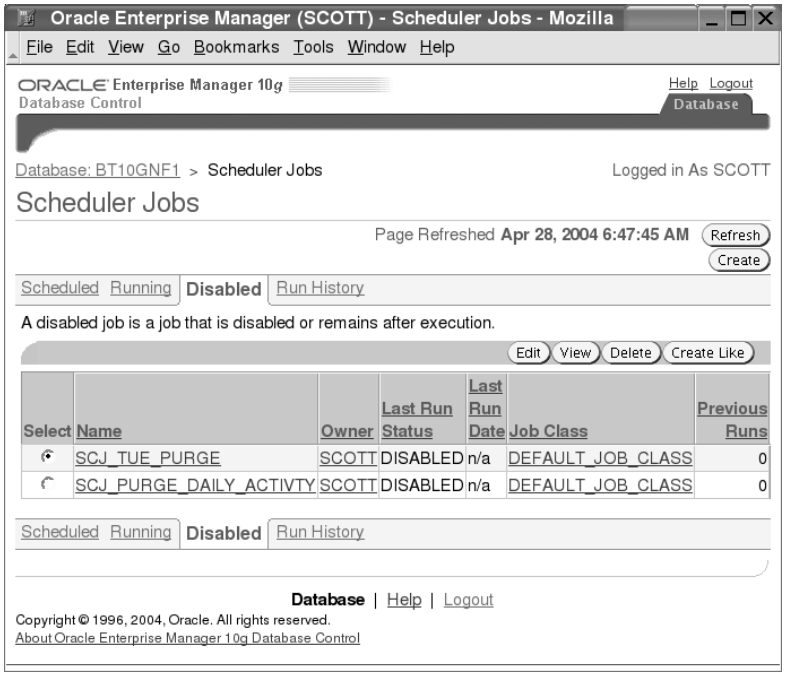
You can clear the values for job arguments using the DBMS_SCHEDULER.RESET_JOB_ARGUMENT_VALUE procedure. This procedure accepts two parameters: job_name and argument_position or argument_name. If the corresponding saved program does not have a default value, the job will be disabled. The following two examples show resetting argument value using positional notation and using argument name (SCHEMA_NAME).

```
SQL> EXEC DBMS_SCHEDULER.RESET_JOB_ARGUMENT_VALUE ( -
 >        'SCOTT.SCJ_PURGE_DAILY_ACTIVTY', 1);
SQL> EXEC DBMS_SCHEDULER.RESET_JOB_ARGUMENT_VALUE ( -
 >        'SCOTT.SCJ_PURGE_DAILY_ACTIVTY', SCHEMA_NAME);
```

You can use the DBMS_SCHEDULER.COPY_JOB procedure to copy all the attributes of an existing job to a new job. There are two parameters: old_job and new_job.

Figure 2.6 shows the EM screen to manage jobs. The jobs are listed under three tabs: Scheduled, Running, and Disabled. You can also view the run history. Using this screen, you can create, view, edit, drop, and copy jobs.

FIGURE 2.6 EM Scheduler Jobs screen



Managing Programs

You have seen enabling and disabling programs using the DBMS_SCHEDULER.ENABLE and DBMS_SCHEDULER.DISABLE procedures earlier. You can drop a saved program using the DBMS_SCHEDLER.DROP_PROGRAM procedure. This procedure accepts two parameters: program_name and force. The default for force is FALSE, which means you can drop a program only if no jobs reference the program. If it is set to TRUE, the jobs referencing the program are disabled before dropping the program. If a job is running when the program is dropped, the job continues with no issues. The program_name parameter can accept a list of comma-delimited program names.

Here is an example:

```
SQL> EXEC DBMS_SCHEDULER.DROP_PROGRAM ( -
'SCOTT.SCP_PURGE_LOG, SCOTT.SCP_TRUNC_DAILY');
```

You can use the DBMS_SCHEDULER.DROP_PROGRAM_ARGUMENT procedure to drop the arguments to a saved program. This overloaded procedure accepts two parameters: program_name and argument_ position or argument_name. The following example shows dropping the arguments from the saved program SCP_PURGE_LOG_TABLE:

```
SQL> BEGIN
  2  DBMS_SCHEDULER.DROP_PROGRAM_ARGUMENT(
  3  program_name=>'SCOTT.SCP_PURGE_LOG_TABLE',
  4  argument_name=>'SCHEMA_NAME');
  5
  6  DBMS_SCHEDULER.DROP_PROGRAM_ARGUMENT(
  7  program_name=>'SCOTT.SCP_PURGE_LOG_TABLE',
  8  argument_position=>2);
  9  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

Managing Schedules

You can use the DBMS_SCHEDULER.DROP_SCHEDULE procedure to drop a schedule. This procedure accepts two parameters: schedule_name and force. If the value of force is set to FALSE (the default), the schedule must not be referenced in any jobs. If set to TRUE, the referenced jobs are disabled before dropping the schedule. The schedule_name can be a list of schedules separated by comma.

Here is an example:

```
SQL> EXEC DBMS_SCHEDULER.DROP_SCHEDULE( -
          'ST.SCS_WED, ST.SCS_THU');
```

Setting Scheduler Attributes

The scheduler has procedures to set global values for the scheduler and to set values for individual scheduler object attributes. You can set three scheduler attributes at a global level using DBMS_SCHEDULER.SET_SCHEDULER_ATTRIBUTE to affect all the scheduler components. They are as follows:

DEFAULT_TIMEZONE The default time zone specified as the time zone name (U.S./Pacific) or using an offset (–8:00).

LOG_HISTORY The number of days log information should be kept. Its default is 30.

MAX_JOB_SLAVE_PROCESSES Specifies the maximum number of slave processes. The default is NULL, and the range is 1–999.

Here is an example of setting these attributes:

```
SQL> BEGIN
  2  DBMS_SCHEDULER.SET_SCHEDULER_ATTRIBUTE
  3    ('DEFAULT_TIMEZONE','US/Central');
  4  DBMS_SCHEDULER.SET_SCHEDULER_ATTRIBUTE
  5    ('LOG_HISTORY','45');
  6  DBMS_SCHEDULER.SET_SCHEDULER_ATTRIBUTE
  7    ('MAX_JOB_SLAVE_PROCESSES','6');
  8  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

You can retrieve the arguments values of the scheduler using the `DBMS_SCHEDULER.GET_SCHEDULER_ATTRIBUTE` procedure. Pass the attribute as the first parameter, and get the value using the second parameter.

You can change the arguments of individual scheduler components using the `DBMS_SCHEDULER.SET_ATTRIBUTE` procedure. You can change all the attributes using this procedure except the component name. The procedure has three attributes: `name`, `attribute`, and `value`. Since the procedure is overloaded, it can accept values to many different datatypes. Table 2.12 shows a few of the common attributes that can be changed for each component.

TABLE 2.12 *DBMS_SCHEDULER.SET_ATTRIBUTE* Values

Component	Attribute	Possible Values
Job	`LOGGING_LEVEL`	`DBMS_SCHEDULER.LOGGING_OFF`, `DBMS_SCHEDULER.LOGGING_RUNS` (default), and `DBMS_SCHEDULER.LOGGING_FULL`.
Job	`RESTARTABLE`	`TRUE` (default) and `FALSE`.
Job	`MAX_FAILURES`	1 to 1,000,000. The default is `NULL`.
Job	`JOB_WEIGHT`	1 to 100. The default is 1.
Job	`JOB_PRIORITY`	1 to 5; 1 is the first to be picked up.

TABLE 2.12 *DBMS_SCHEDULER.SET_ATTRIBUTE* Values *(continued)*

Component	Attribute	Possible Values
Job	SCHEDULE_LIMIT	1 to 99 minutes.
Job	PROGRAM_NAME	Name of the program.
Job	JOB_ACTION	PL/SQL block, executable name, or stored procedure name.
Job	JOB_TYPE	PLSQL_BLOCK, STORED_PROCEDURE, and EXECUTABLE.
Job, program	NUMBER_OF_ARGUMENTS	Number of arguments.
Job	SCHEDULE_NAME	Name of schedule.
Job, schedule	REPEAT_INTERVAL	PL/SQL expression or calendar expression.
Job, schedule	START_DATE	A specific date.
Job, schedule	END_DATE	A specific date.
Job,	JOB_CLASS	A specific job class.
Job, program, schedule	COMMENTS	A specific comment.
Job	AUTO_DROP	TRUE and FALSE
Program	PROGRAM_ACTION	PL/SQL block, executable name, or stored procedure name.
Program	PROGRAM_TYPE	PLSQL_BLOCK, STORED_PROCEDURE, and EXECUTABLE
Job	STOP_ON_WINDOW_CLOSE	If the job uses a window for schedule, specifying TRUE will stop the job when closing the window.
Job	JOB_PRIORITY	Specifies the priority of the job among other jobs in the same job class. Values can be 1 through 5; 1 is the first to be picked up.

Here is an example of setting the attributes to a job:

```
SQL> BEGIN
  2  SYS.DBMS_SCHEDULER.DISABLE(
         'SCOTT.SCJ_WEEKLY_DATA_CHECK' );
  3  SYS.DBMS_SCHEDULER.SET_ATTRIBUTE(
  4  name => 'SCOTT.SCJ_WEEKLY_DATA_CHECK',
  5  attribute => 'job_priority', value => 1);
  6  SYS.DBMS_SCHEDULER.SET_ATTRIBUTE(
  7  name => 'SCOTT.SCJ_WEEKLY_DATA_CHECK',
  8  attribute => 'max_failures', value => 5);
  9  SYS.DBMS_SCHEDULER.SET_ATTRIBUTE(
 10  name => 'SCOTT.SCJ_WEEKLY_DATA_CHECK',
 11  attribute => 'restartable', value => TRUE);
 12  SYS.DBMS_SCHEDULER.ENABLE(
         'SCOTT.SCJ_WEEKLY_DATA_CHECK' );
 13  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

Notice that in the previous example the job is disabled and then enabled after setting the attributes. This is not mandatory; the scheduler automatically disables the job before changing any attribute value and enables it after the attribute is set. If there is an error in setting the attribute, the job will remain disabled.

You can use the `DBMS_SCHEDULER.SET_ATTRIBUTE_NULL` procedure to set an attribute value to `NULL` (to unset an attribute). The following example removes comments from a job:

```
SQL> EXEC SYS.DBMS_SCHEDULER.SET_ATTRIBUTE_NULL( -
> name => 'SCOTT.SCJ_WEEKLY_DATA_CHECK',  -
> attribute => 'comments');

PL/SQL procedure successfully completed.

SQL>
```

So far we discussed only the basic scheduler components: programs, schedules, and jobs. In the next section, we will discuss the advanced components: job classes, windows, and window groups.

Managing Advanced Scheduler Components

Oracle provides advanced scheduler components to manage jobs efficiently. Job classes group individual jobs with common characteristics. You can prioritize jobs within a job class. Windows provide the ability to activate different resource plans at different times. (Resource plans are defined and managed using Resource Manager.) Only one window can be active at any given time, but they are allowed to overlap. A window group is a named collection of windows.

In the following section, we will discuss using these components of the scheduler. The MANAGE_SCHEDULER privilege is required to create a job class, a window, and window groups.

Using Job Classes

You create job classes using the DBMS_SCHEDULER.CREATE_JOB_CLASS procedure. Job classes always belong to the SYS schema. Every database has a job class named DEFAULT_JOB_CLASS. When creating jobs, if no job class is specified, they belong to DEFAULT_JOB_CLASS. The following are the parameters to the CREATE_JOB_CLASS procedure:

JOB_CLASS_NAME Specifies the name of the job class. SYS owns all the job classes; if a schema name is specified, it must be SYS. There is no default for this parameter.

RESOURCE_CONSUMER_GROUP Specifies the name of the resource consumer group. If a resource group is not specified or if the resource group is dropped, the job class will belong to the DEFAULT_CONSUMER_GROUP. The default value for this parameter is NULL.

SERVICE Specifies the name of the service to which the job class belongs. This parameter can be left out and is relevant to Real Application Clusters (RAC) environments. The default value for this parameter is NULL.

LOGGING_LEVEL Specifies how much information is logged when jobs are run. The possible values are DBMS_SCHEDULER.LOGGING_OFF (no logging), DBMS_SCHEDULER.LOGGING_RUNS (information of all job runs in the class), and DBMS_SCHEDULER.LOGGING_FULL (information on runs and operations on jobs such as enable, disable, alter, and so on). The default value for this parameter is NULL.

LOG_HISTORY Specifies the number of days to retain log files. The default is specified using the DBMS_SCHEDULER.SET_SCHEDULER_ATTRIBUTE. The default value for this parameter is NULL.

COMMENTS Specifies a description of the job class. The default value for this parameter is NULL.

The following code creates a job class named FRIDAY_MIRR_BKUP_JOBS that uses the SYS_GROUP consumer group:

```
SQL> BEGIN
  2  SYS.DBMS_SCHEDULER.CREATE_JOB_CLASS(
  3  job_class_name => 'FRIDAY_MIRR_BKUP_JOBS',
  4  logging_level => DBMS_SCHEDULER.LOGGING_FULL,
```

```
  5  log_history => 21,
  6  resource_consumer_group => 'SYS_GROUP',
  7  comments => 'Jobs that backup files from mirror');
  8  END;
  9  /

PL/SQL procedure successfully completed.

SQL>
```

When creating new jobs, you can use the JOB_CLASS parameter to specify the job class where the job belongs. To change the job class in a job, use the SET_ATTRIBUTE procedure. The following code shows assigning the SALES_DB_BKUP job to the FRIDAY_MIRR_BKUP_JOBS job class:

```
SQL> BEGIN
  2  SYS.DBMS_SCHEDULER.SET_ATTRIBUTE(
  3  name => 'SCOTT.SALES_DB_BKUP',
  4  attribute => 'job_class',
  5  value => 'FRIDAY_MIRR_BKUP_JOBS');
  6* END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

For other users to use the job class, they must have the EXECUTE privilege on the job class:

```
SQL> GRANT execute ON sys.friday_mirr_bkup_jobs TO anna;

Grant succeeded.

SQL>
```

Though log information is needed for reviewing what happened, over time the logs can accumulate. The LOG_HISTORY defines the number of days the log information is kept. You can also use the DBMS_SCHEDULER.PURGE_LOG procedure to clear the log files. The PURGE_LOG procedure can take zero to three parameters. If no parameters are specified, all the log files will be deleted.

The three parameters are as follows:

- log_history This specifies how much history (in days) to keep. The valid range is 0–999. If set to 0, no history is kept.

- *which_log* This specifies which type of log. The possible values for *which_log* are JOB_LOG (delete only job logs), WINDOW_LOG (delete only window logs), and the default JOB_AND_WINDOW_LOG (delete all logs).
- *job_name* This specifies which job-specific entries must be purged from the job log. Specify the *job_name* if you want to delete only the logs that belong to a specific job (or list of job names separated by comma).

Here is an example that deletes all the log files:

```
SQL> EXEC DBMS_SCHEDULER.PURGE_LOG();
```

The following example deletes job logs that are older than seven days:

```
SQL> BEGIN
  2  DBMS_SCHEDULER.PURGE_LOG (
  3  log_history=> 7,
  4  which_log=>'JOB_LOG');
  5  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

As with the other components of the scheduler, the job class can be modified using the SET_ATTRIBUTE procedure. You can drop job classes using the DBMS_SCHEDULER.DROP_JOB_CLASS procedure. The job_class_name and force procedures are the parameters to this procedure. The job_class_name can be a list of job classes, delimited by comma. The following example drops the FRIDAY_MIRR_BKUP_JOBS job class.

```
SQL> BEGIN
  2  SYS.DBMS_SCHEDULER.DROP_JOB_CLASS(
  3  job_class_name => 'FRIDAY_MIRR_BKUP_JOBS',
  4  force          => TRUE );
  5  END;
  6  /

PL/SQL procedure successfully completed.

SQL>
```

Using Windows and Window Groups

A window represents a well-defined interval of time for which specific resource parameters are specified. Windows activate different resource plans at different times. In the previous section, you saw how to assign the resource consumer group names to prioritize jobs when creating job classes. Resource plans specify the resource consumer group that belongs to the plan and has directives for how resources have to be allocated among the groups. A systemwide resource plan can be associated with a window to mange the overall resource usage for jobs. The schedule, duration, and resource plan are defined in a window.

You can create a window using the `DBMS_SCHEDULER.CREATE_WINDOW` procedure. The `SYS` schema always owns the window. The procedure has the following parameters:

WINDOW_NAME Specifies a unique name for the window. There is no default value for this parameter.

RESOURCE_PLAN Specifies the name of the resource plan. Only one resource plan can be associated with a window. There is no default value for this parameter.

SCHEDULE_NAME Specifies the name of the schedule associated with the window. There is no default value for this parameter.

DURATION Specifies how long the window will be open. You specify the duration in `INTERVAL DAY TO SECOND` with ranges from 1 minute to 99 days.

WINDOW_PRIORITY Specifies which window will be open when windows overlap. The possible values are `HIGH` and `LOW`. The default is `LOW`.

COMMENTS Specifies notes for the window. There is no default value for this parameter.

If the `SCHEDULE_NAME` is not specified, you must specify `START_DATE`, `REPEAT_INTERVAL`, and `END_DATE`. The following example creates a window that uses the resource plan meant for online users. The window starts every day at 8 a.m. for 9 hours (until 5 p.m.). This window has high priority.

```
SQL> BEGIN
  2  DBMS_SCHEDULER.CREATE_WINDOW(
  3  window_name=>'BUSINESS_HOURS',
  4  resource_plan=>'ONLINE_PLAN',
  5  start_date=>systimestamp at time zone 'US/Central',
  6  duration=>numtodsinterval(9, 'hour'),
  7  repeat_interval=>'FREQ=DAILY;BYHOUR=8',
  8  window_priority=>'HIGH',
  9  comments=>'Resources for Online users');
 10* END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

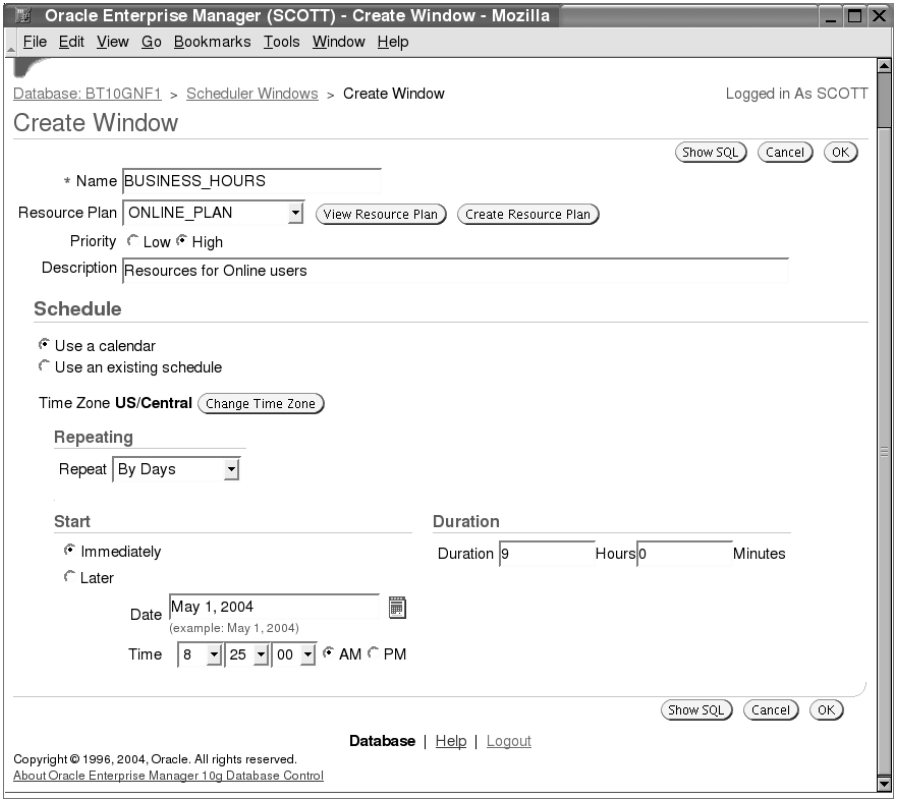
Figure 2.7 shows creating a window using the EM. The screen has options for you to view existing resource plans or to create a new resource plan that should be used with the window. The interval can be specified using the Repeat drop down list.

At any given time, only one window can be active. If there are overlapping windows, the window with the highest priority gets preference. If there are two windows with the same priority, the window that started earlier remains active. At the end of the running window, if two or more windows with the same priority exist, the database switches to the window that has the highest percentage of its duration left.

Because of overlapping windows, there is possibility that a window will not be active at all. The job that uses this window as its schedule will not be executed.

When switching from a low-priority to a high-priority window, the jobs currently running in the `LOW` priority window continue to run unless the job has the attribute `STOP_ON_WINDOW_CLOSE` explicitly set to `TRUE`.

FIGURE 2.7 EM Create Window screen



You can use the ALTER SYSTEM SET RESOURCE_MANAGER_PLAN *plan name* FORCE to prevent the scheduler window from switching resource plans if you see a need for a specific plan to be effective (maybe when the president of the company is using the database).

A window group is a named collection of windows, created in the SYS schema. You create a window group using the DBMS_SCHEDULER.CREATE_WINDOW_GROUP procedure.

GROUP_NAME Specifies the name of the window group. There is no default value for this parameter.

WINDOW_LIST Specifies the list of windows that should be part of the window group. The default value for this parameter is NULL.

COMMENTS Specifies a comment that can be added to the window group. The default value for this parameter is NULL.

To create a window group, you need to specify a name for the window group and a list of windows. Here is an example:

```
SQL> BEGIN
  2  DBMS_SCHEDULER.CREATE_WINDOW_GROUP(
  3  group_name=>'ALL_MAINTENANCE',
  4  window_list=>'WEEKEND_WINDOW, SYSTEM_MAINT,
     TABLE_MAINT');
  5  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

You can use the DBMS_SCHEDULER.ADD_WINDOW_GROUP_MEMBERS procedure to add more windows to the window group. The group_name and window_list parameters are used with this procedure.

Lets discuss the scheduler programs available for administering windows and window groups in the next two sections.

Administering Windows

A window is open if it is in effect. You can use the DBMS_SCHEDULER.OPEN_WINDOW procedure to open a window. If the FORCE parameter is used, any higher-priority window that is already open will be closed. The new window will be active for the duration specified in the window, which can be overridden by using the DURATION parameter in the OPEN_WINDOW procedure.

Forcefully opening a window does not change the schedule of the window (when it should be opened automatically). Here is an example of force opening a window for two hours:

```
EXEC DBMS_SCHEDULER.OPEN_WINDOW ( -
window_name=> 'CRITICAL_UPDATE',  -
duration=> '2 0:00:00', -
force=> TRUE);
```

Similarly, you can close a window using the DBMS_SCHEDULER.CLOSE_WINDOW procedure. The WINDOW_NAME parameter is the only parameter to this procedure. Running jobs with the attribute STOP_ON_WINDOW_CLOSE will be closed when closing a window.

To drop a window, use the DBMS_SCHEDULER.DROP_WINDOW procedure. If the FORCE parameter is set to TRUE, the window will be dropped even it is open, and the jobs that use the window will be disabled. The WINDOW_NAME can be a list of comma-delimited window names.

You can enable and disable windows using the ENABLE and DISABLE procedures of DBMS_SCHEDULER.

Windows—as well as window groups—are created with access to PUBLIC; therefore, no privileges are needed to access window or window groups.

Managing Window Groups

Use the DBMS_SCHEDULER.REMOVE_WINDOW_GROUP_MEMBERS procedure to delete windows from a window group. The group_name and window_list parameters are used with this procedure.

As with other components, window groups can be enabled and disabled using ENABLE and DISABLE procedures.

Setting Scheduler Administrator Privileges

Though we have discussed the privileges required to create and manage each component of the scheduler in their respective sections, in this section we will discuss the administrative privileges associated with scheduler. The following are the privileges and roles:

***ANY* privileges** The CREATE ANY JOB system privilege is required to create a job, schedule, or program in a schema other than yours. The EXECUTE ANY PROGRAM system privilege gives the user the ability to use the programs belonging to another user. The EXECUTE ANY CLASS system privilege gives the user ability to assign a job to any job class (submit a job with higher privileges).

***MANAGE_SCHEDULER* privilege** The MANAGE_SCHEDULER system privilege is required to create and manage job classes, window, and window groups. This privilege gives the user ability to stop any job and start and stop windows prematurely.

***SCHEDULER_ADMIN* role** The SCHEDULER_ADMIN role has CREATE JOB, CREATE ANY JOB, EXECUTE ANY PROGRAM, EXECUTE ANY CLASS, and MANAGE SCHEDULER privileges. These privileges are granted to this role with the WITH GRANT OPTION. The DBA role has SCHEDULER_ADMIN role by default.

Querying the Data Dictionary

Several data dictionary views hold information about the scheduler components and their status. Table 2.13 lists the dictionary views pertaining to the scheduler.

TABLE 2.13 Scheduler Related Dictionary Views

View Name	Description
DBA_SCHEDULER_GLOBAL_ATTRIBUTE ALL_SCHEDULER_GLOBAL_ATTRIBUTE	Displays information about the global attributes for the scheduler
DBA_SCHEDULER_JOBS ALL_SCHEDULER_JOBS USER_SCHEDULER_JOBS	Displays information about the scheduler jobs
DBA_SCHEDULER_JOB_ARGS ALL_SCHEDULER_JOB_ARGS USER_SCHEDULER_JOB_ARGS	Displays information about the arguments of the scheduler job
DBA_SCHEDULER_JOB_CLASSES ALL_SCHEDULER_JOB_CLASSES	Displays information about the scheduler job classes
DBA_SCHEDULER_JOB_LOG ALL_SCHEDULER_JOB_LOG	Displays log information of the scheduler jobs
DBA_SCHEDULER_JOB_RUN_DETAILS ALL_SCHEDULER_JOB_RUN_DETAILS USER_SCHEDULER_JOB_RUN_DETAILS	Displays log run details for the scheduler jobs (contains each instance of the job)
DBA_SCHEDULER_PROGRAMS ALL_SCHEDULER_PROGRAMS USER_SCHEDULER_PROGRAMS	Displays information about the scheduler programs
DBA_SCHEDULER_PROGRAM_ARGS ALL_SCHEDULER_PROGRAM_ARGS USER_SCHEDULER_PROGRAM_ARGS	Displays information about the arguments of the scheduler programs
DBA_SCHEDULER_RUNNING_JOBS ALL_SCHEDULER_RUNNING_JOBS USER_SCHEDULER_RUNNING_JOBS	Displays information about the scheduler jobs that are currently running
DBA_SCHEDULER_SCHEDULES ALL_SCHEDULER_SCHEDULES USER_SCHEDULER_SCHEDULES	Displays information about the scheduler schedules

TABLE 2.13 Scheduler Related Dictionary Views *(continued)*

View Name	Description
DBA_SCHEDULER_WINDOWS ALL_SCHEDULER_WINDOWS	Displays information about the scheduler windows
DBA_SCHEDULER_WINDOW_DETAILS ALL_SCHEDULER_WINDOW_DETAILS	Displays log details for scheduler windows
DBA_SCHEDULER_WINDOW_GROUPS ALL_SCHEDULER_WINDOW_GROUPS	Displays information about the scheduler window groups
DBA_SCHEDULER_WINDOW_LOG ALL_SCHEDULER_WINDOW_LOG	Displays log information for the scheduler windows
DBA_SCHEDULER_WINGROUP_MEMBERS ALL_SCHEDULER_WINGROUP_MEMBERS	Displays the members of the scheduler's window groups

The following are examples of queries using these views. Job execution details are available in DBA_SCHEDULER_JOB_RUN_DETAILS view, one row for each instance of the job:

```
SQL> SELECT job_name, status, error#,
  2         actual_start_date, run_duration
  3  FROM   dba_scheduler_job_run_details
  4  WHERE  owner = 'SCOTT';
```

To view under which resource group a job is currently running, use the following:

```
SQL> SELECT session_id, slave_process_id,
  2         resource_consumer_group,
  3         elapsed_time, cpu_used
  4  FROM   dba_scheduler_running_jobs
  5  WHERE  job_name = 'SCJ_ADD_PARTITION';
```

To view general information about the jobs owned by current user, use the following:

```
SQL> SELECT program_name, job_type, schedule_name, state,
  2         last_run_duration, stop_on_window_close
  3  FROM   user_scheduler_jobs;
```

To view the job management activities performed on the jobs owned by SCOTT, use the following:

```
SQL> SELECT job_name, operation, status, user_name
  2  FROM   dba_scheduler_job_log
  3  WHERE  operation != 'RUN'
  4  and    owner = 'SCOTT';
```

To view the global attributes defined, use the following:

```
SQL> SELECT attribute_name, value
  2  FROM   dba_scheduler_global_attribute;
```

To view information about all the schedules in the database, use the following:

```
SQL> SELECT owner, schedule_name, start_date,
  2         repeat_interval, end_date
  3  FROM   dba_scheduler_schedules;
```

To view the members of window groups, use the following:

```
SQL> SELECT window_group_name, window_name
  2  from dba_scheduler_wingroup_members;
```

To view the argument values for a job, use the following:

```
SQL> SELECT argument_name, argument_position, value
  2  FROM   all_scheduler_job_args
  3  WHERE  owner = 'ANN'
  4  AND    job_name = 'PARTITION_EXCHANGE';
```

Summary

In this chapter, we discussed Oracle Data Pump, enhancements to external tables, and the Oracle scheduler. Data Pump is a high-speed infrastructure for data and metadata movement. The new client utilities `expdp` and `impdp` unload and load data and metadata.

The Data Pump architecture includes the data and metadata movement engine `DBMS_DATAPUMP`, a direct path API that supports a stream interface, the metadata API `DBMS_METADATA`, an external tables API, and the client utilities. Though the Data Pump utilities `expdp` and `impdp` are similar to `exp` and `imp`, they are different products.

Data Pump export can perform in different modes based on the requirement. It can be a full database export or at a table level. The EXP_FULL_DATABASE privilege is required to perform a schema export (other than the users) as well as a full or tablespace export. The import can be performed from the export dump file without specifying a mode.

Data Pump export and import take place on the server. You can attach to a job from any computer and monitor its progress or make resource adjustments. In the interactive mode, you can add a file to export a dump file set, kill a job, stop a job, change parallelism, and enable detailed status logging.

Data Pump export and import supports fine-grained object selection using the CONTENT, INCLUDE, and EXCLUDE parameters. Using a database link, you can perform network export and network import. Also, using a database link you can perform an import from another database directly without using a dump file.

External tables in Oracle 10*g* can be populated using the ORACLE_DATAPUMP access driver. The external tables are populated and created by using the CREATE TABLE ... AS SELECT ... method. Population can be performed in parallel, and each file in the dump file set can reside in different locations. The ability to define the projected column feature helps performance.

In Oracle 10*g*, the transportable tablespace feature is improved to transport tablespaces across platforms. If the Endian format of the platform is different, you must use RMAN to convert the datafiles.

The Oracle scheduler—DBMS_SCHEDULER—is an advanced version of its predecessor DBMS_JOB. The scheduler components are job, program, schedule, job class, window, and window group. Jobs, schedule, and programs are created in the schema of the user whereas job class, window, and window groups are created in the SYS schema.

The SCHEDULER_ADMIN role and MANAGE SCHEDULER system privilege give administrative rights on the scheduler components. In this chapter, you learned to create, drop, and modify all the scheduler components. A job can have a named schedule and a named program. Job classes help prioritize jobs using the resource consumer groups. Windows manage the resource plan for the database. Window group is a collection of windows. Windows and window groups reside in the SYS schema and everyone has access to window and window groups.

In this chapter you also learned to query the data dictionary to view information on the Data Pump jobs, external table properties, and scheduler components and execution details.

Exam Essentials

Understand the enhancements to cross-platform tablespaces. Know the dictionary view name to check the Endian format of the source and destination database. Learn how to convert a datafile using RMAN to copy to an operating system platform with different Endian format.

Know the architecture of Data Pump. Understand the components involved in the Data Pump architecture. Review the benefits of Data Pump.

Understand how to use the Data Pump components. Be familiar with the methods to attach to a running job, stop a job, kill a job, and change its characteristics. Know the data and metadata filtering options available. Know the dictionary views to monitor the Data Pump job. Understand the methods available to remap and transform database objects.

Learn the external table enhancements. Know the access driver used to unload data (or populate an external table). Understand the projected column feature.

Know the components of the scheduler. Understand the purpose of each scheduler component. Learn the privileges required to create each component.

Know how to use the scheduler. Learn to specify calendaring expressions for schedule and jobs. Know how to prioritize jobs. Know to change the characteristics (attributes) of scheduler components.

Review Questions

1. Which two PL/SQL packages are used by the Oracle Data Pump?
   - **A.** `UTL_DATAPUMP`
   - **B.** `DBMS_METADATA`
   - **C.** `DBMS_DATAPUMP`
   - **D.** `UTL_FILE`
   - **E.** `DBMS_SQL`

2. Which of the following options that list the benefits of Oracle Data Pump are not true? (Choose two.)
   - **A.** Data Pump supports fine-grained object selection using the `EXCLUDE`, `INCLUDE`, and `CONTENT` options.
   - **B.** Ability to specify the target version of the database so that the objects exported is compatible. This is useful in moving data from Oracle 10*g* to Oracle 9*i*.
   - **C.** Ability to specify the maximum number of threads to unload data.
   - **D.** The DBA can choose to perform the export using direct path or external tables.
   - **E.** The Data Pump job can be monitored from another computer on the network.

3. The Data Pump job maintains a master control table with information about Data Pump. Which of the following statements are true?
   - **A.** The master table is the heart of Data Pump operation and is maintained in the `SYS` schema.
   - **B.** The master table contains one row for the operation that keeps track of the object being worked so that the job can be restarted in the event of failure.
   - **C.** During the export, the master table is written to the dump file set at the beginning of export operation.
   - **D.** The Data Pump job runs in the schema of the job creator with that user's rights and privileges.
   - **E.** All of the above.

4. When using the `expdp` and `impdp` clients, the parameters `LOGFILE`, `DUMPFILE`, and `SQLFILE` need a directory object, where the files will be written to or read from. Which of the following are nonsupported methods of specifying the directory?
   - **A.** Specify the `DIRECTORY` parameter.
   - **B.** Specify the file name parameters with `directory:`*`file_name`*
   - **C.** Use the initialization parameter `DATA_PUMP_DIR`.
   - **D.** None of the above (all of the above are supported).

5. Which command-line parameter of `expdp` and `impdp` clients connects you to an existing job?
   - **A.** `CONNECT_CLIENT`
   - **B.** `CONTINUE_CLIENT`
   - **C.** `APPEND`
   - **D.** `ATTACH`

6. Which option unloads the data and metadata of the SCOTT user, except the tables that begin with `TEMP`? The dump file also should have the DDL to create the user.
   - **A.** `CONTENT=BOTH TABLES=(not like 'TEMP%') SCHEMAS=SCOTT`
   - **B.** `SCHEMAS=SCOTT EXCLUDE=TABLE:"LIKE 'TEMP%'"`
   - **C.** `INCLUDE=METADATA EXCLUDE=TABLES:"NOT LIKE 'TEMP%'" SCHEMAS=SCOTT`
   - **D.** `TABLES="NOT LIKE 'TEMP%'" SCHEMAS=SCOTT`

7. Which parameter is not a valid one for using the `impdp` client?
   - **A.** `REMAP_TABLE`
   - **B.** `REMAP_SCHEMA`
   - **C.** `REMAP_TABLESPACE`
   - **D.** `REMAP_DATAFILE`

8. When performing Data Pump import using `impdp`, which of the following options is not a valid value to the `TABLE_EXISTS_ACTION` parameter?
   - **A.** `SKIP`
   - **B.** `APPEND`
   - **C.** `TRUNCATE`
   - **D.** `RECREATE`

9. When do you use the `FLASHBACK_TIME` parameter in the `impdp` utility?
   - **A.** To load data from the dump file that was modified after a certain time.
   - **B.** To discard data from the dump file that was modified after a certain time.
   - **C.** Used when the `NETWORK_LINK` parameter is used.
   - **D.** `FLASHBACK_TIME` is valid only with `expdp`, not with `impdp`.

10. Choose two statements that are true regarding external tables.
    - **A.** The `PROJECT COLUMN REFERENCED` clause of `ALTER TABLE` for external tables improves the performance of data loads to the external table.
    - **B.** You can use `INSERT` statements to populate external tables.
    - **C.** You can have the external table populated in Oracle and use the file to load to another database.
    - **D.** Oracle uses the `ORACLE_LOADER` access driver to populate external tables.
    - **E.** The `PROPERTY` column of the `DBA_EXTERNAL_TABLES` view shows the projected column setting.

11. You have a Unix script to be executed on the FINANCE database every four hours. What components must be created in the database to schedule this using the DBMS_DATAPUMP subprograms?

A. Program, schedule, job

B. Schedule, job

C. Job

D. Job, window

E. Program, schedule

12. Which privilege is the least powerful that is required to create a program under your schema?

A. CREATE PROGRAM

B. CREATE JOB

C. MANAGE SCHEDULER

D. EXECUTE ANY PROGRAM

13. When specifying the frequency for schedules using Oracle calendaring expressions, which one of the following is not a valid expression?

A. YEARLY

B. QUARTERLY

C. MONTHLY

D. WEEKLY

E. SECONDLY

14. How do you prioritize jobs in the scheduler?

A. Using the CREATE_JOB procedure

B. Using the CREATE_JOB_CLASS procedure

C. Using the SET_ATTRIBUTE procedure

D. Using the SET_SCHEDULER_ATTRIBUTE procedure

15. The following are valid calendaring expressions:

```
1  FREQ=YEARLY; BYYEARDAY=-4; BYHOUR=20
2  FREQ=MONTHLY; BYMONTH=12; BYMONTHDAY=28; BYHOUR=20
3  FREQ=MONTHLY; BYYEARDAY=-4; BYHOUR=20
4  FREQ=YEARLY; BYMONTH=DEC; BYMONTHDAY=28; BYHOUR=20
```

Choose from the following options the expressions that specify to run a schedule every Dec. 28 at 8 p.m.?

A. Items 1, 2, and 4

B. Items 1 and 4

C. Items 2 and 3

D. Items 1, 2, 3, and 4

16. Which data dictionary view can be used to know the latest change made to a job owned by you?
    A. USER_SCHEDULER_JOBS
    B. USER_SCHEDULER_JOB_LOG
    C. USER_JOBS
    D. USER_SCHEDULER_JOB_RUN_DETAILS

17. To which component is the resource manager resource plan associated with?
    A. Window
    B. Job class
    C. Job
    D. Window and Job class

18. What happens when creating a job if you do not specify the job class?
    A. The JOB_CLASS column of USER_SCHEDULER_JOBS will be NULL.
    B. An error occurs; you must specify a job class.
    C. The job is assigned to a default job class defined by the SET_SCHEDULER_ATTRIBUTE.
    D. None of the above.

19. What should be the value for PROGRAM_TYPE when defining an anonymous PL/SQL block?
    A. ANONYMOUS_BLOCK
    B. STORED_PROCEDURE
    C. PLSQL_PROCEDURE
    D. PLSQL_BLOCK
    E. EXECUTABLE

20. When you create a window, in which schema does it get created? (Choose the most appropriate answer.)
    A. Irrespective of whom creates the window, the window will be always created in the SYS schema.
    B. In the schema of the user who creates the window.
    C. The schema specified with the window name.
    D. You must be logged in with SYSDBA privilege, so it always gets created in the SYS schema.

Answers to Review Questions

1. B, C. The DBMS_METADATA package provides the database object definitions to the export worker process in the proper order of their creation. The DBMS_DATAPUMP package has the API for high-speed export and import for bulk data and metadata loading and unloading.

2. B, D. Oracle Data Pump is known to versions Oracle 10*g* and higher. Oracle 9*i* does not support Data Pump. Though Data Pump can perform data access using the direct path or external table method, Data Pump makes the decision automatically; DBA cannot specify the data access method. Data Pump also supports network mode to import directly from the source database and can estimate the space requirements for dump file.

3. D. The master table is the heart of the Data Pump operation and is maintained in the schema of the job creator. It bears the name of the job, contains one row for each object and each operation, and keeps status. Using this information helps to restart a failed job or to suspend and resume a job. The master table is written to the dump file as the last step of the export and is loaded to the schema of the user as the first step of the import.

4. C. If a directory object is created with the name DATA_PUMP_DIR, the privileged users can use this location as the default location for Data Pump files. Privileged users are users with EXP_FULL_DATABASE or IMP_FULL_DATABASE roles. Using %U in the filename generates multiple files for parallel unloads with each parallel process writing to one file.

5. D. The ATTACH parameter lets you attach or connect to an existing Data Pump job and places you in the interactive mode. The ATTACH without any parameters attaches to the currently running job, if there is only one job from the user. Otherwise, you must specify the job name when using the ATTACH parameter.

6. B. If the CONTENT parameter is not specified, both data and metadata will be unloaded. The valid values for CONTENT are METADATA_ONLY, DATA_ONLY, and ALL. If Scott is performing the export, SCHEMAS=SCOTT is optional.

7. A. REMAP_DATAFILE changes the name of the source datafile to the target datafile name in all DDL statements where the source datafile is referenced. REMAP_SCHEMA loads all objects from the source schema into the destination schema. When using REMAP_TABLESPACE, all objects selected for import with persistent data in the source tablespace are remapped to create in the destination tablespace. Since the Dump File is in XML format, the Data Pump can make these transformations easily.

8. D. REPLACE is the valid value; it drops the existing table and creates the table using the definition from the dump file. SKIP leaves the table untouched. APPEND inserts rows to the existing table. TRUNCATE leaves the structure but removes all existing rows before inserting rows.

9. C. You can specify FLASHBACK_TIME or FLASHBACK_SCN parameters only when performing a network import, where the source is a database.

10. C, E. The PROJECT COLUMN REFERENCED clause helps the queries on external tables, where only a few columns are queried. The default is ALL; set it to REFERENCED if you know the datafile where the external table is referenced is clean. Only using the CREATE TABLE ... AS SELECT ... with ORACLE_DATAPUMP as the access loader can populate external tables.

11. C. Though named programs and named schedules can be used when creating a job, they are not a must. The job can define what need to be executed and when.

12. B. The CREATE JOB privilege is required to create a job, program, or schedule in your schema. CREATE PROGRAM is not a valid privilege. MANAGE SCHEDULER system privilege gives you the ability to administer scheduler components. EXECUTE ANY PROGRAM privilege gives you the ability to execute a program that belongs to another schema. CREATE ANY JOB gives you privilege to create program, schedule, or job in any schema.

13. B. QUARTERLY is not a valid expression. To perform a job quarterly, you need to specify the frequency as MONTHLY and INTERVAL as 3.

14. C. Using the JOB_PRIORITY as the argument to the SET_ATTRIBUTE procedure, you can specify the priority of job from 1 through 5 within the job class.

15. D. All the four calendaring expressions execute a schedule every Dec. 28 at 8 p.m. "BYYEARDAY=-4" or "BYMONTH=DEC; BYMONTHDAY=28" specifies the date and month for the interval Though all four are correct, the most meaningful and easy to understand would be item 1 or 4.

16. B. The LOG_DATE and OPERATION columns of the USER_SCHEDULER_JOB_LOG view show the time and activity on the job.

17. A. A systemwide resource plan can be associated with a window. A resource consumer group is associated with the job class.

18. D. When a job class is not specified while creating a job, the job belongs to the DEFAULT_JOB_CLASS. This job class is the default for the scheduler, which cannot be changed using SET_SCHEDULER_ATTRIBUTE.

19. D. Specify PLSQL_BLOCK for anonymous PL/SQL blocks, EXECUTABLE for any external program, and STORED_PROCEDURE for all stored programs in the database. ANONYMOUS_BLOCK and PLSQL_PROCEDURE are not valid values for PROGRAM_TYPE.

20. A. Job classes, windows, and window groups are always created in the SYS schema. Any user with the MANAGE SCHEDULER privilege can create windows.

Chapter 3

Automating Management

ORACLE DATABASE 10*g* NEW FEATURES FOR ADMINISTRATORS EXAM OBJECTIVES OFFERED IN THIS CHAPTER:

- ✓ **Automatic Management**
  - Use Automatic Database Diagnostic Monitor
  - Use Automatic Shared Memory Management
  - Use Automatic Optimizer Statistics Collection
  - Use Automatic Undo Retention Tuning
- ✓ **Manageability Infrastructure**
  - Monitor and maintain the AWR
  - Use the Active Session History (ASH)
  - Monitor and manage server-generated alerts
  - Explain the automated tasks feature
  - Describe the advisory framework
- ✓ **System Resource Management**
  - Automatically switch a session back to the original consumer group at the end of the top call
  - Set idle time-outs for consumer groups
  - Create mappings for the automatic assignment of sessions to consumer groups

Exam objectives are subject to change at any time without prior notice and at Oracle's sole discretion. Please visit Oracle's training and certification website (`http://www.oracle.com/education/certification/`) for the most current exam objectives listing.

Oracle Database 10*g* (Oracle 10*g*) has implemented several steps to relieve you from routine monitoring and administrative activities and to help you concentrate on the enterprise architecture. The self-managing features of Oracle 10*g* capture information on key performance metrics and keep them in a repository. You can review the findings of Oracle 10*g* automatic collections and take appropriate action. The database even has options to fix the problems automatically.

The Oracle 10*g* Common Manageability Infrastructure (CMI) includes several components to manage and tune the database. In this chapter, we will discuss the components of CMI.

The Automatic Workload Repository (AWR) collects and maintains the statistics for tuning and problem detection. The Automatic Database Diagnostic Monitor (ADDM) is a self-diagnostic engine built in the Oracle 10*g* database engine that uses the WR information. Using the AWR information, Oracle 10*g* can alert you to potential issues based on the threshold metrics defined.

Oracle 10*g* also automatically manages the components of the Shared Global Area (SGA), which helps achieve the maximum memory utilization. For the optimizer to generate optimal execution plans, it needs to have statistics on the objects involved in the query. In Oracle 9*i*, the DBA was responsible for making sure the statistics are current. The Automatic Optimizer Statistics Collection feature is automated, and the DBA no longer needs to worry about stale statistics (exceptions exist, however).

Using the statistics collected by the Oracle database, Oracle 10*g* automatically tunes the undo retention and checkpoints. The Resource Manager has many enhancements, such as returning a session back to its original consumer group and defining a maximum idle time. In Oracle 10*g*, you can flush the buffer cache in addition to flushing the shared pool.

We will discuss all these new features in this chapter.

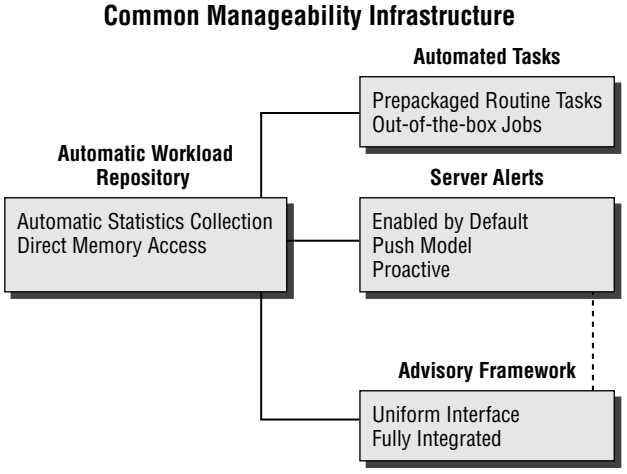
Collecting Performance Statistics

Oracle introduced the STATSPACK program in Oracle 8*i*. This program collected and stored database performance statistics in the database. Oracle 10*g* has improved the Automatic Optimizer Statistics Collection feature to collect more sophisticated information about the operating system and database by introducing a new set of programs called the *Automatic Workload Repository (AWR)*. The AWR takes a snapshot of the database in specified intervals (the default is one hour) and stores it in the SYSAUX tablespace.

In Oracle 10*g*, the statistical and performance information is collected automatically with minimal or no DBA intervention. Also, you do not need to worry about what to capture and where to save the statistics that were gathered.

The AWR is the central element of the *Common Manageability Infrastructure* (CMI). The CMI is a sophisticated self-management infrastructure that allows the database to learn about itself, use this information to adapt to the workload of the database, and correct any potential problems. Figure 3.1 shows the components of CMI architecture, which will be discussed in the following sections.

FIGURE 3.1 The CMI architecture



The Automatic Workload Repository may not contain detailed information on currently active sessions since it is populated on set intervals. The Active Sessions History (ASH) samples the `V$SESSION` view every second for active sessions and records the information, which can be used for current diagnosis. The ASH and AWR together provide detailed diagnostic information. We will discuss these in the following sections.

Using the Automatic Workload Repository

The AWR contains performance statistics and workload information on the database. The information is captured every hour and preserved for seven days by default. Historical information is important to diagnose a performance problem that has already happened. Normally when you know about the performance issue, the session would have already disconnected from

the database. Another reason to have historical statistics is for trend analysis. You must set the proper retention period policy based on the business requirements. Remember, the more days or frequent snapshots, the more disk space you need.

AWR is enabled only when the STATISTICS_LEVEL initialization parameter is set to TYPICAL (the default) or ALL. A value BASIC turns off all AWR statistics and metrics collection and disables all self-tuning capabilities of the database. The V$STATISTICS_LEVEL view shows the statistic component, description, and at what level of the STATISTICS_LEVEL parameter the component is enabled. Here is an example:

```
SQL> SELECT statistics_name, activation_level
  2  FROM   v$statistics_level
SQL> /

STATISTICS_NAME                          ACTIVAT
---------------------------------------- -------
Buffer Cache Advice                      TYPICAL
MTTR Advice                              TYPICAL
Timed Statistics                         TYPICAL
Timed OS Statistics                      ALL
Segment Level Statistics                 TYPICAL
PGA Advice                               TYPICAL
Plan Execution Statistics                ALL
Shared Pool Advice                       TYPICAL
Modification Monitoring                  TYPICAL
Longops Statistics                       TYPICAL
Bind Data Capture                        TYPICAL
Ultrafast Latch Statistics               TYPICAL
Threshold-based Alerts                   TYPICAL
Global Cache Statistics                  TYPICAL
Cache Stats Monitor                      TYPICAL
Active Session History                   TYPICAL
Undo Advisor, Alerts and Fast Ramp up    TYPICAL

17 rows selected.

SQL>
```

The AWR data is used by many components within the database (such as ADDM, discussed later in the section "Using the Automatic Database Diagnostic Monitor") and by external clients (such as SQL*Plus or the Enterprise Manager).

AWR consists of two main components.

In-memory statistics collection area These are statistics collected and saved in the memory (the SGA). You can access these statistics using fixed views. The size of the SGA area allocated for AWR statistics is fixed and depends on the operating system and number of CPUs but is never more than five percent of the shared pool size. The in-memory statistics collection area is a circular buffer, where the old data is overwritten after flushing to disk.

AWR Snapshots of the memory statistics are captured at specific intervals (the default is one hour or whenever the in-memory area becomes full) and stored in the disk. AWR is the persistent statistical data used for historical analysis. Data is owned by the SYS schema and can be accessed using data dictionary views. The MMON (which stands for *manageability monitor*) process is responsible for filtering and transferring the memory statistics to the disk every hour. When the buffer is full, the MMNL (which stands for *manageability monitor light*) process is responsible to flush the information to the repository.

For more information, see the section "Working with Active Session History."

AWR collects the following types of data:

- Time model statistics that show the amount of time spent by each activity
- Object statistics that determine access and usage of database segments (database feature usage)
- Selected statistics from V$SYSSTAT and V$SESSTAT (wait classes)
- SQL statements that are producing high load on the system
- ASH, which represents the history of recent sessions activity sampled from V$SESSION every second
- Operating system statistics

We will explain the AWR in more detail in the section "Working with the Automatic Workload Repository."

In the next section we will discuss the contents of ASH.

Working with Active Session History

The *ASH* contains recent information on active sessions sampled every second. The AWR takes snapshots of the database every hour, so the information in the AWR could be almost an hour old and will not help in diagnosing issues that are current on the database. Typically, to resolve issues currently on the database, detailed information pertaining to the last 5 or 10 minutes is

critical. Because recording session activity is expensive, ASH samples V$SESSION every second and records the events for which the sessions are waiting.

ASH is designed as a rolling buffer in memory; old information is overwritten after saving it to the AWR. You can query ASH information using the V$ACTIVE_SESSION_HISTORY view. The view contains one row for each active session per sample and returns the latest session's sample rows first. Most of the columns of this view are present in V$SESSION view. They include the following:

- SQL identifier of SQL statement
- Object number, file number, and block number
- Wait event identifier and parameters
- User identifier, session identifier, and serial number
- Client identifier and name of operating system program

For instance, to diagnose the performance problems for SID 12, you can use the following query:

```
SELECT session_state, event, current_obj#
FROM   v$active_session_history
WHERE  session_id  = 12;
```

History of the V$ACTIVE_SESSION_HISTORY view resides in the DBA_HIST_ACTIVE_SESS_HISTORY view. This view does not contain all the information but instead contains sampled information.

Working with Automatic Workload Repository

The AWR is a collection of persistent system performance statistics owned by the SYS schema. Over time, you should purge the statistics, and sometimes you may want to get a snapshot of the system for performance diagnosing outside the regular interval. Oracle 10*g* provides several programs in a package named DBMS_WORKLOAD_REPOSITORY. Using these programs, you can manage the snapshots and perform baselines. We will discuss the programs in the following sections.

Creating Snapshots

The DBMS_WORKLOAD_REPOSITORY.CREATE_SNAPSHOT procedure creates a snapshot at a time other than the one generated automatically. It can accept the optional parameter flush_level, with default value of TYPICAL. Here is an example of creating a snapshot:

```
SQL> EXEC sys.dbms_workload_repository.create_snapshot();

PL/SQL procedure successfully completed.
```

```
SQL> SELECT sys.dbms_workload_repository.create_snapshot()
  2  FROM   dual;

SYS.DBMS_WORKLOAD_REPOSITORY.CREATE_SNAPSHOT()
----------------------------------------------
                                           453

SQL>
```

The CREATE_SNAPSHOT is also a function. The return value will be the snapshot ID.

The DBA_HIST_SNAPSHOT dictionary view shows the snapshot information. It includes the database startup time along with snapshot details. Here is an example:

```
SQL> SELECT snap_id id, begin_interval_time,
  2         end_interval_time
  3  FROM   dba_hist_snapshot
  4  WHERE  snap_id > 450
SQL> /

 ID BEGIN_INTERVAL_TIME       END_INTERVAL_TIME
--- ------------------------- -------------------------
451 13-MAY-04 09.00.43.893 AM 13-MAY-04 10.00.08.258 AM
452 13-MAY-04 10.00.08.258 AM 13-MAY-04 10.31.37.335 AM
453 13-MAY-04 10.31.37.335 AM 13-MAY-04 10.32.06.113 AM

SQL>
```

The code output shows 3 snapshot ids. 451 and 452 were taken with an hour difference, but 453 is taken after 31 minutes of 452, which was taken manually.

Dropping Snapshots

You can drop snapshots by using the DBMS_WORKLOAD_REPOSITORY.DROP_SNAPHOT_RANGE procedure. The parameters to this procedure are low and high snapshot IDs. A third optional parameter can be the database ID, which defaults to the local database. The following example drops the snapshots from 200 to 250:

```
SQL> EXEC dbms_workload_repository.drop_snapshot_range -
 >    (200,250);
```

When dropping the snapshots, the ASH history (DBA_HIST_ACTIVE_SESS_HISTORY) that belongs to the time period is also dropped from the AWR.

Though the snapshot creation of the AWR is similar to the snapshot creation of STATSPACK, the AWR does not directly support the `statspack` information. You also have no way to migrate the `statspack` data to the AWR.

Creating Baselines

AWR baselines are performance data that you can use for comparison when a problem occurs. You can have many baselines defined for different times of the database. The `DBMS_WORKLOAD_REPOSITORY.CREATE_BASELINE` procedure creates a baseline. It can accept four parameters:

- Start snapshot ID
- End snapshot ID
- Name for the baseline
- An optional database ID

The following example shows a query on the `DBA_HIST_SNAPSHOT` whose output is used to create an online baseline called `ONLINE PEAK` based on the workload between 8 a.m. and 6 p.m.; the example also shows querying the `DBA_HIST_BASELINE` dictionary view to see the baselines created:

```
SQL> SELECT snap_id, begin_interval_time
  2  FROM   dba_hist_snapshot
  3  WHERE  begin_interval_time between
  4         TO_TIMESTAMP('12-MAY-04 08.00.00 AM') and
  5         TO_TIMESTAMP('12-MAY-04 06.00.00 PM')
SQL> /

   SNAP_ID BEGIN_INTERVAL_TIME
---------- --------------------------
       426 12-MAY-04 08.00.09.836 AM
       427 12-MAY-04 09.00.35.691 AM
       428 12-MAY-04 10.01.01.591 AM
       429 12-MAY-04 11.00.25.928 AM
       430 12-MAY-04 12.00.51.854 PM
       431 12-MAY-04 01.00.16.196 PM
       432 12-MAY-04 02.00.42.015 PM
       433 12-MAY-04 03.00.06.369 PM
       434 12-MAY-04 04.00.32.365 PM
       435 12-MAY-04 05.00.58.567 PM
```

```
10 rows selected.

SQL> BEGIN
  2  dbms_workload_repository.create_baseline (
  3   start_snap_id => 426,
  4   end_snap_id => 435,
  5   baseline_name => 'ONLINE PEAK');
  6  END;
  7  /

PL/SQL procedure successfully completed.

SQL>
SQL> SELECT baseline_name, start_snap_time, end_snap_time
  2  FROM   dba_hist_baseline;

BASELINE_NA  START_SNAP_TIME       END_SNAP_TIME
------------ --------------------- ---------------------
ONLINE PEAK  12-MAY-04 09.00.35 AM 12-MAY-04 06.00.23 PM

SQL>
```

Similar to the CREATE_SNAPSHOT function, CREATE_BASELINE also can be called as a function, which returns the baseline ID.

The snapshots belonging to a baseline are retained until the baseline is dropped.

Dropping Baselines

You can drop baseline using the DBMS_WORKLOAD_REPOSITORY.DROP_BASELINE procedure. You must specify the baseline name as a parameter. This procedure also has optional CASCADE and DBID parameters.

The default for CASCADE is FALSE, which means the snapshots related to the baseline are not dropped when the baseline is dropped. Here is an example of dropping a baseline:

```
SQL> EXEC dbms_workload_repository.drop_baseline -
 >        ('ONLINE PEAK');
```

Changing Snapshot Settings

You can change the interval of the snapshot generation and how long the snapshots are retained using the DBMS_WORKLOAD_REPOSITORY.MODIFY_SNAPSHOT_SETTINGS procedure. This determines the snapshot capture and purging policy.

The RETENTION parameter specifies the new retention period in minutes. The specified value must be in the range of 1,440 minutes (1 day) to 52,560,000 minutes (100 years). If you specify zero, the maximum value of 100 years will be used; if you specify NULL, the retention will not be changed. The MMON process is responsible for purging the WR data.

The INTERVAL parameter specifies the new snapshot interval in minutes. The specified value must be between 10 minutes and 5,256,000 (1 year). If you specify zero, the maximum value of 1 year will be used; if you specify NULL, the interval will not be changed.

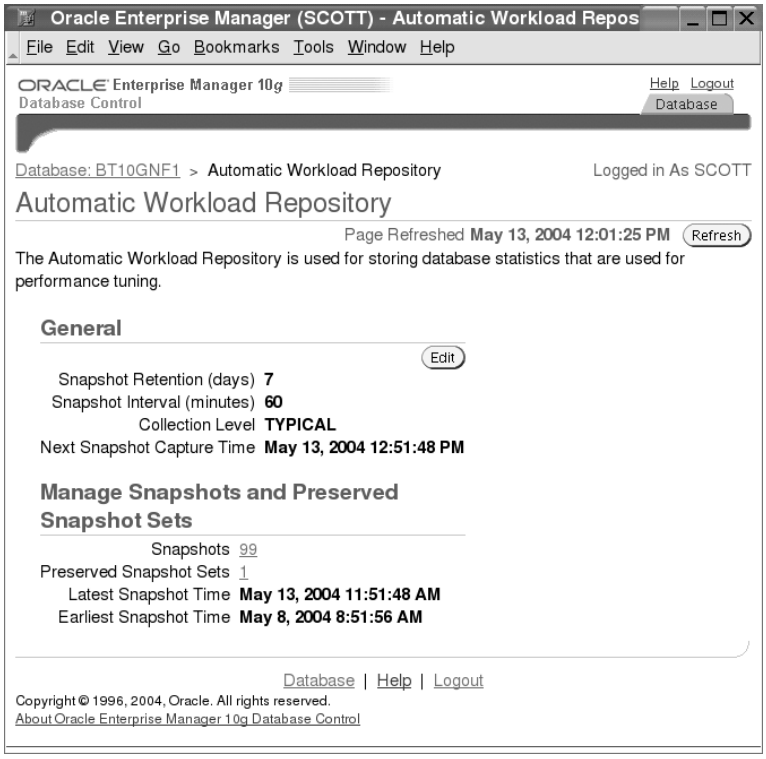
You can view the current settings from the DBA_HIST_WR_CONTROL dictionary view. The following example shows changing the retention period to 15 days and the interval to 30 minutes:

```
SQL> SELECT * from dba_hist_wr_control;

      DBID SNAP_INTERVAL              RETENTION
---------- -------------------------- ------------------
2449818325 +00000 01:00:00.0          +00007 00:00:00.0

SQL> BEGIN
  2  dbms_workload_repository.modify_snapshot_settings (
  3   retention => 21600,
  4   interval => 30);
  5  END;
SQL> /

PL/SQL procedure successfully completed.

SQL> SELECT * from dba_hist_wr_control;

      DBID SNAP_INTERVAL              RETENTION
---------- -------------------------- ------------------2449818325 +00000
00:30:00.0          +00015 00:00:00.0

SQL>
```

You can access the AWR using the Enterprise Manager (EM) Database Control, from its Administration tab. Click the Automatic Workload Repository from the Workload section. You can change the WR settings, you can define the baselines, and you can view detailed information of snapshots using the EM Database Control.

Figure 3.2 shows the Automatic Workload Repository screen.

FIGURE 3.2 The Automatic Workload Repository screen



If AWR detects that SYSAUX tablespace is out of space, it automatically reuses space occupied by the oldest set of snapshots by deleting them. An alert is also sent to the DBA to indicate that the SYSAUX is out of space.

Viewing AWR Reports

You can view AWR reports using the `awrrpt.sql` and `awrrpti.sql` scripts located in the `$ORACLE_HOME/rdbms/admin` directory. The `awrrpt.sql` script displays statistics for a range of snapshot IDs. The report can be saved as text file or HTML file. The `awrrpti.sql` script is similar to `awrrpt.sql`; the only difference is you can specify the database ID and instance ID as parameters. The report contains the following categories of information:

- Report summary
- Wait events statistics
- SQL statistics

- Instance activity statistics
- I/O statistics
- Buffer pool statistics
- Advisory statistics
- Wait statistics
- Undo statistics
- Latch statistics
- Segment statistics
- Dictionary cache statistics
- Library cache statistics
- SGA statistics
- Resource limit statistics
- `init.ora` parameters

You need the `SELECT ANY DICTIONARY` privilege to run the AWR reports.

The `awrinfo.sql` script displays general information on AWR such as snapshot information and ASH usage information. The report includes the following:

- AWR snapshots information
- SYSAUX tablespace usage
- Size estimates for AWR snapshots
- Space usage by AWR components
- Space usage by non-AWR components
- AWR control settings: interval and retention
- AWR contents: row counts for each snapshots
- ASH histogram
- ASH details
- ASH sessions

The data dictionary view `DBA_HIST_DATABASE_INSTANCE` shows the database instances in the Automatic Workload Repository. Each instance startup will have one row.

Base Statistics and Metrics

Base statistics represent the raw data collected by the Oracle server. For example, the number of physical reads since instance startup is a base statistic. A *metric* is a secondary statistic derived from base statistics. Metrics track the rate of changes in the database. For example, the average SQL response time for the last 30 minutes is a metric. The AWR has several metrics information. The V$ views without the _HISTORY extension show the most current information, the V$ views with the _HISTORY extension show all the information in the database, and DBA_HIST_ views show persistent information captured with the snapshots. Table 3.1 lists the data dictionary views with metric information.

TABLE 3.1 Data Dictionary Views with Metric Information

Most Current	Instance	Persistent
V$METRICGROUP	V$METRIC_HISTORY	DBA_HIST_METRIC_NAME
V$METRICNAMEV	$SYSMETRIC_HISTORY	DBA_HIST_SYSMETRIC_HISTORY
V$METRIC	V$SYSMETRIC_SUMMARY	DBA_HIST_SYSMETRIC_SUMMARY
V$SYSMETRIC	V$FILEMETRIC_HISTORY	DBA_HIST_SESSMETRIC_HISTORY
V$SESSMETRIC	V$WAITCLASSMETRIC_HISTORY	DBA_HIST_FILEMETRIC_HISTORY
V$FILEMETRIC	V$SERVICEMETRIC_HISTORY	
V$EVENTMETRIC		
V$WAITCLASSMETRIC		
V$SERVICEMETRIC		

To look at the database as a whole, the common metric you can use for comparison is time. Oracle 10*g* uses the time model statistics to identify quantitative effects on the database operations. You can view the time model statistics using the V$SYS_TIME_MODEL and V$SESS_TIME_MODEL dictionary views. The time reported is the total elapsed or CPU time in microseconds. Here is a sample query from V$SYS_TIME_MODEL:

```
SQL> SELECT stat_name, value
  2  FROM   v$sys_time_model;
```

```
STAT_NAME                                                  VALUE
---------------------------------------------------------- ----------
DB time                                                 8529656260
DB CPU                                                  3346929994
background elapsed time                                 1.5619E+10
background cpu time                                      612558894
sequence load elapsed time                                  419315
parse time elapsed                                       245993518
hard parse elapsed time                                  201029366
sql execute elapsed time                                7524056827
connection management call elapsed time                  12167988
failed parse elapsed time                                  150737
failed parse (out of shared memory) elapsed time                0
hard parse (sharing criteria) elapsed time                4925958
hard parse (bind mismatch) elapsed time                   1702307
PL/SQL execution elapsed time                           1777438570
inbound PL/SQL rpc elapsed time                                 0
PL/SQL compilation elapsed time                          43689860
Java execution elapsed time                               6424790

17 rows selected.

SQL>
```

The MMON process is responsible for updating the metric data from the corresponding base statistics. The metrics are kept in memory for one hour.

Diagnosing Performance Statistics

The AWR has all the information on the activities and waits on the Oracle 10g database. The database also includes tools for diagnosing these base statistics and metrics and provides you with proactive information. The *ADDM* is the primary client for the AWR information. ADDM can be considered as an expert residing in the Oracle 10*g* database.

In addition to providing suggestions for fixing problems, Oracle 10*g* can automatically fix certain problems. In the following sections, we will discuss the ADDM and other components available in the database that assist the DBA in achieving the best performance from the database.

Using the Automatic Database Diagnostic Monitor

The ADDM, part of the overall advisory architecture of Oracle 10*g*, is a self-diagnostic engine built into the database server. The ADDM is automatically invoked by the Oracle 10*g* database and performs analysis to determine any issues in the database. The ADDM recommends solutions to the issues it identifies.

ADDM analysis is performed every time an AWR snapshot is taken. The `MMON` process triggers ADDM analysis each time a snapshot is taken to do an analysis of the period corresponding to the last two snapshots. This approach proactively monitors the database and detects bottlenecks before they become significant problems. It is also possible to invoke the ADDM manually to analyze across any two snapshots. Along with areas that have problems identified, ADDM also reports areas of the system that have no problems. This allows you to quickly see that there is little to be gained by performing actions in those areas.

The results of the ADDM analysis are also stored in the AWR and are accessible through the dictionary views and the EM Database Control. Analysis is performed from the top down, identifying symptoms first and then refining them to reach the root cause.

The goal of analysis is to reduce a single throughput metric called the `DBtime`. `DBtime` is the cumulative time spent by the database server in processing user requests, which includes wait time and CPU time. You can view this metric from the time model dictionary views. By reducing `DBtime`, the database is able to support more user requests using the same resources; in other words, the database can perform the same workload in less time.

Since the ADDM is integrated into the database server, running the analysis has a minor impact on the database. It normally takes less than three seconds to complete the analysis. The ADDM analysis results are represented as findings, and each finding belongs to one of three categories: problem (root cause), symptom, or information.

ADDM results can be viewed using the EM Database Control, the next section discusses this.

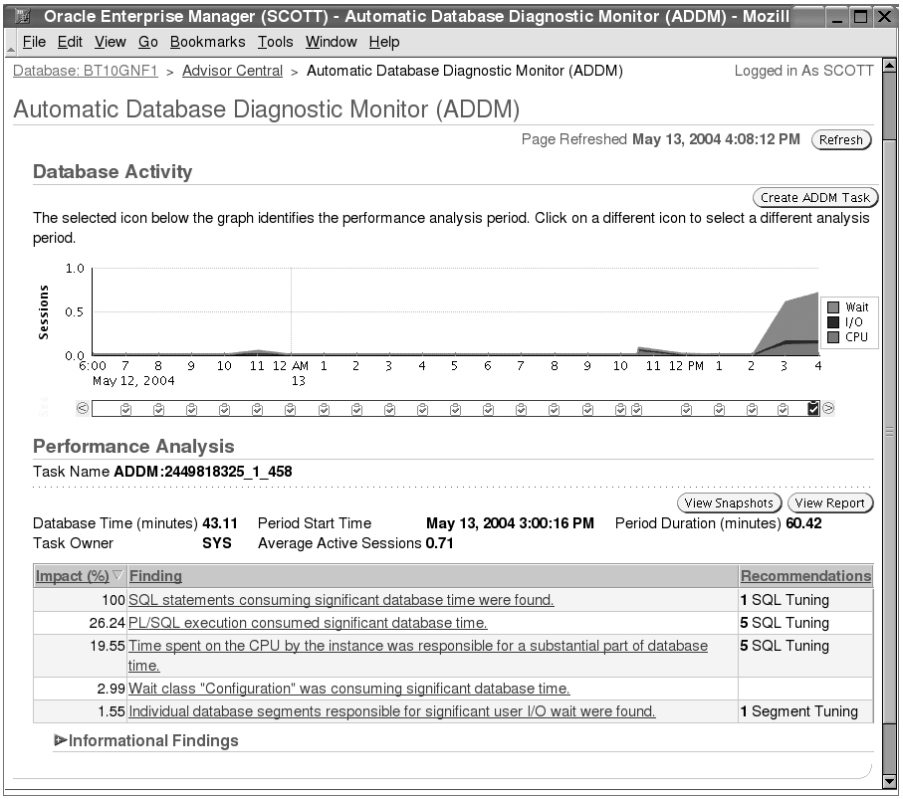
Viewing ADDM Results Using EM

The ADDM results are best viewed using the EM Database Control. From the Database home page, under Diagnostic Summary, click the Performance Findings link to go to the ADDM page. Figure 3.3 shows the ADDM main page of the EM Database Control.

On the ADDM page, you can see the details of findings. Here you can click View Report to see the ADDM report as a text file and save it to disk. Click the finding, and you will be taken to another screen with more details on the finding, the recommended solution, and the finding's impact. Depending on the type of recommendation, it is possible that the ADDM recommends invoking another adviser such as the SQL Tuning Advisor or the Segment Tuning Advisor.

Figure 3.4 shows the Performance Finding Details screen. The screen shows the performance findings, the recommendation for the performance problem and why ADDM arrived at the solution.

FIGURE 3.3 The ADDM page



From the ADDM page, you can click the Create ADDM Task button to manually create snapshots.

Querying the ADDM Dictionary

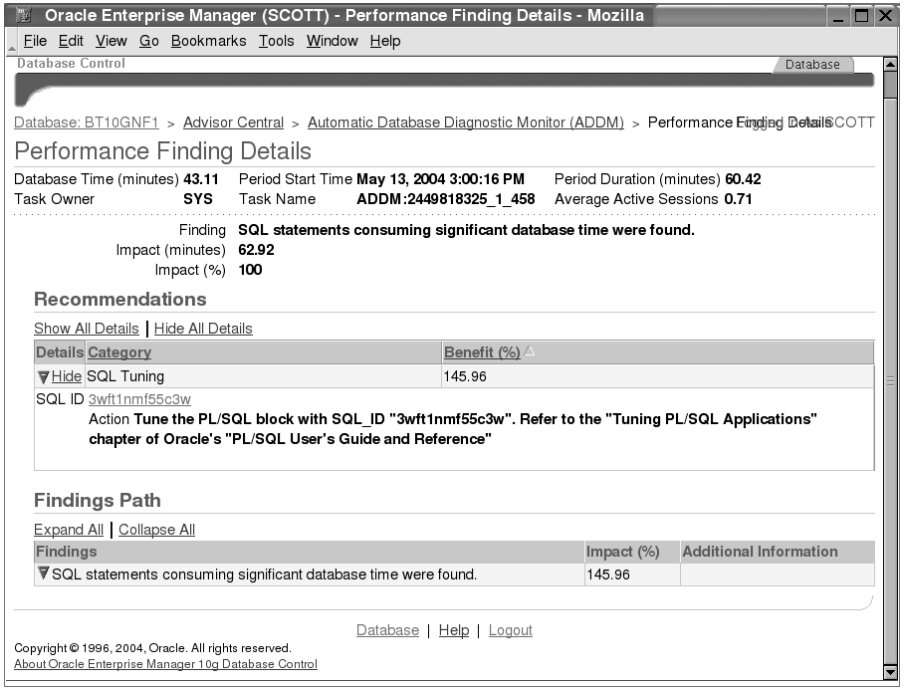
You can query the ADDM findings using the `DBA_ADVISOR_FINDINGS` database dictionary view. The following query shows the number of findings of ADDM for the last 24 hours by category:

```
SQL> SELECT type, count(*)
  2  FROM   dba_advisor_findings
  3  NATURAL JOIN dba_advisor_tasks
  4  WHERE  created between sysdate -1 and sysdate
  5  GROUP BY type
SQL> /
```

```
TYPE           COUNT(*)
-----------  ----------
INFORMATION          26
PROBLEM              15
SYMPTOM              10

SQL>
```

You can invoke the ADDM report using SQL*Plus by running the `$ORACLE_HOME/rdbms/admin/addmrpt.sql` script. The output is saved as a text file. The `addmrpti.sql` is another SQL*Plus script that prompts for `dbid` and `instance_number` to run ADDM analysis on a pair of AWR snapshots and display the textual ADDM report of the analysis.

FIGURE 3.4 The Performance Finding Details page



The DBA_ADVISOR_RECOMMENDATIONS view shows the result of the completed diagnostic task with recommendations for the problems identified in each run. You should look at the recommendations in the order they're listed in the RANK column. The BENEFIT column gives the resulting affect to the system if the recommendation is carried out. Here is an example query:

```
SQL> SELECT distinct message
  2  FROM   dba_advisor_recommendations
  3  JOIN   dba_advisor_findings
  4  USING  (finding_id, task_id)
  5  WHERE  rank = 0
SQL> /

MESSAGE
--------------------------------------------------------
Individual database segments responsible for significant
user I/O wait were found.
The buffer cache was undersized causing significant
additional read I/O.

SQL>
```

Changing ADDM Attributes

The ADDM is enabled automatically only when the STATISTICS_LEVEL parameter is set to TYPICAL or ALL. You can adjust some attributes using the DBMS_ADVISOR.SET_DEFAULT_TASK_PARAMETER procedure. These parameters control the advisory results. You can query the values of the parameters from the DBA_ADVISOR_DEF_PARAMETERS dictionary view. Here is an example:

```
SQL> SELECT parameter_name, parameter_value
  2  FROM   dba_advisor_def_parameters
  3  WHERE  advisor_name = 'ADDM';

PARAMETER_NAME       PARAMETER_VALUE
-------------------- --------------------
ANALYSIS_TYPE        PERIOD
DBIO_EXPECTED        10000
DB_ELAPSED_TIME      0
DB_ID                0
HISTORY_TABLE        UNUSED
SCOPE_TYPE           UNUSED
SCOPE_VALUE          UNUSED
```

```
7 rows selected.

SQL>
```

For example, if you determine you have a slow hard disk and the typical I/O speed is around 16 milliseconds, you can change the parameter using the following:

```
SQL> EXEC dbms_advisor.set_default_task_parameter ( -
'ADDM', 'DBIO_EXPECTED', 16000);

PL/SQL procedure successfully completed.

SQL>
```

Using Server-Generated Alerts

Server-generated alerts are part of the Oracle 10*g* CMI. It is the capability of the Oracle 10*g* database to automatically detect alarming situations and suggest some remedial actions. Server-generated alerts are used when problems cannot be resolved automatically by the database and require your intervention.

The database's monitoring activities take place during normal database operation, which ensures that the database is aware of the problem as soon as it arises. With the introduction of the MMON process, internal components can schedule regular monitoring actions. You can have alerts triggered because of threshold levels or simply because an event has occurred. Threshold-based alerts can be triggered at the warning level and/or critical level. The value for these levels can be user-defined.

The Oracle 10*g* database keeps a history of the metrics in the AWR, which is used by the self-tuning components. In the previous releases of Oracle, the EM maintained the performance metrics of the database (after they are set up and enabled). The server-generated metrics and alerts are more efficient because the metric computation and threshold validation are performed by MMON process, which can access the SGA directly.

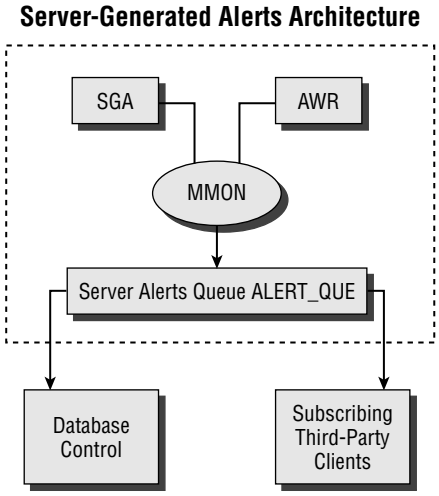
When the Oracle 10*g* database discovers an alert condition, it creates an alert with the following information and queues it to the predefined alert queue ALERT_QUE owned by SYS:

- The identity of the database entity on which the alert is produced
- A description of the problem
- A remedial or corrective action
- An optional name of an advisor for detailed advice
- The level of severity

Third-party tools and SQL*Plus may use PL/SQL API to read the alert queue. The EM Database Control is the primary subscriber of the alert queue. Depending on the setup in the EM

Database Control, the administrators are notified by e-mail or pager. The alerts are always displayed on the EM Database Control home page. Figure 3.5 shows the server-generated alerts architecture of Oracle 10*g*.

FIGURE 3.5 Server-generated alerts architecture



Threshold alerts, also known as *stateful alerts*, are automatically cleared when the alert condition clears. The alerts appear in the DBA_OUTSTANDING_ALERTS view and are moved to DBA_ALERT_HISTORY with a resolution of CLEARED when the alert condition is automatically cleared.

The nonthreshold alerts, also known as *event-based alerts* or *stateless alerts*, go directly to DBA_ALERT_HISTORY. "Snapshot too old" errors or "resumable session suspended" errors are examples of stateless alerts. Clearing a stateless alert is applicable only when using the EM Database Control, because the EM stores the stateless alerts in its own repository.

The V$ALERT_TYPES dictionary view shows information about each alert reason type. Here is an example:

```
SQL> SELECT DISTINCT type, group_name, object_type
  2  FROM   v$alert_types
SQL> /

TYPE      GROUP_NAME         OBJECT_TYPE
--------- ------------------ --------------------
Stateful  Performance        EVENT_CLASS
Stateful  Performance        FILE
Stateful  Performance        SERVICE
Stateful  Performance        SESSION
Stateful  Performance        SYSTEM
```

```
Stateful  Space             DATA OBJECT
Stateful  Space             QUOTA
Stateful  Space             RECOVERY AREA
Stateful  Space             ROLLBACK SEGMENT
Stateful  Space             SYSTEM
Stateful  Space             TABLESPACE
Stateless Configuration     EVENT_CLASS
Stateless Configuration     FILE
Stateless Configuration     SERVICE
Stateless Configuration     SESSION
Stateless Configuration     SYSTEM
Stateless Configuration     TABLESPACE
Stateless Performance       SYSTEM
Stateless Space             ROLLBACK SEGMENT
Stateless Space             SYSTEM
Stateless Space             TABLESPACE

21 rows selected.

SQL>
```

Figure 3.6 shows the All Metrics screen of the EM Database Control, where the status of each metric displays. Navigate to this screen from the EM Database Control home pages using the All Metrics link at the bottom of the page.

The figure shows the metrics in groups and when the metric was last collected. You can expand the metric to see each component, for example in the figure the Alert Log is expanded to show all the components.

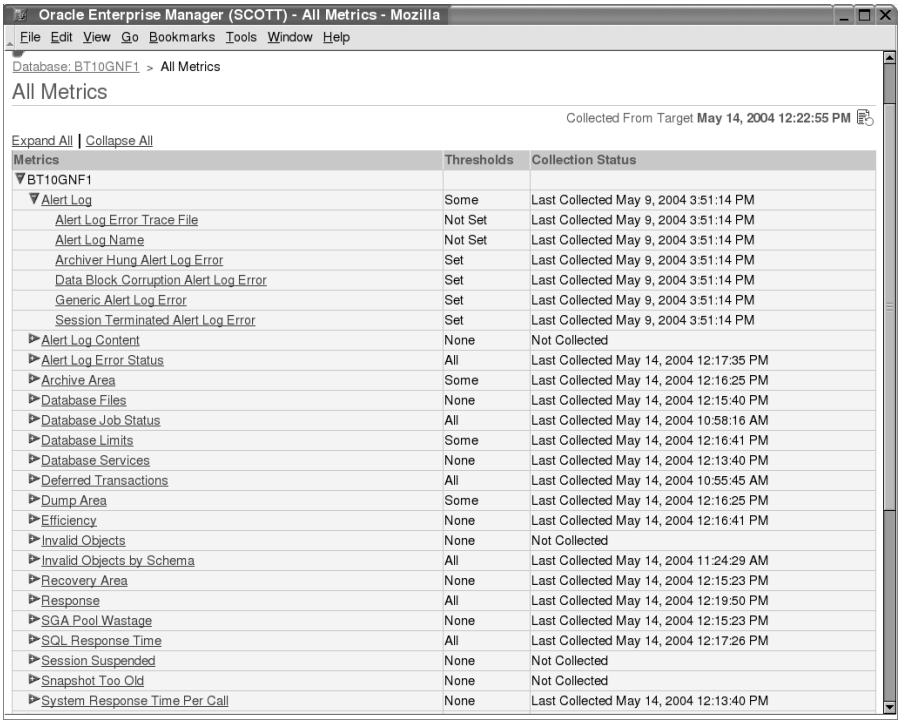
The server-generated alert history is purged according to the snapshot purging policy.

The following are out-of-the-box server-generated alerts, set up in the database by default:

- "Tablespace space usage" (warning 85 percent, critical 97 percent)
- "Snapshot too old" error
- "Recovery area low on free space"
- "Resumable session suspended"

The alerts avoid false peak values. For an alert to be triggered, the observation period and number of consecutive occurrences must be satisfied.

FIGURE 3.6 The All Metrics page

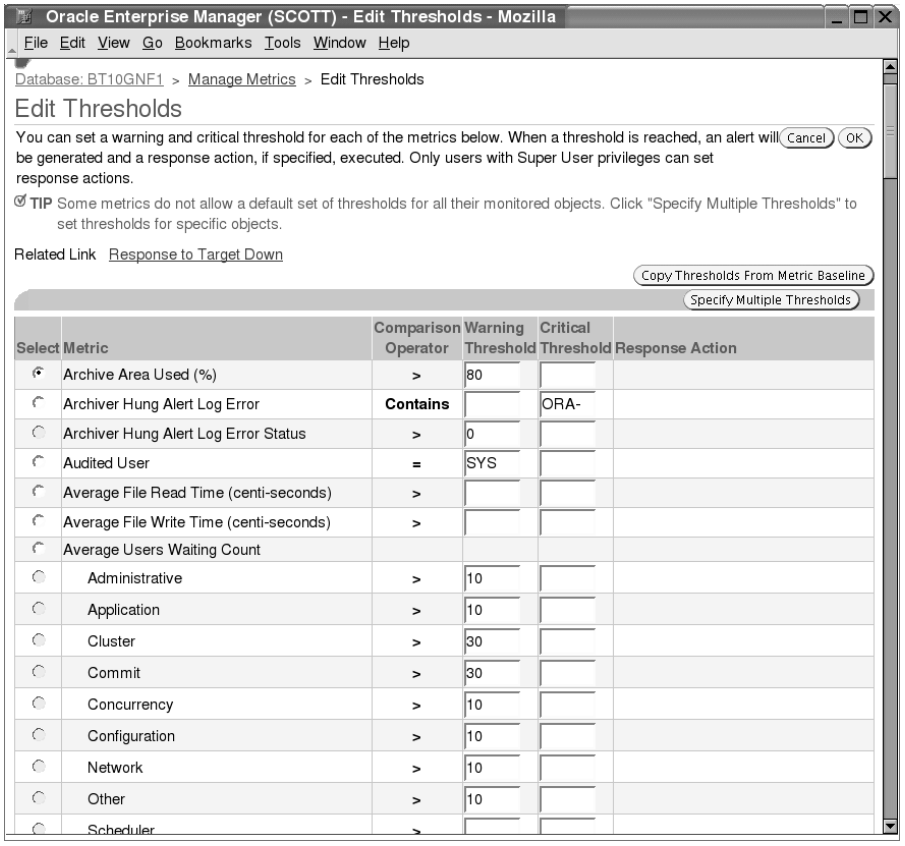


Setting Alert Thresholds

You can change alert thresholds using the EM Database Control or using PL/SQL. To edit the thresholds using the EM Database Control, from the home page click the Manage Metrics link at the bottom of the page. The Manage Metrics page shows the current thresholds for each metric. Click the Edit Threshold button to make changes to the thresholds. Figure 3.7 shows the screen to edit thresholds using the EM Database Control. In the screen, the Metric and Comparison Operator are predefined. You can set the Warning Threshold and Critical Threshold. If the Select button is enabled for a threshold, you can use the Specify Multiple Threshold button to specify more than one threshold. For example, in Archive Area Used you can specify different threshold levels for each archive log destination.

Using the EM Database Control for setting the threshold has two advantages that are not available when using PL/SQL. The EM Database Control has the ability to specify response action when thresholds are violated. The response action can be a script or stored procedure. It can also specify thresholds based on baselines.

FIGURE 3.7 The Edit Thresholds page



You can set the thresholds using the PL/SQL package DBMS_SERVER_ALERT. You can use the SET_THRESHOLD procedure to define a threshold and the GET_THRESHOLD procedure to retrieve the current threshold value for the metric. Both procedures use `metrics_id` as a parameter, which can be found from the V$METRICNAME view. There are more than 180 metrics defined.

DBMS_SERVER_ALERT has the metric names defined internally and can be used instead of the metric ID. The object types and relational operators are also defined as constants in the DBMS_SERVER_ALERT package, which can be used in the SET_THRESHOLD procedure.

The DBA_THRESHOLDS dictionary view shows the threshold settings. The V$ALERT_TYPE shows information on each alert reason type. The V$METRIC and V$METRIC_HISTORY contain system-level metric values in memory.

The following example shows using the DBMS_SERVER_ALERT constants to define a threshold for the number of users blocked by a session. Here we set an alert for the number of blocked users in the database and define 2 as the warning level and 4 as the critical level.

```
SQL> BEGIN
  2  DBMS_SERVER_ALERT.SET_THRESHOLD (
  3   metrics_id=>DBMS_SERVER_ALERT.BLOCKED_USERS,
  4   warning_operator=>DBMS_SERVER_ALERT.OPERATOR_GE,
  5   warning_value=>2,
  6   critical_operator=>DBMS_SERVER_ALERT.OPERATOR_GE,
  7   critical_value=>4,
  8   observation_period=>2,
  9   consecutive_occurrences=>4,
 10   instance_name=>'BT10GNF1',
 11   object_type=>DBMS_SERVER_ALERT.OBJECT_TYPE_SESSION,
 12   object_name=>NULL);
 13  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

Building Your Own Alert Mechanism

You can use the following steps to set up a threshold and alert mechanism if you do not want to use the EM Database Control:

1. Query V$METRICNAME to identify the metrics in which you are interested.
2. Set warning and critical thresholds using the DBMS_SERVER_ALERT.SET_THRESHOLD procedure.
3. Subscribe to the ALERT_QUE AQ using the DBMS_AQADM.ADD_SUBSCRIBER procedure.
4. Create an agent for the subscribing user of the alerts using the DBMS_AQADM.CREATE_AQ_AGENT procedure.
5. Associate the user with the AQ agent using the DBMS_AQADM.ENABLE_DB_ACCESS procedure.
6. Grant the DEQUEUE privilege using the DBMS_AQADM.GRANT_QUEUE_PRIVILEGE procedure.
7. Optionally register for the alert *enqueue* notification using the DBMS_AQ.REGISTER procedure.
8. Configure e-mail using the DBMS_AQELM.SET* procedures.

9. Dequeue the alert using the DBMS_AQ.DEQUEUE procedure.
10. After the message has been dequeued, use DBMS_SERVER_ALERT.EXPAND_MESSAGE to expand the text of the message.

Automating Database Management

Oracle 10*g* has automated several of the components to manage automatically or provide automatic tuning advice. In the following sections, we will discuss the management enhancements made to the Oracle 10*g* database that help you be more proactive.

Using Automatic Shared Memory Management (ASMM)

Automatic Shared Memory Management (ASMM) is another self-management enhancement in Oracle 10*g*. This functionality automates the management of shared memory structures used by the database and relieves you from configuring each component. This feature simplifies the SGA administration by introducing a dynamic, flexible, and automatic memory management scheme.

In previous releases of Oracle, you had to manually configure the shared pool size, Java pool size, large pool size, and database buffer cache. It was often a challenge to optimally configure these components because sizing them too small could cause memory errors and sizing them too large could lead to waste of memory. In Oracle 10*g*, you need to specify only the SGA_TARGET parameter, which specifies the total size of the SGA. Individual components of the SGA are automatically allocated by the database based on the workload and history information. So during the normal online operations, the buffer cache and Java pool may be bigger. During the batch window, the database can automatically increase the large pool and reduce the buffer cache.

The new parameter SGA_TARGET is the size of total SGA, which includes the automatically sized components, manually sized components, and any internal allocations during instance startup.

Let us discuss how we can enable and disable Automatic Shared Memory Management in the next section.

Enabling Automatic Shared Memory Management

ASMM is enabled when the STATISTICS_LEVEL parameter is set to TYPICAL or ALL and the SGA_TARGET parameter is set to a nonzero value. When enabled, ASMM distributes memory appropriately for the following memory areas:

- Database buffer cache (default pool): DB_CACHE_SIZE
- Shared pool: SHARED_POOL_SIZE
- Large pool: LARGE_POOL_SIZE
- Java pool: JAVA_POOL_SIZE

The following areas should be manually configured and are not affected by ASMM:

- Log buffer: LOG_BUFFER
- Other buffer caches: DB_KEEP_CACHE_SIZE, DB_RECYCLE_CACHE_SIZE, DB_nK_CACHE_SIZE
- Streams pool: STREAMS_POOL_SIZE
- Fixed-SGA area and internal allocations

The memory allocated for the manually configured areas are included in the SGA_TARGET size. For example, if SGA_TARGET is 400MB, LOG_BUFFER is set to 1MB, and DB_KEEP_CACHE_SIZE is set to 50MB, then the memory available for automatically configured components is 349MB.

The SGA_TARGET parameter is dynamic and can be resized using the ALTER SYSTEM statement. The value of SGA_TARGET cannot be higher than the SGA_MAX_SIZE parameter, which is not dynamically changeable. Reducing the size of SGA_TARGET affects only the autotuned components of the SGA. SGA_TARGET can be reduced until one of the autotuned components reaches its minimum size (a user-specified or Oracle-determined minimum).

You can also enable/disable ASMM using the EM Database Control. From the Administration tab, select Memory Parameters under the Instance heading. When you click the Enable button, enter the value for SGA_TARGET. To change the SGA_MAX_SIZE parameter (which requires a cycle of the database), you need to be logged in as SYSDBA. Figure 3.8 shows the Memory Parameters screen of the EM Database Control.

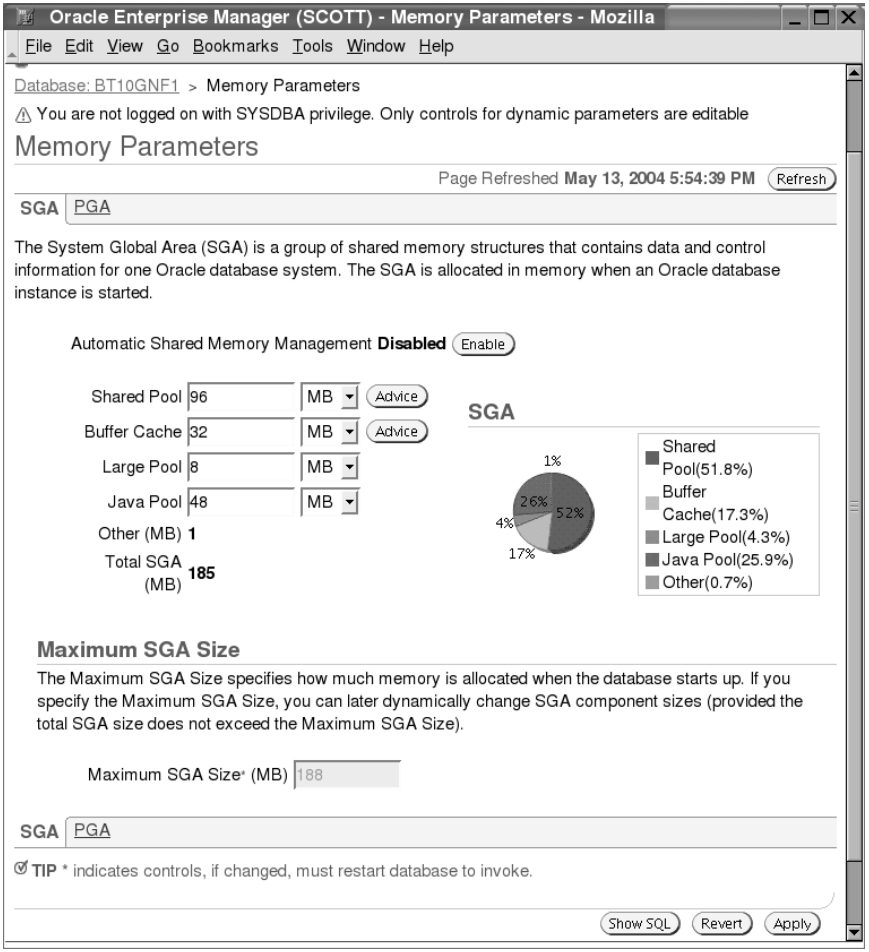
You can query the current sizes of the SGA components using the V$SGA_DYNAMIC_COMPONENTS dictionary view, like so:

```
SQL> SELECT component, current_size
  2  FROM   v$sga_dynamic_components;

COMPONENT                 CURRENT_SIZE
------------------------- ------------
shared pool                  100663296
large pool                     4194304
java pool                     50331648
streams pool                         0
DEFAULT buffer cache          37748736
KEEP buffer cache                    0
RECYCLE buffer cache                 0
DEFAULT 2K buffer cache              0
DEFAULT 4K buffer cache              0
DEFAULT 8K buffer cache              0
DEFAULT 16K buffer cache             0
DEFAULT 32K buffer cache             0
```

```
OSM Buffer Cache                       0

13 rows selected.

SQL>
```

When SGA_TARGET is set to a nonzero value, the autotuned SGA parameters will have default values of zero. If you specify a value for the autotuned SGA parameters, the value will be treated as the lower limit of that component.

FIGURE 3.8 The Memory Parameters page



Setting SGA_TARGET to zero will disable ASMM. The autotuned components will have values of their current sizes, and these values are written to the SPFILE to use for the next instance startup.

Resizing the autotuned SGA parameters is possible even if ASMM is enabled. For autotuned parameters, manual resizing will result in immediate component resizing if the current value is smaller than the new value. If the new value is smaller, the component is not resized, but a new minimum size is set.

For manually configured SGA parameters, resizing will immediately take effect to the precise new value. If the size of a component is increased, one or more of the autotuned components will be reduced. If the size of a manually configured component is reduced, the memory that is released is given to the automatically sized components.

The following views provide information on the dynamic SGA resize operations:

V$SGA_CURRENT_RESIZE_OPS SGA resize operations that are currently in progress

V$SGA_RESIZE_OPS Information about the last 400 completed SGA resize operations

V$SGA_DYNAMIC_COMPONENTS Information about the dynamic components of the SGA

V$SGA_DYNAMIC_FREE_MEMORY Information about the amount of SGA memory available for future dynamic SGA resize operations

The Memory Manager Process

Oracle 10*g* comes with the new MMAN process (which stands for *memory manager*) to manage the automatic shared memory. MMAN serves as the SGA memory broker and coordinates the sizing of the memory components. It keeps track of the sizes of the components and pending resize operations.

The MMAN process observes the system and workload to determine the ideal distribution of memory. MMAN performs this check every few minutes so that memory can always be present where needed. Based on the workload, ASMM does the following:

- It captures statistics periodically in the background.
- It uses different memory advisors.
- It performs what-if analysis to determine optimal distribution of memory.
- It moves memory to where it is needed.
- When SPFILE is used, component sizes are used from the last shutdown.

Tuning Automatic Undo Retention

Oracle 9*i* introduced automatic undo management. Oracle 10*g* goes one step further and calculates the optimum value for the UNDO_RETENTION parameter. The default for this parameter is 900 seconds. If UNDO_RETENTION is set to zero or if no value is specified, Oracle 10*g* automatically tunes the undo retention for the current undo tablespace using 900 as the minimum value. If you set UNDO_RETENTION to a value other than zero, Oracle 10*g* autotunes the undo retention using the specified value as the minimum.

Real World Scenario

Tuning Memory in OLTP DSS Systems

One of our critical databases is big in disk storage size and SGA size. For better performance of online applications, we had a huge portion of SGA allocated for buffer cache. Since the tables used by nightly batch jobs were huge and were heavy users of parallel query, we had a big large pool size also. After upgrading the database to Oracle 10*g*, the first thing we did on the database was enable ASSM. Querying V$SGA_RESIZE_OPS, we could see that the buffer and that the large pool was increased automatically a little after the batch window started.

Automatic tuning is performed by collecting database usage statistics, such as the undo generation rate, and estimating undo capacity needed for successfully completing queries. Automatic undo retention tuning is enabled by the architecture (meaning you cannot disable it). Undo retention is tuned for longest-running query, and query duration information is collected every 30 seconds.

The Undo Advisor is a new feature in Oracle 10*g*: the database automatically analyzes the undo usage to advise the undo tablespace size to support the longest-running query when using automatic undo.

Figure 3.9 shows the Undo Advisor screen of the EM Database Control. You can specify the required undo retention minutes, the Undo Advisor uses the metrics collected to determine the undo tablespace size. The graph shows the undo retention minutes and the space required in the tablespace.

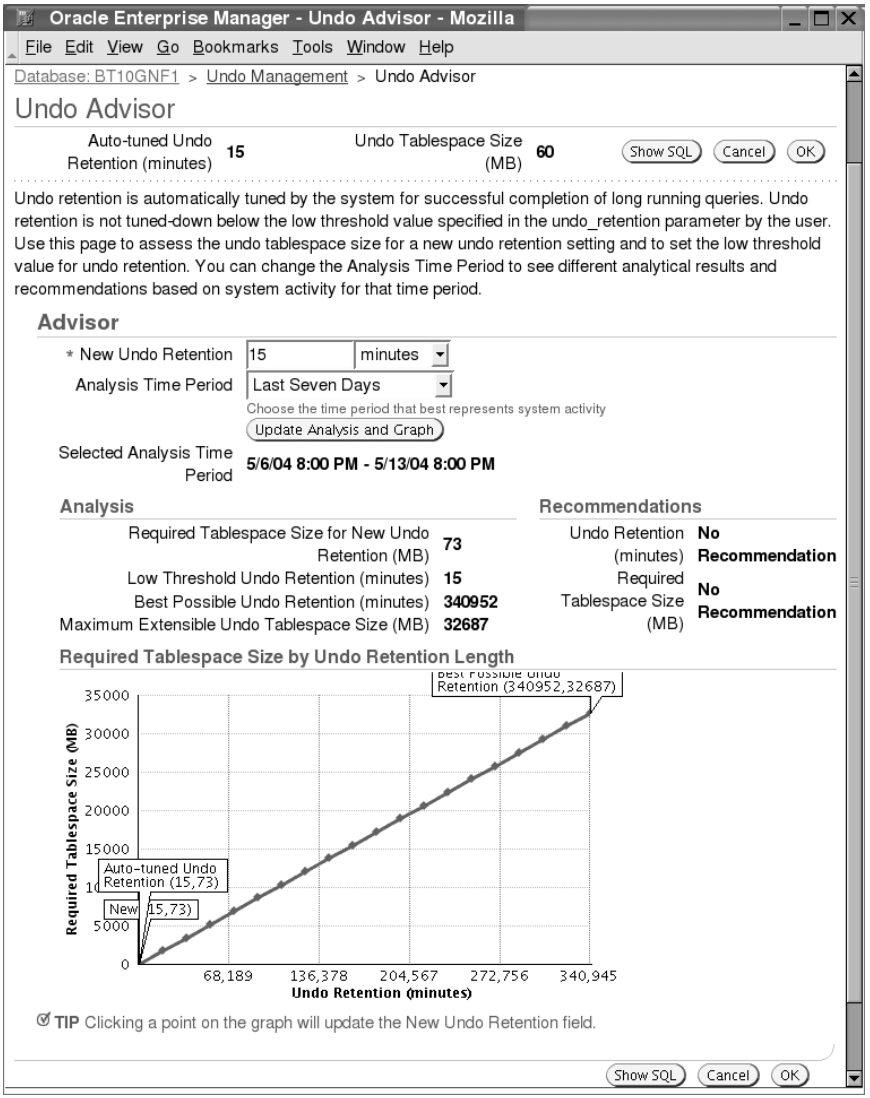
You can also invoke the Undo Advisor from PL/SQL using the DBMS_ADVISOR package, which is discussed later in the chapter.

Oracle 10*g* also simplifies the undo configuration by removing several undo-related parameters of previous releases. The parameters are as follows:

- MAX_ROLLBACK_SEGMENTS
- UNDO_SUPPRESS_ERRORS
- ROW_LOCKING
- SERIALIZABLE
- TRANSACTION_AUDITING

Oracle 10*g* automatically tunes the UNDO_RETENTION parameter to avoid the "snapshot too old" error. But when heavy DML operations are performed on the database, UNDO_RETENTION is not guaranteed. Oracle 10*g* introduces a RETENTION GUARANTEE clause to guarantee the undo retention. This means that the database will make certain that undo will always be available for the specified undo retention period. You can use the RETENTION GUARANTEE clause when creating the undo tablespace (CREATE UNDO TABLESPACE or CREATE DATABASE) or later using the ALTER TABLESPACE statement. To turn the retention guarantee off, use the RETENTION NOGUARANTEE clause. You can view the current retention from the DBA_TABLESPACES view.

FIGURE 3.9 The Undo Advisor



The following example code demonstrates the undo guarantee setting:

```
SQL> SELECT tablespace_name, contents, retention
  2  FROM   dba_tablespaces;

TABLESPACE_NAME CONTENTS  RETENTION
--------------- --------- -----------
```

```
SYSTEM           PERMANENT NOT APPLY
UNDOTBS1         UNDO      NOGUARANTEE
SYSAUX           PERMANENT NOT APPLY
TEMP             TEMPORARY NOT APPLY
EXAMPLE          PERMANENT NOT APPLY
APPDATA          PERMANENT NOT APPLY

SQL> ALTER TABLESPACE undotbs1 RETENTION GUARANTEE;

Tablespace altered.

SQL> SELECT tablespace_name, contents, retention
  2  FROM   dba_tablespaces
  3  WHERE  contents = 'UNDO';

TABLESPACE_NAME CONTENTS  RETENTION
--------------- --------- -----------
UNDOTBS1        UNDO      GUARANTEE

SQL>
```

Tuning the Automatic Checkpoint

The Mean Time to Recovery Advisor (the MTTR Advisor) performs automatic checkpoint tuning. Oracle 9*i* introduced the FAST_START_MTTR_TARGET parameter to specify the expected crash recovery time. Though Oracle 9*i* Release 2 introduced the MTTR Advisor, it was not easy to set the right target for MTTR_FAST_START_TARGET. You always had a trade-off between the small recovery time and runtime physical I/Os.

By default, Oracle 10*g* supports the automatic checkpoint tuning by making the best effort to write out dirty buffers without impacting the throughput, thus achieving reasonable crash-recovery time. With automatic checkpoint tuning, you do not need to set up any checkpoint-related parameters.

Setting the FAST_START_MTTR_TARGET parameter to a nonzero value or not setting this parameter enables automatic checkpoint tuning. If you explicitly set this parameter to zero, you disable automatic checkpoint tuning. The STATISTICS_LEVEL parameter must be set to TYPICAL or ALL.

After the database runs a typical workload for some time, the V$MTTR_TARGET_ADVICE dictionary view shows advisory information and an estimate of the number of additional I/O operations that would occur under different FAST_START_MTTR_TARGET values.

A new column OPTIMAL_LOGFILE_SIZE is now available in V$INSTANCE_RECOVERY. This column shows the redo log file size in megabytes, which is considered optimal based on the current FAST_START_MTTR_TARGET setting. The online redo log files must be at least set to the size recommended.

Chapter 5, "Automated Storage Management," discusses the Redo Logfile Size Advisor.

Collecting Automatic Optimizer Statistics

For the query optimizer to generate optimal query execution plans, the statistics on the objects must be valid. The optimizer statistics collection has improved with each version of the Oracle database. Oracle 8*i* introduced the DBMS_STATS package. The DBA determined when to gather statistics and how to gather statistics. Oracle 9*i* introduced the monitoring feature; the database determined how to gather statistics (the monitoring option must be manually enabled), but you determined when to gather statistics. You used the GATHER AUTO option to update the statistics for the objects when the current statistics were considered stale.

In Oracle 10*g*, the optimizer statistics collection is fully automated. You don't need to worry about statistics gathering at all, and table monitoring is enabled by default.

The automatic table monitoring is enabled when the STATISTICS_LEVEL parameter is set to TYPICAL (default) or ALL. The [NO]MONITORING clause of ALTER TABLE and CREATE TABLE are obsolete in Oracle 10*g*. The clause is still valid, but Oracle 10*g* ignores it.

How Statistics Are Maintained Current

When an Oracle 10*g* database is created or a database is upgraded to Oracle 10g, a job by the name of GATHER_STATS_JOB is created. The job is managed by the scheduler and runs when the MAINTENANCE_WINDOW_GROUP window group is opened. The MAINTENANCE_WINDOW_GROUP window group, which has the WEEKEND_WINDOW window and the WEEKNIGHT_WINDOW window, are also created at the database creation time. By default WEEKNIGHT_WINDOW opens Monday through Friday at 10 p.m. for 8 hours. By default WEEKEND_WINDOW opens Saturday at 0000 hours and continues for 48 hours.

The GATHER_STATS_JOB job is scheduled to run only when you create the database using the DBCA utility or you upgrade the database using DBUA utility. Otherwise, the job is created but is not scheduled to run.

The GATHER_STATS_JOB executes the DBMS_STATS.GATHER_DATABASE_STATS_JOB_PROC procedure, which is internal to Oracle 10*g* but is similar to the DBMS_STATS.GATHER_DATABASE_STATS procedure. It collects statistics on database objects when the object has no previously gathered statistics or when the existing statistics are stale because the underlying object has more than 10 percent of the rows modified. The DBMS_STATS.GATHER_DATABASE_STATS_JOB_PROC procedure prioritizes the database objects that require statistics so that the objects that need the statistics most are processed first, before the maintenance window closes. Unlike the DBMS_STATS.GATHER_DATABASE_STATS_JOB_PROC procedure, the GATHER_STATS_JOB continues until finished even if it exceeds the allocated time for the maintenance window.

You can adjust the automatic statistics-gathering job to start at a different time by changing the window properties using the EM Database Control or the procedures discussed in Chapter 2, "Moving Data and Managing the Scheduler." You can also disable the automatic statistics gathering using the `DBMS_SCHEDULER.DISABLE ('GATHER_STATS_JOB')` procedure. Disabling the `GATHER_STATS_JOB` is not recommended unless you have other methods to keep the statistics current.

You must gather statistics manually for the following situations:

- When a table is loaded using bulk operation
- When using external tables
- To collect system statistics
- To collect statistics on fixed objects (dynamic performance dictionary tables)

For Automatic Optimizer Statistics Collection to work, the `STATISTICS_LEVEL` parameter must not be set to `BASIC`. Since `GATHER_STATS_JOB` updates statistics only for stale objects, with `STATISTICS_LEVEL` set to `BASIC`, there will be no tracking mechanism.

Collecting Statistics on Dictionary Objects

Unlike previous versions of Oracle, for the best performance Oracle 10*g* requires statistics on all dictionary objects and the operating system. `DBMS_STATS` includes programs to collect dictionary statistics and fixed table statistics.

It is best to analyze the dictionary using the `GATHER AUTO` option. That way only objects that need statistics are analyzed. Executing any of the following three `DBMS_STATS` programs can collect statistics on dictionary objects:

DBMS_STATS.GATHER_DATABASE_STATS (GATHER_SYS=>TRUE, OPTIONS=> 'GATHER AUTO'); The default for `GATHER_SYS` parameter is `FALSE`. If you set it to `TRUE`, the statistics on the objects owned by the `SYS` schema are analyzed along with the other objects of the database.

DBMS_STATS.GATHER_SCHEMA_STATS ('SYS', OPTIONS=>'GATHER AUTO'); Use this option to gather the schema statistics by specifying the `SYS` schema name.

DBMS_STATS.GATHER_DICTIONARY_STATS (OPTIONS=>'GATHER AUTO'); This option collects statistics on the `SYS`, `SYSTEM`, and any other schema that owns the server components.

You would need the new privilege `ANALYZE ANY DICTIONARY` to collect dictionary statistics. `OPTIONS=>'GATHER AUTO'` is specified in all the three methods to show a best practice; it is not required to use this option.

None of the previous options gather statistics on the fixed memory tables. It is necessary to collect statistics on the fixed dictionary objects only once, preferably during normal workload. The DBMS_STATS.GATHER_FIXED_OBJECTS_STATS procedure collects statistics on fixed dictionary objects. Since the fixed tables do not have I/O cost because the rows reside in memory, the optimizer takes into account only the CPU cost of reading rows.

When deriving an execution plan for a query, the optimizer considers the I/O and CPU resources required for the query. Collecting system statistics enables the optimizer to estimate the CPU and I/O costs more accurately. Use the DBMS_STATS.GATHER_SYSTEM_STATS procedure to gather the system statistics (available in Oracle9i). When this procedure is invoked, the system statistics are gathered over a period of time. The first argument to this procedure is GATHERING_MODE, which defaults to NOWORKLOAD, which means the database is idle and is good time to capture the average read seek time and transfer speed for the I/O system. Workload can be used to specify if the database is performing normal operations or is doing specific tasks. For workload specific statistics, you can use the START and STOP values for this parameter. If system statistics should be collected for a specific time, specify INTERVAL as the value for GATHERING_MODE. You must specify the time in minutes using the INTERVAL parameter when INTERVAL is specified as GATHERING_MODE.

The following code collects statistics when there is no workload; run this typically after creating the database and all tablespaces:

```
SQL> EXEC DBMS_STATS.GATHER_SYSTEM_STATS ('NOWORKLOAD');
```

To collect statistics when there is specific workload, use the following code at the beginning of the work:

```
SQL> EXEC DBMS_STATS.GATHER_SYSTEM_STATS ('START');
```

When the work is finished, run the procedure with STOP as the parameter.

The Automatic Optimizer Statistics Collection job collects statistics on the dictionary objects automatically. It does not collect statistics for external tables, system statistics, and fixed tables.

Managing Statistics

Due to application design sometimes it may be necessary to lock statistics on tables. If a table is populated by a job and is being used in the job subsequently, it would be a good idea to collect stats on the table when the table is populated and lock the statistics on the table. When working with Oracle8i and Oracle9i, how many times you would have wished that you saved the statistics before you analyzed the table, which the new analyze changed the execution plan completely. Oracle 10g provides answers to all these - you can lock statistics, maintain statistics history and restore statistics. In the following sections, we will discuss these significant enhancements made to the DBMS_STATS program in Oracle 10*g*.

Locking Statistics

Statistics on a table or schema can be locked. Once locked, gathering statistics will not update the statistics on those tables or schema. Locking table statistics is useful for tables that are populated only during certain operations. You can also lock statistics on a table without statistics (after deleting the statistics) to prevent automatic statistics collection so that dynamic sampling will be used during query execution.

The DBMS_STATS.LOCK_TABLE_STATS procedure locks table statistics. You need to provide the owner name and table name as parameters. When statistics on a table are locked, all its dependents' statistics are also locked (for example, column statistics, histograms, and index statistics).When table statistics are locked, using the SET_*, DELTE_*, IMPORT_*, or GATHER_* procedures of DBMS_STATS with the locked table as a parameter will generate an error, but gathering schema statistics will skip modifying the statistics of a table if it is locked.

Use the DBMS_STATS.UNLOCK_TABLE_STATS procedure to unlock table statistics. Similar to the LOCK_TABLE_STATS procedure, you need to provide the owner and table name as parameters.

The DBMS_STATS.LOCK_SCHEMA_STATS procedure locks all the table statistics of a schema. DBMS_STATS.UNLOCK_SCHEMA_STATS unlocks the schema statistics.

The STATTYPE_LOCKED column of the DBA_TAB_STATISTICS dictionary view will be marked as ALL when the statistics are locked. The following code shows examples of using the lock statistics programs of DBMS_STATS:

```
SQL> EXEC dbms_stats.lock_table_stats -
          ('TRAING','ENROLLMENT');

PL/SQL procedure successfully completed.

SQL> EXEC dbms_stats.lock_schema_stats('HR');

PL/SQL procedure successfully completed.

SQL> EXEC dbms_stats.gather_table_stats
          ('TRAING','ENROLLMENT');

ERROR at line 1:
ORA-20005: object statistics are locked (stattype = ALL)
ORA-06512: at "SYS.DBMS_STATS", line 11568
ORA-06512: at "SYS.DBMS_STATS", line 11587
ORA-06512: at line 1

SQL> EXEC dbms_stats.gather_schema_stats('TRAING');
```

```
PL/SQL procedure successfully completed.

SQL> EXEC dbms_stats.gather_schema_stats('HR');

PL/SQL procedure successfully completed.

SQL> SELECT owner, table_name
  2  FROM   dba_tab_statistics
  3  WHERE  stattype_locked = 'ALL'
SQL> /

OWNER      TABLE_NAME
---------- ------------------------------
HR         REGIONS
HR         COUNTRIES
HR         LOCATIONS
HR         DEPARTMENTS
HR         JOBS
HR         EMPLOYEES
HR         JOB_HISTORY
TRAING     ENROLLMENT

8 rows selected.

SQL>
```

Using the FORCE=>TRUE argument for the DELETE_*, IMPORT_*, RESTORE_*, and SET_* procedures of DBMS_STATS will override the statistics even if they are locked.

Managing History

Whenever statistics are modified using the DBMS_STATS programs, old versions of the statistics are saved automatically for future restoration. This is a useful feature when new statistics adversely affect the query's performance. The GATHER_*, IMPORT_*, and SET_* procedures of DBMS_STATS write the current statistics to the AWR before updating the new statistics.

The DBA_OPTSTAT_OPERATIONS dictionary view shows the start and end time of all database-level and schema-level statistics update operations. The DBA_TAB_STATS_HISTORY view shows the statistics updated at a table level.

The following sample query shows the times when the statistics for the enrollment table was updated:

```
SQL> SELECT stats_update_time
  2  FROM   dba_tab_stats_history
  3  WHERE  owner = 'TRAING'
  4  AND    TABLE_NAME = 'ENROLLMENT';

STATS_UPDATE_TIME
---------------------------------
20-APR-04 11.45.49.898795 AM -05:00
14-MAY-04 06.20.41.034775 AM -05:00

SQL>
```

The old statistics are purged from the AWR at regular intervals; the default is 31 days. You can change the retention days using the `DBMS_STATS.ALTER_STATS_HISTORY_RETENTION` procedure. The `DBMS_STATS.GET_STATS_HISTORY_RETENTION` function gives the current setting for history retention. The `DBMS_STATS.GET_STATS_HISTORY_AVAILABILITY` function gives the oldest time stamp for which statistics history is available. You can also manually purge the statistics using the `DBMS_STATS.PURGE_STATS` procedure.

The following are examples of using these programs:

```
SQL> SELECT DBMS_STATS.GET_STATS_HISTORY_RETENTION
  2  FROM   dual;

GET_STATS_HISTORY_RETENTION
---------------------------
                         31

SQL> SELECT DBMS_STATS.GET_STATS_HISTORY_AVAILABILITY
  2  FROM   dual;

GET_STATS_HISTORY_AVAILABILITY
-----------------------------------
12-APR-04 10.07.31.886403000 PM -05:00

SQL> EXEC DBMS_STATS.ALTER_STATS_HISTORY_RETENTION (15);

PL/SQL procedure successfully completed.
```

```
SQL> EXEC DBMS_STATS.PURGE_STATS -
          (TO_TIMESTAMP('010504','DDMMYY'));

PL/SQL procedure successfully completed.

SQL> SELECT DBMS_STATS.GET_STATS_HISTORY_AVAILABILITY
  2  FROM   dual;

GET_STATS_HISTORY_AVAILABILITY
---------------------------------------
01-MAY-04 12.00.00.000000000 AM -05:00

SQL> SELECT DBMS_STATS.GET_STATS_HISTORY_RETENTION
  2  FROM   dual;

GET_STATS_HISTORY_RETENTION
---------------------------
                         15

SQL>
```

The following procedures are available in DBMS_STATS to restore various types of statistics:

- RESTORE_DATABASE_STATS
- RESTORE_DICTIONARY_STATS
- RESTORE_FIXED_OBJECTS_STATS
- RESTORE_SCHEMA_STATS
- RESTORE_SYSTEM_STATS
- RESTORE_TABLE_STATS

All the RESTORE_* procedures use a time stamp as an argument to restore the statistics as of that time stamp.

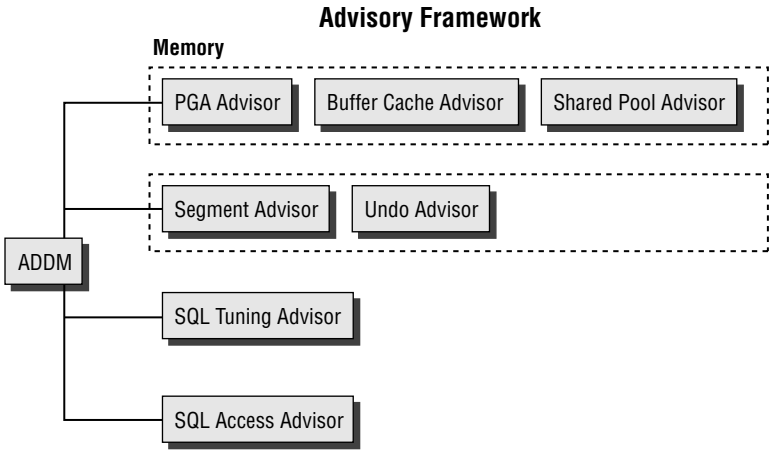
When statistics are gathered using ANALYZE statements, old versions are not stored in the AWR and are not available for restore.

In Oracle 10*g* index statistics collection occurs by default during index creation and rebuilding (except when statistics are locked). The COMPUTE STATISTICS clause of CREATE INDEX and ALTER INDEX is now obsolete.

Identifying the Advisory Framework

The advisory framework is another component of the CMI. The advisory framework consists of various server components that provide diagnosis and recommendations on database resource utilization and performance. In this chapter we have already discussed the ADDM, the ultimate advisor for Oracle 10*g*. Figure 3.10 shows the components of the advisory framework.

FIGURE 3.10 Advisory framework



The advisory framework provides a uniform interface for all advisors. It also provides seamless integration between the advisors, because all advisors have a common data source and results storage using the AWR.

The components of the advisory framework are as follows:

ADDM ADDM does a top-down instance analysis, identifies problems, and provides recommendations. It also gives recommendations to use the other more detailed advisors of the advisory framework.

SQL Tuning Advisor The SQL Tuning Advisor provides expert tuning advice for badly performing SQL statements. The SQL Tuning Advisor uses the Automatic Tuning Optimizer to tune the SQL statements.

Chapter 6, "Performance and Application Tuning," discusses the SQL Tuning Advisor.

SQL Access Advisor The SQL Access Advisor can automatically analyze the schema for a given workload and recommend indexes and materialized views to create, retain, or drop as appropriate for the workload.

Chapter 6 also discusses the SQL Access Advisor.

Segment Advisor The Segment Advisor makes recommendations on space-related issues such as wasted-space reclamation and growth trend analysis.

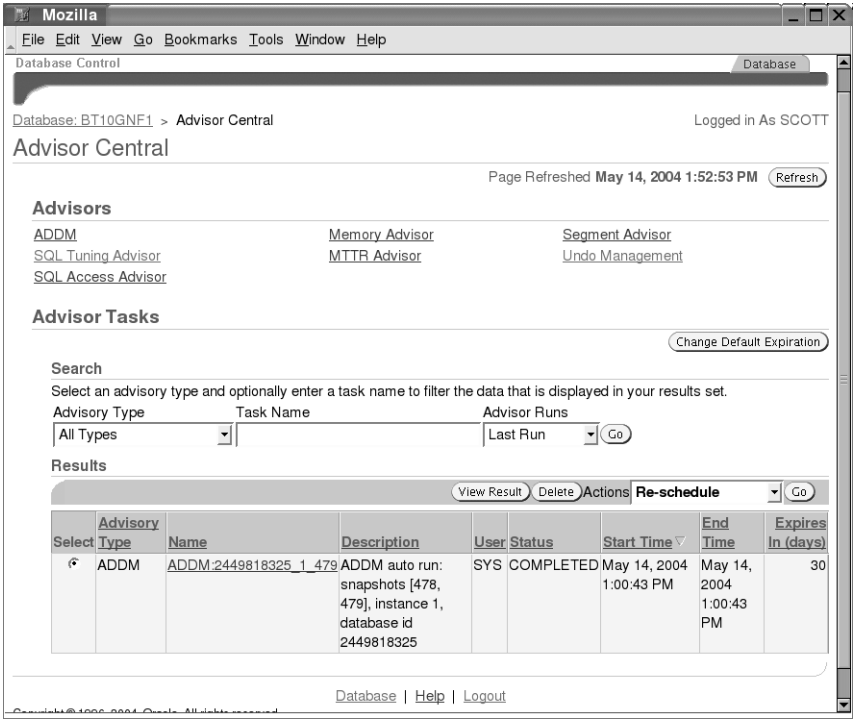
Undo Advisor The Undo Advisor suggests parameter values for the best undo retention and advises on additional space needed to support flashback for a specific time.

PGA Advisor The Program Global Area (PGA) Advisor tunes PGA memory allocated to the server processes. It recommends optimal value for the `PGA_AGGREGATE_TARGET` parameter.

Memory Advisor The Memory Advisor determines the optimum size for the buffer cache and the optimal shared pool size by tracking its use by the library cache. The Memory Advisor statistics provide information on predicting how changes in the size of the shared pool can affect how long objects are kept in the shared pool.

You can invoke the advisors from the EM Database Control using the Advisor Central link on the Database home page. Figure 3.11 shows the Advisor Central page of the EM Database Control. Notice that the EM does not support all the advisors. You can view the advisor recommendations and make changes using the EM Database Control.

FIGURE 3.11 The Advisor Central page



In the next section we will discuss using the DBMS_ADVISOR PL/SQL package to analyze and report advisor findings.

Using *DBMS_ADVISOR*

The DBMS_ADVISOR package, new to Oracle 10*g*, provides the PL/SQL application programming interface (API) to manage all the advisors. The ADVISOR privilege is required to use the procedures in the DBMS_ADVISOR package. The data dictionary view DBA_ADVISOR_DEFINITIONS contains the unique advisor names that can be used in the DBMS_ADVISOR package to get tuning advice.

```
SQL> SELECT * FROM dba_advisor_definitions;

ADVISOR_ID ADVISOR_NAME                       PROPERTY
---------- ------------------------------ ----------
         1 ADDM                                    1
         2 SQL Access Advisor                     15
         3 Undo Advisor                            1
         4 SQL Tuning Advisor                      3
         5 Segment Advisor                         3
         6 SQL Workload Manager                    0
         7 Tune MView                             31

7 rows selected.

SQL>
```

Table 3.2 lists the commonly used procedures of the DBMS_ADVISOR package that are available to all advisors. Certain procedures are applicable only to specific advisors; for example, the TUNE_MVIEW is applicable only to the SQL Access Advisor.

TABLE 3.2 *DBMS_ADVISOR* Programs

Procedure Name	Purpose
CREATE_TASK	Creates a new advisor task in the repository.
DELETE_TASK	Deletes the specified advisor task.
EXECUTE_TASK	Executes a specified task. The execution is a synchronous operation; control will not be returned to the caller until the operation is completed or an interrupt was detected.
CANCEL_TASK	Cancels a currently executing task.

TABLE 3.2 *DBMS_ADVISOR* Programs *(continued)*

Procedure Name	Purpose
INTERRUPT_TASK	Stops the currently executing task, with normal exit.
RESUME_TASK	Resumes an interrupted task.
RESET_TASK	Resets a task to its original state.
CREATE_OBJECT	Defines objects, normally input data for advisors. For the Segment Advisor, defined at the segment or tablespace level.
UPDATE_TASK_ATTRIBUTES	Changes various attributes of a task.
SET_TASK_PARAMETER	Modifies a user parameter within a task. A task can be modified only when it is in its initial state.
MARK_RECOMMENDATION	Accepts, rejects, or ignores a recommendation.
GET_TASK_SCRIPT	Creates a SQL*Plus-compatible SQL script of all the recommendations that are accepted from a specified task. The output is a CLOB buffer.
GET_TASK_REPORT	Creates and returns an XML report for the specified task. The type can be text, HTML, or XML.
CREATE_FILE	Creates an external file from a PL/SQL CLOB variable, used for creating scripts and reports.
QUICK_TUNE	Analyzes and generates recommendations for a single SQL statement.

Using the procedures of the DBMS_ADVISOR package, a typical tuning advisor session may comprise the following steps:

1. Create an advisor task using the DBMS_ADVISOR.CREATE_TASK procedure. The advisor task is a data area in the advisor repository that manages the tuning efforts. An existing task can be a template for another task.
2. Use the DBMS_ADVISOR.SET_TASK_PARAMETERS procedure to set up appropriate parameters to control the advisor's behavior. Typical parameters are TARGET_OBJECTS, TIME_WINDOW, and TIME_LIMIT.

3. Perform analysis using the DBMS_ADVISOR.EXECUTE_TASK procedure. You can interrupt the analysis process anytime to review the results up to that point. You can then resume the interrupted analysis for more recommendations, or you can adjust the task parameters and then resume execution.
4. Review the results using the DBMS_ADVISOR.GET_TASK_REPORT procedure. You can also view the results using dictionary views.

The $ORACLE_HOME/rdbms/admin/addmrpti.sql script is a good example of DBMS_ADVISOR usage.

The following example shows analyzing ADDM manually using the DBMS_ADVISOR procedures (the snapshots range 450 to 460 is used for the analysis; inline comments are provided to explain each step):

```
declare
 taskid number;
 taskname varchar2(100);
BEGIN

 -- create a new task, task name is system generated
 dbms_advisor.create_task('ADDM', taskid, taskname);

 -- set the snapshots to analyze
 dbms_advisor.set_task_parameter(taskname,
              'START_SNAPSHOT', 450);
 dbms_advisor.set_task_parameter(taskname,
              'END_SNAPSHOT', 460);

 -- perform analysis
 dbms_advisor.execute_task(taskname);

 -- buffer the report and save to file
 -- WORK_DIR is a directory already created in the db
 dbms_advisor.create_file(
    dbms_advisor.get_task_report(taskname, 'TEXT', 'ALL'),
                              'WORK_DIR', 'addmrpt.txt');
end;
/
```

One section of the report mentioned the following:

```
FINDING 7: 2% impact (104 seconds)
----------------------------------
Individual database segments responsible for significant
user I/O wait were found.

   RECOMMENDATION 1: Segment Tuning, 2% benefit
                     (104 seconds)
      ACTION: Run "Segment Advisor" on
                          TABLE "VOLEST.DAILY_ESTIMATES"
         with object id 53122.
         RELEVANT OBJECT: database object with id 53122
      ACTION: Investigate application logic involving I/O
         on TABLE  "VOLEST.DAILY_ESTIMATES" with
         object id 53122.
         RELEVANT OBJECT: database object with id 53122
      RATIONALE: The SQL statement with SQL_ID
         "3wft1nmf55c3w" spent  significant time
         waiting for User I/O on the hot object.
         RELEVANT OBJECT: SQL statement with SQL_ID
         3wft1nmf55c3w
         BEGIN
         SYS.KUPW$WORKER.MAIN('SYS_IMPORT_FULL_01',
                          'SCOTT');
         END;

   SYMPTOMS THAT LED TO THE FINDING:
      Wait class "User I/O" was consuming significant
      database time. (5.2% impact [269 seconds])

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

Though it is clear that the I/O wait was caused by the `Import` operation, for the sake of demonstration, we will invoke the Segment Advisor for more advice. The following code analyzes the `DAILY_ESTIMATES` table using the Segment Advisor. The Segment Advisor determines if an object is a good candidate for shrink operation. Here also inline comments are provided for each step.

Here is the code:

```
declare

 objectid number;
 taskid   number;
 taskname varchar2(100) := 'SEGADV001';

 BEGIN
  -- Create task, task name is passed in
  dbms_advisor.create_task(
    advisor_name=>   'Segment Advisor',
    task_id=>        taskid,
    task_name=>      taskname);

  -- Define the object where analysis to be made
  dbms_advisor.create_object (
     task_name=>     taskname,
     object_type=>   'TABLE',
     attr1=>         'VOLEST',
     attr2=>         'DAILY_ESTIMATES',
     attr3=>         'NULL',
     attr4=>         'NULL',
     attr5=>         'NULL',
     object_id=>     objectid);

  -- Define the level of analysis
  dbms_advisor.set_task_parameter (
     task_name=>     taskname,
     parameter=>     'RECOMMEND_ALL',
     value=>         'TRUE');

  -- Execute task
  dbms_advisor.execute_task(taskname);

end;
/
```

View the result from the dictionary using the following query:

```
SQL> SELECT message, more_info
  2  FROM   dba_advisor_findings
  3  WHERE  task_name = 'SEGADV001';
```

```
MESSAGE
MORE_INFO
------------------------------------------------------------
The object has less than 1% free space, it is not worth
shrinking.
Allocated Space:545259520: Used Space:543181080:
Reclaimable Space :0:

SQL>
```

The previous example of using ADDM and the Segment Advisor is readily available in the Database Control. You do not need to write any code but just need to click, click, click….

Advisor Dictionary Views

Many advisor-related data dictionary views exist. For each DBA_ADVISOR view listed here, a corresponding USER_ and ALL_ dictionary view exists. The views are as follows:

DBA_ADVISOR_ACTIONS Displays information about the actions associated with all recommendations in the database.

DBA_ADVISOR_COMMANDS Displays information about the commands used by all advisors for specifying recommendation actions.

DBA_ADVISOR_DEFINITIONS Displays properties of all the advisors in the database; contains one row for each task.

DBA_ADVISOR_FINDINGS Displays the findings discovered by all advisors.

DBA_ADVISOR_JOURNAL Displays journal entries for all tasks in the database.

DBA_ADVISOR_LOG Displays information about the current state of all tasks in the database.

DBA_ADVISOR_OBJECTS Displays information about the objects currently referenced by all the advisors.

DBA_ADVISOR_PARAMETERS Displays the parameters and their current values for all tasks.

DBA_ADVISOR_RATIONALE Displays information about the rationales for all recommendations.

DBA_ADVISOR_RECOMMENDATIONS Displays the results of an analysis. A recommendation can have multiple actions associated with it.

DBA_ADVISOR_SQLA_* Displays recommendation and workload information on SQL Access Advisor findings.

DBA_ADVISOR_SQLW_* Displays the workload parameters, templates, objects that are used by the SQL Access Advisor.

DBA_ADVISOR_TASKS Displays information about the tasks in the database; contains one row for each task.

DBA_ADVISOR_TEMPLATES Displays information about all templates.

DBA_ADVISOR_USAGE Displays the usage information for each type of advisor.

Automating Tasks

Automatic routine administration tasks are another component of the CMI. By analyzing the information stored in the AWR, the database can identify the need to perform routine maintenance tasks, such as updating optimizer statistics. The automated tasks infrastructure enables the database to perform such operations. It uses the scheduler to run such tasks in a predefined window.

Please review Chapter 2 to read about the job scheduling features.

Automated Optimizer Statistics Collection is an example of automated task. It is created automatically at the Oracle 10*g* database creation time and runs every day during the maintenance window.

Chapter 1 reviewed another example of an automated task, when we discussed the *Database Configuration Assistant (*DBCA). If you enable automatic backups, the database will setup a job to perform the backup every day at 2 a.m.

Resource Manager Enhancements

The Database Resource Manager gives the Oracle database more control over resource management. The `DBMS_RESOURCE_MANAGER` and `DBMS_RESOURCE_MANAGER_PRIVS` packages administer resource management. Oracle 8*i* introduced the Database Resource Manager.

You can administer the Resource Manager using the EM Database Control. From the database home page, click the Administration tab; under Resource Manager you will see several links to manage the components of the Resource Manager.

Oracle 10*g* introduced new features into the Resource Manager to effectively manage resources. The key features include switching a session back to its original consumer group, setting resource directives to limit the amount of session idle time, and establishing priorities to consumer groups using the adaptive mapping feature. In the following sections, we will discuss the enhancements made to the Resource Manager.

Automatic Session Switchback

Oracle 9*i* allowed automatic switching of users from one resource group to another if a user's session executed longer than the specified amount of time defined in the user's resource group. Once the switching was done, the session remained in the switched group for the remainder of the life of the session.

In Oracle 10*g*, you can specify that at the end of a switched resource group call the session be returned to its original resource group. You do this by introducing a new parameter, SWITCH_TIME_IN_CALL, for the DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE procedure and the NEW_SWITCH_TIME_IN_CALL parameter for the DBMS_RESOURCE_MANAGER.UPDATE_PLAN_DIRECTIVE procedure. These parameters accept the time in seconds.

If you use the SWITCH_TIME parameter, the behavior will be as it was in Oracle 9*i* where the session will be switched to the new resource group and remain in that group until the session ends. The SWITCH_TIME and SWITCH_TIME_IN_CALL parameters are mutually exclusive, and they specify the time in seconds that a session can execute before an action is taken. The default for both parameters is NULL.

Whether you use SWITCH_TIME or SWITCH_TIME_IN_CALL, the SWITCH_GROUP parameter specifies the resource group to which the session will be switched if the switch criteria are met.

The SWITCH_TIME_IN_CALL parameter is primarily beneficial for three-tier applications where the middle tier is implementing session pooling. In this situation, the middle tier uses the same session for different calls from different users (the boundary of work is a call). The new parameter will help in not penalizing the users for the calls made by a prior user. The SWITCH_TIME parameter is primarily beneficial for the client-server architecture.

The following is an example of creating a new resource plan directive with automatic switching to the OTHER_GROUPS resource group from ONLINE_GROUP when the session uses 100 percent of the CPU for five minutes. Once the call is completed, the session will be switched back to ONLINE_GROUP. Here is the example:

```
SQL> BEGIN
  2  DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA();
  3  DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP (
  4  CONSUMER_GROUP     => 'ONLINE_GROUP',
  5  COMMENT            => 'New Group for online users');
  6  DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(
  7  PLAN               => 'ONLINE_PLAN',
  8  GROUP_OR_SUBPLAN   => 'ONLINE_GROUP',
  9  CPU_P1             => 100,
 10  CPU_P2             => 0,
 11  SWITCH_GROUP       => 'OTHER_GROUPS',
 12  SWITCH_TIME_IN_CALL=> 300,
 13  COMMENT            => 'Automatic Switch Example');
 14  DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA();
 15  END;
 16  /
```

```
PL/SQL procedure successfully completed.

SQL>
```

Setting Idle Timeout

Oracle 10*g* has two new settings to limit the idle time for a session. You can specify the amount of time a session can be idle, as well as specify if the session is idle and blocking other sessions. This new option of limiting the idle time by blocking other session features is useful for online applications, where users update certain transactions and go out for lunch, for example, thus blocking a bunch of other users.

The MAX_IDLE_TIME parameter defines the maximum amount of time in seconds a session can be inactive or idle. The default is NULL (unlimited). When the session exceeds the limit, the PMON process will terminate the session and clean up its state.

The MAX_IDLE_BLOCKER_TIME parameter defines the maximum amount of time in seconds a session can be idle and block the acquisition of resources for another user. The default is NULL (unlimited).

The following example updates the ONLINE_GROUP to set the idle time to one hour and the idle blocking time to five minutes:

```
SQL> BEGIN
  2  DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA();
  3  DBMS_RESOURCE_MANAGER.UPDATE_PLAN_DIRECTIVE(
  4  PLAN                      => 'ONLINE_PLAN',
  5  GROUP_OR_SUBPLAN          => 'ONLINE_GROUP',
  6  NEW_MAX_IDLE_TIME         => 3600,
  7  NEW_MAX_IDLE_BLOCKER_TIME => 300);
  8  DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA();
  9  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

Creating a Mapping

A new procedure for DBMS_RESOURCE_MANAGER maps users to an initial resource group based on certain attributes of the user when connecting to the database (known as the Adaptive Consumer Group Mapping feature). The SET_CONSUMER_GROUP_MAPPING procedure can add,

delete, or modify entities that map sessions to resource consumer groups based on the session's login and runtime attributes.

The ATTRIBUTE, VALUE, and CONSUMER_GROUP are parameters to the SET_CONSUMER_GROUP_MAPPING procedure. The following example shows how to assign the user B2T to ONLINE_GROUP based on the Oracle login username and how to assign a user to LOW_GROUP when the client program used is TOAD.EXE:

```
SQL> BEGIN
  2  DBMS_RESOURCE_MANAGER.CLEAR_PENDING_AREA();
  3  DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA();
  4  DBMS_RESOURCE_MANAGER.SET_CONSUMER_GROUP_MAPPING (
  5   DBMS_RESOURCE_MANAGER.ORACLE_USER,
                               'B2T', 'ONLINE_GROUP');
  6  DBMS_RESOURCE_MANAGER.SET_CONSUMER_GROUP_MAPPING (
  7   DBMS_RESOURCE_MANAGER.CLIENT_PROGRAM,
                             'TOAD.EXE', 'LOW_GROUP');
  8  DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA();
  9  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

The SET_INITIAL_CONSUMER_GROUP procedure has been deprecated in Oracle 10*g*. You should use the SET_CONSUMER_GROUP_MAPPING procedure instead.

The valid ATTRIBUTE constants are as follows:

- CLIENT_MACHINE: The login attribute specifies the name of the machine from which a client is making connection to the database.
- CLIENT_OS_USER: This login attribute specifies OS username of the client that is logging in to the database.
- CLIENT_PROGRAM: This login attribute specifies the name of the client program used to login to the database.
- MODULE_NAME: This runtime attribute specifies the module name in the application that is currently executing. Module name is set by the DBMS_APPLICATION_INFO.SET_MODULE_NAME procedure.
- MODULE_NAME_ACTION: This runtime attribute specifies the current module and action being performed by the user. The attribute is specified by the module name, followed by a period (.), followed by the action name.

- ORACLE_USER: This login attribute specifies standard Oracle user name.
- SERVICE_MODULE: This runtime attribute specifies a combination service and module names in this form *service_name.module_name*
- SERVICE_MODULE_ACTION: This runtime attribute specifies a combination of service, module name and action name, in this form *service_name.module_name.action_name*
- SERVICE_NAME: This login attribute specifies the service name used by the client to establish a connection to the database.

If more than one attribute satisfies a session, then the default attribute precedence set in the database determines the resource consumer group. For example, say that it is defined that when CLIENT_OS_USER is BILL, use DSS_GROUP; and when the ORACLE_USER is LARRY, use ONLINE_GROUP. Then, if Larry uses Bill's machine to log into the database using his own ID, you have ambiguity. The default attribute priorities are set so that the Oracle user name takes precedence over the client operating system user name.

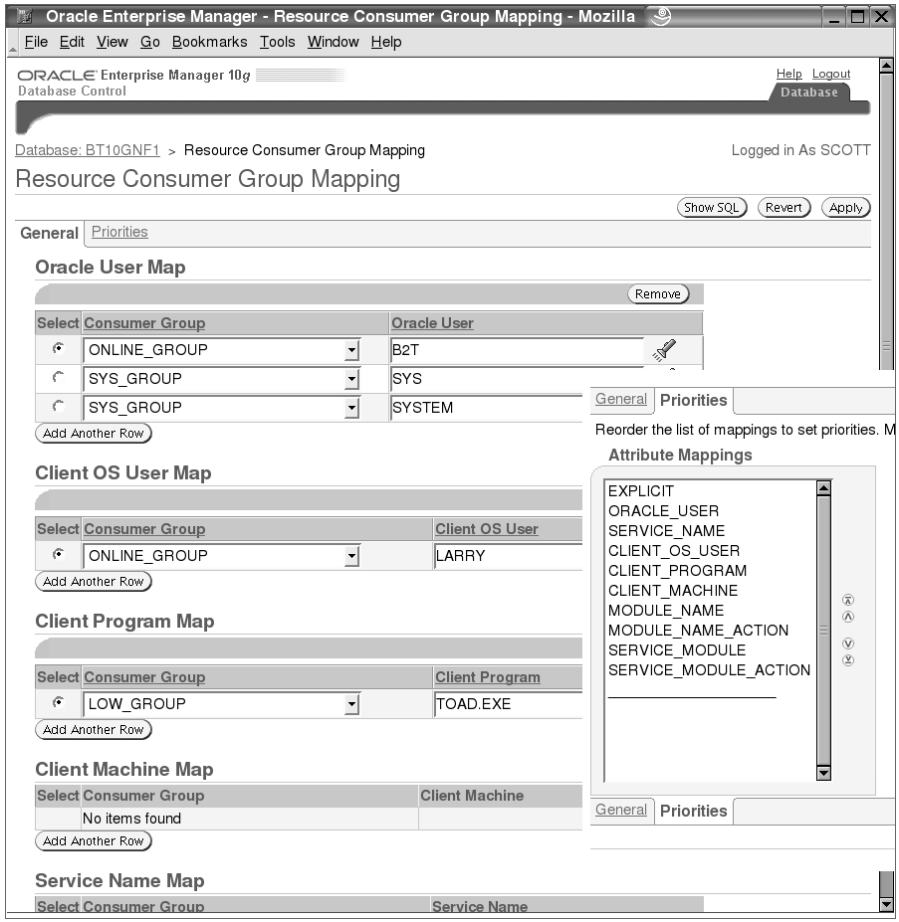
To change the default attribute priorities, use the SET_CONSUMER_GROUP_MAPPING_PRI procedure. The following example shows all the parameters of this procedure and how to set the priority. The priorities are defined using an integer of value 1 through 10; 1 is the highest, and 10 is the lowest. EXPLICIT is the priority of the explicit mapping. Here is the example:

```
SQL> BEGIN
  2  DBMS_RESOURCE_MANAGER.CLEAR_PENDING_AREA();
  3  DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA();
  4  DBMS_RESOURCE_MANAGER.SET_CONSUMER_GROUP_MAPPING_PRI
  5  (EXPLICIT             => 1,
  6  ORACLE_USER           => 2,
  7  SERVICE_NAME          => 3,
  8  CLIENT_OS_USER        => 4,
  9  CLIENT_PROGRAM        => 5,
 10  CLIENT_MACHINE        => 6,
 11  MODULE_NAME           => 7,
 12  MODULE_NAME_ACTION    => 8,
 13  SERVICE_MODULE        => 9,
 14  SERVICE_MODULE_ACTION=> 10);
 15  DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA();
 16  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

The MODULE_NAME and MODULE_NAME_ACTION attributes are useful for middle-tier applications that use the same username for all clients but set their module and actions consistently for different operations performed by the users. The modules and actions characterize the type of work performed, which the Resource Manager can use to determine the resource management policy.

You can set up the Resource Manager mappings and priorities using the EM Database Control. From the Administration tab of the EM Database Control home page, click the Resource Consumer Group Mappings link under Resource Manager. Figure 3.12 shows the screen where you can define the mappings. You can click the Priorities tab to define priorities. The figure also shows a portion of the Priorities screen in the inset.

FIGURE 3.12 The Resource Consumer Group Mapping screen



Changes to Resource Allocation Method

In Oracle 9*i*, the only CPU allocation method allowed when creating a resource plan was EMPHASIS, which was also the only method available. In Oracle 10*g*, a new method—RATIO—is available. The default method is still EMPHASIS, which is used for multilevel plans that use percentages to specify how the CPU is distributed among consumer groups. In Oracle 10*g*, you can specify an additional CPU allocation policy, called the RATIO policy, for single-level plans to partition CPU resources by using ratios.

Specify RATIO as the value for the CPU_MTH parameter of the CREATE_PLAN procedure to define ratio-based CPU allocation.

You specify a resource allocation method for the distribution of CPU among sessions in the consumer group using the CPU_MTH parameter of the CREATE_CONSUMER_GROUP procedure. The default and only value available for CPU_MTH in Oracle 9*i* was ROUND-ROBIN. In Oracle 10*g*, the default is ROUND ROBIN, but you can also specify RUN-TO-COMPLETION. RUN-TO-COMPLETION specifies that sessions with the largest active time be scheduled ahead of other sessions. ROUND-ROBIN scheduling ensures that sessions are fairly executed.

Summary

In this chapter, you learned about the components of the Common Management Infrastructure (CMI) and the automatic management of the database. The Automatic Workload Repository (AWR) is the central element of the management infrastructure. It provides services to internal Oracle database components to collect, maintain, process, and use performance statistics for problem detection and self-tuning purposes. The AWR has two main areas: the in-memory statistics collection area stored in the SGA and the Workload Repository stored in the SYSAUX tablespace. The in-memory statistics is transferred to the disk by the MMON process.

The Active Sessions History (ASH) represents the history of recent sessions activity, to analyze the system performance at the current time. ASH samples the active sessions at one-second intervals and records the events for which these sessions are waiting.

The initialization parameter STATISTICS_LEVEL controls the level of statistics capture. BASIC turns off statistics collection, TYPICAL is the default and collects most statistics needed for monitoring the database, and ALL collects all the possible statistics that can be used for manual diagnosis.

Server-generated alerts allow Oracle 10*g* to automatically detect alarming situations in the database and suggest remedial actions. Oracle 10*g* discovers alert conditions using the threshold specified. The alerts can be threshold based or events based. The DBMS_SERVER_ALERTS package is the PL/SQL API to set thresholds.

The automated tasks component of the CMI schedules automatic jobs using the scheduler. The Automatic Optimizer Statistics Collection feature on the database is one such automatic job. The predefined job GATHER_STATS_JOB is scheduled to run during the MAINTENANCE_WINDOW_GROUP window group.

The DBMS_STATS package includes new features to lock statistics on a table or schema. The new DBA_OPTSTAT_OPERATIONS view shows start and end times of all DBMS_STATS operations executed at the schema or database level. The history of statistic collection is kept in the AWR, and DBMS_STATS has procedures to restore the statistics as of a previous date if needed.

The advisory framework is another component of the CMI. Advisors provide useful feedback about resource utilization and performance of a component. The Automatic Database Diagnostic Monitor (ADDM) is the advisor for the database instance. It can invoke other advisors such as the SQL Tuning Advisor, the Segment Advisor, or Memory Advisors. The DBMS_ADVISOR PL/SQL package contains constants and all procedure declarations for all advisor modules.

ADDM is a server-based performance expert in the database that is automatically used for proactive and effective tuning. ADDM is scheduled to run every hour by the MMON process and detect problems. The ADDM findings display on the EM Database Control home page.

The Automatic Shared Memory Management (ASMM) feature enables the database to automatically determine the size of each of the SGA components, within the limits of the total SGA size. DB_CACHE_SIZE, SHARED_POOL_SIZE, LARGE_POOL_SIZE, and JAVA_POOL_SIZE are managed automatically.

The Automatic Undo Retention Tuning feature of the database automatically determines the optimal undo retention time depending on the size of the undo tablespace. Oracle 10*g* can dynamically adjust to the change in undo requirements depending on undo activity. With this feature, you have no need to manually set the undo retention period.

You also learned about the Resource Manager enhancements in this chapter. At the end of every top call, a session can be returned to its original consumer group. The session can be terminated if it is idle for a certain time period or if the session is idle and blocking other users resources. Using the Adaptive Consumer Group Mapping feature, you can establish priorities and assign consumer groups.

Exam Essentials

Understand the Automatic Database Diagnostics Monitor. Know how the ADDM uses a top-down approach to drill down to the root cause of problems. Learn to change the ADDM attributes.

Learn Automatic Shared Memory Management. Know the components of SGA that are managed by ASSM. Understand the benefits of ASSM. Learn the behavior of the autotuned SGA parameters and manually tuned SGA parameters when they are resized.

Learn how Automatic Optimizer Statistics Collection works. Understand the window group, windows, the job name, and the internal procedure used to collect statistics. Learn how statistics can be locked and forcefully overwritten using the FORCE option. Learn how previous versions of statistics are kept in the AWR and how they can be restored.

Understand the automatic tuning capabilities of the database. Know how the Automatic Undo Retention Tuning and Automatic Checkpoint Tuning features work.

Know how the Automatic Workload Repository operates. Understand the purpose of the `MMON` process. Know where to look for the ASH. Learn to change the retention policies and snapshot intervals of AWR.

Understand server-generated alerts. Know the architecture of server-generated alerts and the types of alerts. Remember an alert is generated only when the observation period and consecutive occurrences are satisfied. Learn to set alert thresholds and how to query the information about them.

Know the enhancements to the Resource Manager. Learn to set idle timeouts. Know how sessions can be switched back to their original resource consumer group at the end of a call. Understand how to use the mapping feature and set priorities.

Review Questions

1. To enable the Automatic Workload Repository performance statistic collection at a minimal scale, the STATISTICS_LEVEL parameter must be set to what?
   - **A.** TYPICAL
   - **B.** NONE
   - **C.** ALL
   - **D.** BASIC
2. Which process is responsible for analyzing the AWR information for the ADDM?
   - **A.** PMON
   - **B.** MMON
   - **C.** ADDM
   - **D.** SNPn
3. Which data dictionary view would you query to find out the stateless (event-based or nonthreshold) server alerts?
   - **A.** DBA_ALERT_LOG
   - **B.** DBA_OUTSTANDING_ALERTS
   - **C.** DBA_ALERT_HISTORY
   - **D.** DBA_ADVISOR_FINDINGS
4. Which of the following is not an out-of-the-box server-generated alert?
   - **A.** "Tablespace space usage"
   - **B.** "Recovery area low on free space"
   - **C.** "Resumable session suspended"
   - **D.** "Tables missing optimizer statistics"
   - **E.** "Snapshot too old"
5. Which parameters enable the Automatic Shared Memory Management feature? (Choose two.)
   - **A.** SGA_SIZE
   - **B.** SGA_TARGET
   - **C.** AUTO_SGA
   - **D.** STATISTICS_LEVEL

6. Which component of the SGA is not automatically configured when Automatic Shared Memory Management is enabled?

   A. Java pool

   B. Buffer cache

   C. Log buffer

   D. Large pool

7. Which process is responsible for allocating the various components of the SGA when Automatic Shared Memory Management is used?

   A. PMON

   B. SMON

   C. MMON

   D. MMAN

8. How is automatic undo retention tuning enabled?

   A. Set the UNDO_RETENTION parameter to zero.

   B. Set the UNDO_MANAGEMENT parameter to AUTO.

   C. Configure it using the DBMS_ADVISOR package.

   D. Set the UNDO_RETENTION parameter to nonzero value.

9. Identify the statement that is not true regarding the Automatic Optimizer Statistics Collection feature in Oracle 10*g*.

   A. After creating an Oracle 10*g* database, the DBA does not have to perform any special activity to keep the optimizer statistics current.

   B. After upgrading an Oracle database to Oracle 10*g*, the DBA does not have to perform any special activity to keep the optimizer statistics current.

   C. The statistics are kept current by periodically (automatic) executing the DBMS_STATS.GATHER_DATABASE_STATS procedure with the GATHER AUTO option.

   D. For the automatic statistic collection to work properly, the STATISTICS_LEVEL must be set to TYPICAL or ALL.

10. Identify two statements that are true regarding the procedures of DBMS_STATS.

    A. Every time you collect statistics on a table, schema, or database using DBMS_STATS, the previous version of statistics is stored in the AWR.

    B. The retention period of optimizer statistics stored in the AWR is determined by the DBMS_WORKLOAD_REPOSITORY.MODIFY_SNAPSHOT_SETTINGS (RETENTION=> *nn)* procedure.

    C. When you lock statistics on a table, the schema level statistics collection skips the table.

    D. Restoring statistics from the AWR is based on the time stamp when the statistics were collected.

11. The following are a few of the steps involved in getting the tuning advice from AWR snapshots using the DBMS_ADVISOR PL/SQL API.

1 Use the DBMS_ADVISOR.SET_TASK_PARAMETERS procedure.
2 Use the DBMS_ADVISOR.CREATE_TASK procedure.
3 Use the DBMS_ADVISOR.GET_TASK_REPORT procedure.
4 Use the DBMS_ADVISOR.EXECUTE_TASK procedure.

In which order should be these steps executed?

A. 1, 3, 4, 2

B. 1, 2, 3, 4

C. 2, 1, 4, 3

D. 2, 1, 3, 4

12. Choose the most appropriate statement regarding collecting optimizer statistics:

A. The DBMS_STATS package and the ANALYZE statement have same behavior.

B. When statistics are collected using the ANALYZE statement, previous version of statistics is saved in the Workload Repository.

C. When statistics are collected using the DBMS_STATISTICS package, the previous version of statistics is saved in the Workload Repository.

D. When gathering statistics using the DBMS_STATS package, you must specify the SAVE_VERSION parameter to save the old statistics to the Workload Repository.

13. Which parameter of the DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE procedure ensures that at the end of the switched resource group call, the session is returned back to its original resource group?

A. SWITCH_TIME_IN_CALL

B. SWITCH_TIME

C. SWITCH_GROUP

D. SWITCH_BACK_AT_CALL_END

14. In the DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE procedure, the MAX_IDLE_TIME parameter is used to define what?

A. The maximum amount of time a session is inactive and is blocking another session. The session will be switched to switch group defined when the amount of time is met.

B. The total amount of time a session is inactive or idle cumulative since the session startup. The session will be terminated when the criteria is met.

C. The maximum amount of time a session is idle. The session will be switched to switch group defined when the amount of time is met.

D. The maximum amount of time a session is idle. The session will be terminated when the criteria is met.

15. Identify two statements that are not true regarding AWR.
    A. The snapshot data is not purged from the AWR for the snapshots that are part of a baseline.
    B. The automatic capturing of AWR snapshots is disabled by dropping or disabling the corresponding job using DBMS_SCHEDULER.
    C. To get AWR report in HTML format, you must use the EM Database Control.
    D. No data migration from STATSPACK to AWR is supported.

16. The alerts generated by the database server are delivered to the DBA using which method?
    A. Writing the alert to the database alert log file
    B. Sending e-mail to the DBA using the e-mail address specified when creating the database
    C. Using a trigger on the DBA_OUTSTANDING_ALERTS view
    D. Using DBMS_AQ procedures

17. When is the ADDM analysis performed?
    A. Every time an AWR snapshot is taken
    B. Whenever an AWR snapshot is taken automatically by the MMON process
    C. Whenever an AWR snapshot is taken using the CREATE_SNAPSHOT procedure
    D. Every hour or at specified interval irrespective on AWR snapshots

18. Identify a true statement from the following regarding Automatic Shared Memory Management.
    A. ASMM is enabled by default.
    B. ASMM is disabled by setting SGA_TARGET to zero.
    C. SGA_TARGET cannot be altered dynamically using ALTER SYSTEM.
    D. When SGA_TARGET is specified as a nonzero value, all the SGA parameters related to the autotuned components must be set to zero.
    E. The MMON process is responsible for coordinating the sizing of the memory components.

19. The FORCE=>TRUE option of the DBMS_STATS.DELETE_TABLE_STATS procedure is used for what?
    A. To delete statistics from the table, even if the table is read only.
    B. To delete statistics from the table and to clear out all the SQL statements referring to the table from the shared pool.
    C. To delete statistics from the table, even if the statistics on the table are locked.
    D. The value of FORCE must be TRUE always, as this parameter is reserved for a future enhancement.

20. Which of the following is true about Automatic Checkpoint Tuning?
    A. You do not need to specify the LOG_CHECKPOINT_INTERVAL or LOG_CHECKPOINT_TIMEOUT parameter.
    B. You do not need to specify the FAST_START_MTTR_TARGET parameter.
    C. You do not need to specify the LOG_BUFFER parameter.
    D. All of the above are true.

Answers to Review Questions

1. A. The valid values for STATISTICS_LEVEL parameter are BASIC, TYPICAL, and ALL. BASIC disables the AWR and other statistics collection, TYPICAL collects statistics needed for day-to-day monitoring, and ALL collects statistics for manual diagnosis.

2. B. The new process MMON is responsible for writing the ASH information to the Automatic Workload Repository and also analyzing the statistics each time an AWR snapshot is taken.

3. C. The stateless alerts are always written to DBA_ALERT_HISTORY. DBA_OUTSTANDING_ALERTS will have the alerts for threshold or stateful alerts. When the status of such alerts is CLEARED, they will be moved to DBA_ALERT_HISTORY.

4. D. In Oracle 10*g*, the optimizer statistics for tables, including the dictionary, are collected automatically unless the STATISTICS_LEVEL parameter is set to BASIC. The tables have the MONITORING feature enabled by default. So, no need exists for such an alert to look for missing optimizer statistics.

5. B, D. Setting the SGA_TARGET and leaving the STATISTICS_LEVEL to its default (TYPICAL) enables ASMM. SGA_TARGET specifies the total size of the SGA, including the manually configured areas. SGA_TARGET cannot be higher than SGA_MAX_SIZE.

6. C. The log buffer should be configured using the LOG_BUFFER parameter. Setting SGA_TARGET automatically manages SHARED_POOL_SIZE, JAVA_POOL_SIZE, LARGE_POOL_SIZE, and BUFFER_CACHE.

7. D. The memory manager process (MMAN) is responsible for managing the components of SGA when the Automatic Shared Memory Management feature is used. It serves as a memory broker, coordinates the sizing of the memory components, and keeps track of the component's sizes.

8. B. By keeping UNDO_MANAGEMENT set to AUTO (this is the default when creating a new database), the Automatic Undo Retention Tuning feature is enabled in Oracle 10*g*. If you set a value for the UNDO_RETENTION parameter, Oracle 10*g* uses that value as the minimum. If no value or zero is set for UNDO_RETENTION, Oracle 10*g* uses 900 seconds as the default minimum.

9. C. The DBMS_STATS.GATHER_DATABASE_STATS_JOB_PROC internal procedure collects the missing statistics and update statistics in the database. This procedure prioritizes the database objects that require statistics so that the objects that need the statistics most are processed first, before the maintenance window closes.

10. A, C. The retention period of the statistics history kept in the AWR is 31 days by default, which can be modified by using the DBMS_STATS.ALTER_STATS_HISTORY_RETENTION procedure. The statistics from the AWR are restored using the time stamp as an argument to restore statistics as of that time stamp (not when the statistics are collected).

11. C. To get tuning advice using the advisory framework DBMS_ADVISOR package, you should create the task first, set appropriate parameters for the task (specify the start snapshot and end snapshot), perform analysis, and optionally get a report or query from the DBA_ADVISOR_FINDINGS view.

12. C. Oracle10g saves the statistics to the workload repository before setting new statistics values using the DBMS_STATS package. Statistics are not preserved when using the ANALYZE statement.

13. A. The SWITCH_TIME and SWITCH_TIME_IN_CALL parameters are mutually exclusive, and they specify the time in seconds that a session can execute before an action is taken. The default for both parameters is NULL. The SWITCH_TIME_IN_CALL parameter specifies that the session should be returned to the original consumer group at the end of the call, where as when using the SWITCH_TIME, the session remains in the switched consumer group. Whether you use SWITCH_TIME or SWITCH_TIME_IN_CALL, the SWITCH_GROUP parameter specifies the resource group to which the session will be switched if the switch criteria are met.

14. D. The MAX_IDLE_TIME parameter defines the maximum amount of time in seconds a session can be inactive or idle. When the session exceeds the limit, the PMON process will terminate the session and clean up its state. The MAX_IDLE_BLOCKER_TIME parameter defines the maximum amount of time in seconds a session can be idle and block the acquisition of resources for another user.

15. B, C. You can disable the automatic capturing of AWR snapshots by setting the INTERVAL parameter to zero in the DBMS_WORKLOAD_REPOSITORY.MODIFY_SNAPSHOT_SETTINGS procedure. You can produce AWR reports in HTML format using SQL*Plus by specifying the report type as HTML or text. The snapshots that are older than the retention period defined are not purged when they are part of a baseline. Though STATSPACK is still available in Oracle 10*g*, no integration exists between the data collected by STATSPACK and AWR.

16. D. The alerts generated by the server are queued to the AQ mechanism of the database, a predefined persistent queue ALERT_QUE. You may write your own subscribing programs. You can use the EM Database Control to enable paging and e-mail to the DBA. You may also query DBA_OUTSTANDING_ALERTS to view the alerts that are not resolved. A message about the alert is written to the alert log file only if the alert cannot be written to the ALERT_QUE.

17. A. ADDM is run by the MMON process every time an AWR snapshot is performed—automatic or manual. Each time a snapshot is taken, ADDM is triggered to do an analysis of the period corresponding to the last two snapshots. You may run the addmrpti.sql script to analyze the data between two different snapshot IDs.

18. B. The default value for SGA_TARGET is zero, which means ASMM is not enabled by default. SGA_TARGET can be increased or decreased dynamically within the limits of the SGA_MAX_SIZE parameter. When ASMM is used and a value for the automatically tuned component is also specified, the value would be considered as the minimum required size for the component. The memory manager process (MMAN) is the SGA memory broker and is responsible for the sizing of the SGA components.

19. C. You can use the FORCE=>TRUE option with the DELETE_*_STATS, IMPORT_*_STATS, RESTORE_*_STATS, and SET_*_STATS procedures of the DBMS_STATS package to overwrite the statistics even if they are locked.

20. A. Automatic Checkpoint Tuning is enabled if you specify a value for the FAST_START_MTTR_TARGET or if you do not specify any value for this parameter. Automatic Checkpoint Tuning is disabled when FAST_START_MTTR_TARGET is set to zero explicitly. You do not need to specify any of the checkpoint-related parameters when the FAST_START_MTTR_TARGET parameter is set.

Chapter 4

General Storage Management

ORACLE DATABASE 10*g* NEW FEATURES FOR ADMINISTRATORS EXAM OBJECTIVES OFFERED IN THIS CHAPTER:

- ✓ **Improved VLDB Support**
  - Create and maintain bigfile tablespaces
  - Create temporary tablespace groups
  - Assign temporary tablespace groups to users
  - Skip unuseable indexes
  - Specify storage characteristics for index partitions in the table partition DML commands
  - Create hash-partitioned global indexes
  - Maintain hash-partitioned global indexes
- ✓ **General Storage Enhancement**
  - Create the SYSAUX tablespace
  - Relocate SYSAUX occupants
  - Rename tablespaces
  - Create a default permanent tablespace
  - Copy files using the Database Server

Exam objectives are subject to change at any time without prior notice and at Oracle's sole discretion. Please visit Oracle's training and certification website (`http://www.oracle.com/education/certification/`) for the most current exam objectives listing.

Oracle Database 10*g* (Oracle 10*g*) provides a number of general enhancements to help the DBA manage the disk space in the database. These general enhancements fall into two broad categories: tablespace management and index management. In both cases, the Oracle Enterprise Manager (EM) Database Control provides wizards and a graphical interface for these enhancements, making it easy to leverage these enhancements in short order.

At the tablespace level, there is a new required tablespace and new ways to create tablespaces; temporary tablespaces can be grouped together to provide adequate temporary space for multiple concurrent sessions for a single user. In addition, several new tablespace features reduce the number of manual steps a DBA needs to perform functions such as renaming a tablespace, transporting a tablespace with the same name, or copying tablespace images between databases.

Partitioning methods are also enhanced in Oracle 10*g*. EM Database Control automates many of the partitioning tasks; partitioning capabilities have been expanded for Index Organized Tables (IOTs).

Index maintenance and usability has been enhanced. By default, unusable indexes because of partition maintenance no longer generate fatal ORA- errors. Hash partitioning is a new index type available for global indexes, improving the performance of inserts in an OLTP environment.

In this chapter, we will review many new and enhanced tablespace-related features, such as how to create and maintain one of the new tablespaces in Oracle 10*g*, the SYSAUX tablespace. We'll show you how to specify the default permanent tablespace in the database to ensure that user objects are not created in the SYSTEM tablespace. Temporary tablespaces have a number of enhancements including how a group of temporary tablespaces can be combined into a tablespace group. Last, but not least, we'll show you how to create a bigfile tablespace, both increasing the maximum size of the database as well as simplifying maintenance tasks on a tablespace. At the end of the chapter we'll review the new index-related enhancements: skipping unusable indexes, more flexible index storage specifications, and hash-partitioned global indexes.

Managing Tablespaces

The release of Oracle 10*g* brings a number of features that enhance the performance, availability, and maintainability of the database. The new SYSAUX tablespace offloads noncritical application metadata from the SYSTEM tablespace, reducing or eliminating hotspots in the SYSTEM tablespace, in addition to consolidating the metadata from several other tablespaces.

Bigfile tablespaces not only expand the maximum size of the database, but because a bigfile tablespace contains only one datafile, it also moves the maintenance point from the physical

datafile level to the logical database level. This increases the maintainability of the tablespace. Arriving along with bigfile tablespaces is a new ROWID format, along with the stored procedures and packages to support the new ROWIDs.

To increase the throughput of queries and other operations, the DBA can create tablespace groups for temporary tablespaces. Temporary tablespace groups are used anywhere that a temporary tablespace is used.

Other general enhancements to tablespace management include renaming tablespaces, creating a default permanent tablespace, and performing datafile and other binary file copy operations between directories on the same database server or between different servers on the network.

The *SYSAUX* Tablespace

The SYSAUX *tablespace*, a companion tablespace to the SYSTEM tablespace, helps to improve the availability of the database by offloading some application data from applications that used the SYSTEM tablespace or other separate tablespaces before Oracle 10*g*. As a result, some of the I/O bottlenecks frequently associated with the SYSTEM tablespace have been reduced or eliminated.

The SYSAUX tablespace is required and has the same storage characteristics as the SYSTEM tablespace.

- ONLINE
- PERMANENT
- READ WRITE
- EXTENT MANAGEMENT LOCAL
- SEGMENT SPACE MANAGEMENT AUTO

To put it another way, the SYSAUX tablespace cannot ever be OFFLINE, cannot be a temporary tablespace, cannot be READ ONLY, and cannot be dictionary managed (and therefore eliminate some of the benefits of reducing SYSTEM tablespace overhead). Also, its segment extent sizes cannot be manually defined and maintained.

The SYSAUX tablespace reduces the overall number of tablespaces in the database in addition to reducing the space requirements of the SYSTEM tablespace. For example, in previous versions of Oracle, the Enterprise Manager Repository metadata was stored in the tablespace OEM_REPOSITORY. Using the SYSAUX tablespace helps reduce the total number of tablespaces that the DBA must maintain and monitor. The applications that use the SYSAUX tablespace are not permanently tied to that tablespace; as you will see later in this section, you can move some of the SYSAUX occupants into their own tablespace if circumstances require it, such as when a space problem exists in the SYSAUX tablespace.

In a Real Application Clusters (RAC) environment using raw devices, the SYSAUX tablespace can ease tablespace management, as each tablespace in this environment requires a separate raw device.

When a new database is created, the SYSAUX tablespace is created along with the SYSTEM tablespace, the undo tablespace, and the temporary tablespace in the CREATE DATABASE command,

but a development or test database require only the SYSTEM and SYSAUX tablespaces. A database upgraded from a previous version of Oracle requires that a SYSAUX tablespace be created during the database upgrade procedure.

In the following sections, we'll show you how to create a SYSAUX tablespace, either as part of a new database or for an upgraded database; we'll also show you how to review the contents of the SYSAUX tablespace. Finally, we'll show you how to move a SYSAUX occupant to another tablespace, and back again if necessary.

Creating the *SYSAUX* Tablespace

The SYSAUX tablespace is created in one of two scenarios: as part of a new database or as part of an upgrade from a previous version of Oracle. In both cases, you have two ways to create the tablespace, with a GUI-based Oracle tool or from the SQL*Plus command line.

Creating *SYSAUX* As Part of a Database Upgrade

For a database upgrade to Oracle 10*g*, the Database Upgrade Assistant (DBUA) requires you to create a SYSAUX tablespace but allows you to specify the datafile name as well as whether the datafile will be automatically extensible using the AUTOEXTEND parameter. From the SQL*Plus command line, creating the SYSAUX tablespace is part of a several-step procedure. If there is a tablespace in the previous database version named SYSAUX, it must be dropped or renamed before upgrading the database. First, start up the database in MIGRATE mode.

```
SQL> STARTUP MIGRATE;
```

Next, create the SYSAUX tablespace with the required attributes.

```
SQL> CREATE TABLESPACE SYSAUX
  2      DATAFILE '/U05/ORADATA/ORD/SYSAUX.DBF' SIZE 200M
  3      AUTOEXTEND ON
  4      EXTENT MANAGEMENT LOCAL
  5      SEGMENT SPACE MANAGEMENT AUTO;
```

Finally, to complete the database upgrade and convert all data dictionary objects to the latest version, run the script corresponding to the previous version of the database; in this case, you are upgrading from an Oracle 9*i* Release 2 database:

```
SQL> @u0902000.sql
```

After the script has run successfully, you can shut down the database and start it up normally.

You can find a complete discussion of database upgrade issues and procedures in the *Oracle Database Upgrade Guide 10*g *Release 1*.

Creating *SYSAUX* As Part of a New Database

For a new database installation, the Database Configuration Assistant (DBCA) will automatically include a SYSAUX tablespace as one of the tablespaces created during the installation, and it will allow you to adjust the storage parameters just as the DBUA does. If you are creating a database from the command line, you can include the definition of the SYSAUX tablespace:

```
SQL> CREATE DATABASE
  2     DATAFILE '/u01/oradata/ord/system01.dbf' SIZE 250M
  3     SYSAUX DATAFILE '/u02/oradata/ord/sysaux01.dbf'
  4        SIZE 350M
  5     DEFAULT TEMPORARY TABLESPACE
  6       TEMP TEMPFILE '/u03/oradata/ord/temp01.dbf'
  7        SIZE 100M
  8     UNDO TABLESPACE UNDO1
  9       DATAFILE '/u04/oradata/ord/undo01.dbf'
 10        SIZE 100M;
```

If the SYSAUX tablespace definition is omitted in the CREATE DATABASE command, it is automatically created in the default tablespace location for the database, either $ORACLE_HOME/dbs on Unix or %ORACLE_HOME%\database on Windows.

Oracle recommends using the DBUA to upgrade a database from a previous version and the DBCA to create a new database.

Contents of the *SYSAUX* Tablespace

The dynamic performance view V$SYSAUX_OCCUPANTS provides not only the list of applications that use the SYSAUX tablespace but also the amount of space used by each application and the name of the schema that owns each application. The query that follows shows the contents of the SYSAUX tablespace:

```
SQL> select occupant_name, schema_name,
  2          space_usage_kbytes from v$sysaux_occupants;

OCCUPANT_NAME    SCHEMA_NAME          SPACE_USAGE_KBYTES
---------------- -------------------- ------------------
LOGMNR           SYSTEM                             7488
LOGSTDBY         SYSTEM                                0
STREAMS          SYS                                 192
AO               SYS                                 960
XSOQHIST         SYS                                 960
```

```
SM/AWR          SYS                       68352
SM/ADVISOR      SYS                        7360
SM/OPTSTAT      SYS                       21120
SM/OTHER        SYS                        3328
STATSPACK       PERFSTAT                      0
ODM             DMSYS                      5504
SDO             MDSYS                      6080
WM              WMSYS                      6656
ORDIM           ORDSYS                      512
ORDIM/PLUGINS   ORDPLUGINS                    0
ORDIM/SQLMM     SI_INFORMTN_SCHEMA           0
EM              SYSMAN                    61632
TEXT            CTXSYS                     4736
ULTRASEARCH     WKSYS                      7296
JOB_SCHEDULER   SYS                         256

20 rows selected.
```

The SPACE_USAGE_KBYTES column may indicate that an application needs to be moved to its own tablespace.

We will show you how to relocate an application from the SYSAUX tablespace in the next section.

The EM Database Control displays the contents and space usage of the SYSAUX tablespace in a more visual format, as you can see in Figure 4.1.

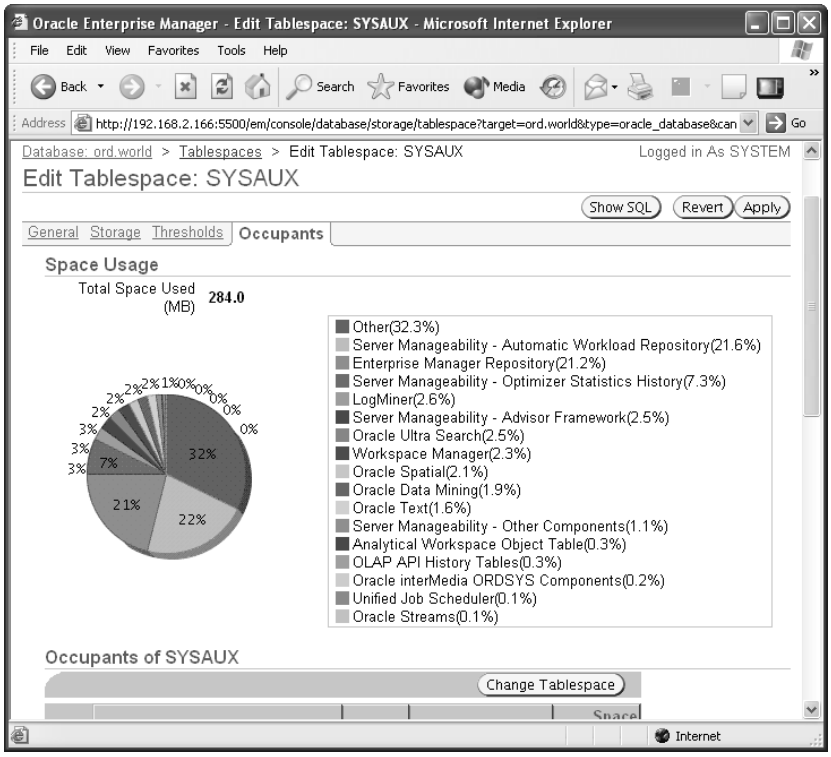
Relocating *SYSAUX* Occupants

In some environments, it may be necessary to move some of the occupants out of the SYSAUX tablespace.

In this example, while the LogMiner application metadata does not appear to be taking up a lot of space right now, you expect the usage to be heavy over the next six months; therefore you decide to create a dedicated tablespace for LogMiner.

```
SQL> create smallfile tablespace LOGMNR_REP
  2     datafile '/u06/oradata/ord/logmnr_rep01.dbf'
  3        size 10g
  4     autoextend on next 5g;
Tablespace created.
```

FIGURE 4.1 Viewing SYSAUX with the EM



Next, find the name of the procedure you can use to move the LogMiner Repository data out of the SYSAUX tablespace. Once again, query the dynamic performance view V$SYSAUX_OCCUPANTS:

```
SQL> select occupant_name, move_procedure from
  2     v$sysaux_occupants;

OCCUPANT_NAME    MOVE_PROCEDURE
---------------- ----------------------------------------
LOGMNR           SYS.DBMS_LOGMNR_D.SET_TABLESPACE
LOGSTDBY         SYS.DBMS_LOGSTDBY.SET_TABLESPACE
STREAMS
AO               DBMS_AW.MOVE_AWMETA
XSOQHIST         DBMS_XSOQ.OlapiMoveProc
```

```
SM/AWR
SM/ADVISOR
SM/OPTSTAT
SM/OTHER
STATSPACK
ODM             MOVE_ODM
SDO             MDSYS.MOVE_SDO
WM              DBMS_WM.move_proc
ORDIM
ORDIM/PLUGINS
ORDIM/SQLMM
EM              emd_maintenance.move_em_tblspc
TEXT            DRI_MOVE_CTXSYS
ULTRASEARCH     MOVE_WK
JOB_SCHEDULER

20 rows selected.
```

SYSAUX occupants without a value for MOVE_PROCEDURE in the view V$SYSAUX_OCCUPANTS cannot be moved out of the SYSAUX tablespace.

For LogMiner, use the procedure SYS.DBMS_LOGMNR_D.SET_TABLESPACE:

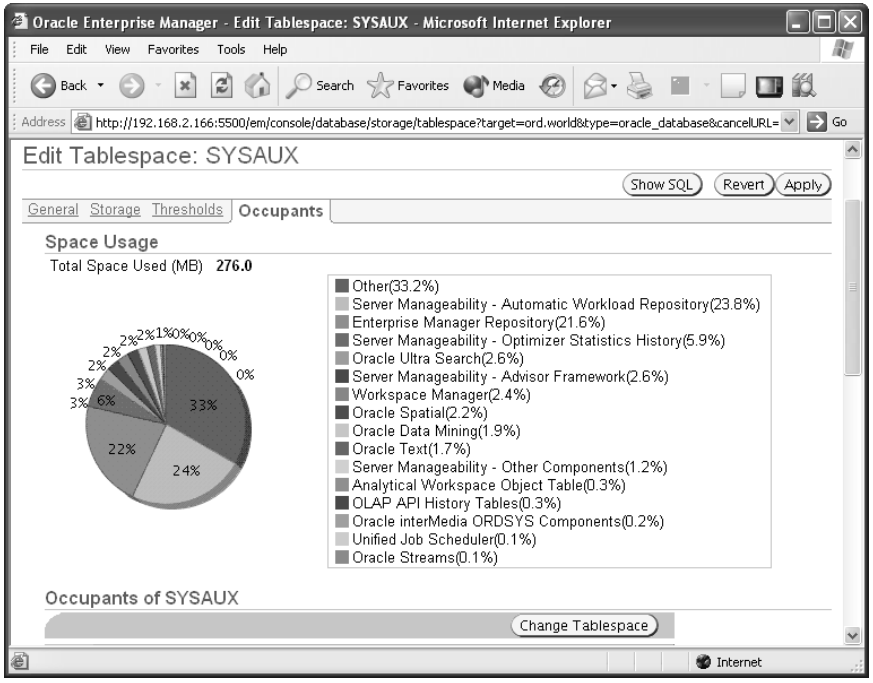
```
SQL> begin
  2     SYS.DBMS_LOGMNR_D.SET_TABLESPACE('logmnr_rep');
  3  end;

PL/SQL procedure successfully completed.
```

Checking V$SYSAUX_OCCUPANTS again, notice that LogMiner is still a resident.

```
SQL> select occupant_name, space_usage_kbytes
  2     from v$sysaux_occupants
  3  where occupant_name = 'LOGMNR';

OCCUPANT_NAME   MOVE_PROCEDURE
--------------- ---------------------------------------
LOGMNR          SYS.DBMS_LOGMNR_D.SET_TABLESPACE

1 row selected.
```

This is because you still need a row in V$SYSAUX_OCCUPANTS to indicate how you can move the application back into the SYSAUX tablespace at some future date. However, looking at the pie chart in EM Database Control, notice that the space usage for LogMiner, formerly using 2.6 percent of the SYSAUX tablespace, is no longer in the pie chart (see Figure 4.2).

FIGURE 4.2 SYSAUX occupants after a move operation



The V$SYSAUX_OCCUPANTS view confirms this.

```
SQL> select occupant_name, space_usage_kbytes
  2     from v$sysaux_occupants
  3  where occupant_name = 'LOGMNR';

OCCUPANT_NAME    SPACE_USAGE_KBYTES
---------------- ------------------
LOGMNR                           0

1 row selected.
```

Real World Scenario

SYSAUX: Dos and Don't

While the SYSAUX tablespace is similar in nature to any other locally managed tablespace with automatic segment space management, it has a few restrictions because of its close ties with the SYSTEM tablespace. Like any other tablespace, you can add datafiles to the SYSAUX tablespace if it is a smallfile tablespace:

```
SQL> ALTER TABLESPACE SYSAUX ADD
  2    DATAFILE '/u08/ordata/ord/sysaux02.dbf' SIZE 250M;
```

But you cannot perform a few actions on the SYSAUX tablespace while the database is open, such as the following:

```
SQL> ALTER TABLESPACE SYSAUX OFFLINE;
SQL> DROP TABLESPACE SYSAUX;
SQL> ALTER TABLESPACE SYSAUX RENAME TO SYSAUX00;
```

These operations may be required, however, if the database is in RESTRICTED mode during a maintenance or repair operation. If the SYSAUX tablespace is a bigfile tablespace—discussed in the following section—then the following command is valid:

```
SQL> ALTER TABLESPACE SYSAUX AUTOEXTEND ON;
```

Since a bigfile tablespace consists of one and only one datafile, the only option you have to expand the size of the tablespace is to extend the size of the single datafile.

Bigfile Tablespaces

One of the most significant changes to tablespace management in Oracle 10*g* is the introduction of *bigfile tablespaces*. A bigfile tablespace is a tablespace containing a single datafile that can be as large as 128 terabytes (TB), depending on the block size of the tablespace. In conjunction with setting the initialization parameter DB_FILES to the maximum value of 65,635, the total size of the database can be more than 8 exabytes (EB); in contrast, a database with smallfile tablespaces can only be 8 petabytes (PB) in size. In Table 1.1, you can see the maximum tablespace size for a bigfile tablespace given the block size.

In contrast, a *smallfile tablespace* is the name given to the type of tablespace available in previous releases of Oracle; it can still be created in Oracle 10*g*.

You can calculate the maximum amount of space (M) in a single Oracle database as the maximum number of datafiles (D) multiplied by the maximum number of blocks per datafile (F) multiplied by the tablespace block size (B): M = D * F * B. Therefore, the maximum database size, given the maximum block size and the maximum number of datafiles, is 65,535 datafiles * 4,294,967,296 blocks per datafile * 32,768 block size = 9,223,231,299,366,420,480 = 8EB.

TABLE 4.1 Maximum Tablespace Sizes

Tablespace Block Size	Maximum Tablespace Size
2K	8TB
4K	16TB
8K	32TB
16K	64TB
32K	128TB

In addition to expanding the size of the tablespace itself, the implementation of bigfile tablespaces means you never need to add datafiles to a tablespace. A bigfile tablespace has one and only one datafile. This simplifies the maintenance of a bigfile tablespace; operations that formerly were performed at the datafile level are now performed at the logical tablespace level. In conjunction with Oracle Managed Files (OMF) or Automatic Storage Management (ASM), you may never need to know the name of the tablespace's underlying datafile name.

We'll present several aspects of bigfile tablespaces so you can leverage their advantages in your terabyte database. First, we'll show you how to create and maintain a bigfile tablespace using new keywords in the `CREATE TABLESPACE` command. We'll also show you how the format of `ROWID`s changes when you use a bigfile tablespace. Finally, we'll go over the related changes to initialization parameters, data dictionary tables, and utilities for bigfile tablespaces.

Creating and Maintaining Bigfile Tablespaces

Bigfile tablespaces must be created as locally managed with automatic segment space management. While the default allocation policy for bigfile tablespaces is `AUTOALLOCATE`, you should consider changing the default to `UNIFORM` with a large extent size for situations where you know how big the table will be to start out with and how it will grow in the future. As with smallfile tablespaces, using `AUTOALLOCATE` is best for tablespaces whose table usage and growth patterns are indeterminate.

Creating a bigfile tablespace is identical to creating a traditional smallfile tablespace, with the addition of the `BIGFILE` keyword and the capability to specify the size of the tablespace in gigabytes (G) or terabytes (T).

```
SQL> create bigfile tablespace big_users
  2     datafile '/u09/oradata/ord/big_users.dbf'
  3     size 10g autoextend on;
```

By default, tablespaces are created as smallfile tablespaces; you can specify the default tablespace type when the database is created or at any time with the ALTER DATABASE command.

```
SQL> alter database set default bigfile tablespace;
```

When a bigfile tablespace is running out of room, you can change the size of the underlying datafile by resizing the tablespace to the desired size, like so:

```
SQL> alter tablespace big_users resize 20g;
```

Alternatively, you can turn on AUTOEXTEND so that the file will grow automatically depending on the value of the NEXT parameter when the tablespace was created, like so:

```
SQL> alter tablespace big_users autoextend on;
```

Managing *ROWID*s with Bigfile Tablespaces

Bigfile tablespaces have a slightly different format for extended ROWIDs of table rows. First, let's review the format for ROWIDs in previous versions of Oracle and for smallfile tablespaces in Oracle 10*g*.

The format for a smallfile ROWID consists of four parts: OOOOOO, FFF, BBBBBB, and RRR. Table 4.2 explains each part of the ROWID.

TABLE 4.2 Smallfile *ROWID* Piece Definitions

Smallfile ROWID Piece	**Definition**
OOOOOO	Data object numberidentifying the database segment (table, index, materialized view)
FFF	Relative datafile number within the tablespace of the datafile that contains the row
BBBBBB	The data block containing the row, relative to the data file
RRR	Slot number, or row number, of the row inside a block

A bigfile tablespace has only one datafile, so the relative data file number is always 1024 and therefore is not needed as part of the ROWID; instead, it is used to expand the block number to allow for a larger number of blocks in a data file and, as a result, a tablespace. The concatenation of the relative data file number (FFF) and the data block number (BBBBBB) results in a new construct called an *encoded block number*. Table 4.3 summarizes the pieces of a bigfile ROWID, which consists of three parts—OOOOOO, LLLLLLLLL, and RRR.

Because of the changes to the ROWID format, and the two different types of tablespaces that can exist in a database, some of the parameters have changed for procedures in the DBMS_ROWID package.

TABLE 4.3 Bigfile ROWID Piece Definitions

Bigfile ROWID Piece	Definition
OOOOOO	Data Object Number identifying the database segment (table, index, view)
LLLLLLLLL	Encoded block number, relative to the tablespace and unique within the tablespace
RRR	Slot number, or row number, of the row inside a block

In previous releases, DBMS_ROWID was not the only way to extract a ROWID from a table; in a bigfile tablespace, DBMS_ROWID is required to extract the correct ROWID.

The procedures within the DBMS_ROWID package operate much as before, except for a new parameter, TS_TYPE_IN, which identifies the type of tablespace to which a particular row belongs. The value of TS_TYPE_IN is either BIGFILE or SMALLFILE.

In the following example, you will extract the block number for a particular set of rows in a copy of the HR.EMPLOYEES table, which was recently moved to a bigfile tablespace:

```
SQL> select rowid,
  2     dbms_rowid.rowid_block_number(rowid,'BIGFILE')
  3        bigblock,
  4     employee_id, last_name from big_emp
  5  where employee_id < 110;

ROWID                BIGBLOCK EMPLOYEE_ID LAST_NAME
------------------ ---------- ----------- --------------
AAAMnfAAAAAAAAAUAAA         20         100 King
AAAMnfAAAAAAAAAUAAB         20         101 Kochhar
AAAMnfAAAAAAAAAUAAC         20         102 De Haan
AAAMnfAAAAAAAAAUAAD         20         103 Hunold
AAAMnfAAAAAAAAAUAAE         20         104 Ernst
AAAMnfAAAAAAAAAUAAF         20         105 Austin
AAAMnfAAAAAAAAAUAAG         20         106 Pataballa
AAAMnfAAAAAAAAAUAAH         20         107 Lorentz
AAAMnfAAAAAAAAAUAAI         20         108 Greenberg
AAAMnfAAAAAAAAAUAAJ         20         109 Faviet

10 rows selected.
```

Miscellaneous Bigfile Considerations

A number of other changes to initialization parameters and the data dictionary are related to bigfile tablespaces. We will cover these changes, along with some changes to DBVERIFY (one of Oracle's external utilities), in the next few sections.

Initialization Parameter Changes for Bigfile Tablespaces

No new initialization parameters or changes to existing parameters exist because of bigfile tablespaces; however, the values for two existing initialization parameters may be reduced because a bigfile tablespace needs only one datafile. These two parameters are as follows:

DB_FILES This is the maximum number of data files that can be opened for this database. If there are less data files to maintain, memory requirements are reduced in the System Global Area (SGA).

MAXDATAFILES When creating a new database or creating a new control file, this parameter specifies the size of the control file section allocated to maintain information about data files. Using bigfile tablespaces, the size of the control file is smaller.

Data Dictionary Changes for Bigfile Tablespaces

The data dictionary view DATABASE_PROPERTIES, which contains a number of other characteristics of the database, such as the database's NLS settings and the name of the default permanent and temporary tablespaces, has a property called DEFAULT_TBS_TYPE. This property indicates the default tablespace type for the database. Here is an example:

```
SQL> select property_name, property_value, description
  2        from database_properties
  3          where property_name = 'DEFAULT_TBS_TYPE';

PROPERTY_NAME     PROPERTY_VALUE   DESCRIPTION
----------------- ---------------- ----------------------
DEFAULT_TBS_TYPE  BIGFILE          Default tablespace type

1 row selected.
```

The data dictionary views USER_TABLESPACES and DBA_TABLESPACES, which show information about tablespaces in the database, both have a new column called BIGFILE. The value of the column is YES if the corresponding tablespace is a bigfile tablespace. The same column exists in the dynamic performance view V$TABLESPACE.

Using *DBVERIFY* with Bigfile Tablespaces

The DBVERIFY utility, available since Oracle 7.3, checks the integrity of an offline database; the files can be datafiles, online redo log files, or archived redo log files. DBVERIFY has been enhanced to analyze the datafile for a bigfile tablespace. In previous versions, several instances of DBVERIFY could simultaneously analyze individual datafiles. However, since a bigfile tablespace consists of a single datafile, you need a new way to analyze the datafile using multiple processes.

The DBVERIFY utility, initiated by the dbv command on all platforms, has two new parameters: START and END, representing the first and last block of the file to analyze. As a result, you must know how many blocks are in the datafile; you can use the dynamic performance view V$DATAFILE to obtain this information.

```
SQL> select file#, blocks, name from v$datafile;

     FILE#     BLOCKS NAME
---------- ---------- -----------------------------------
         1      58880 /u05/oradata/ord/system01.dbf
         2       3840 /u05/oradata/ord/undotbs01.dbf
         3      38400 /u05/oradata/ord/sysaux01.dbf
         4       1280 /u05/oradata/ord/users01.dbf
         5      19200 /u05/oradata/ord/example01.dbf
         6       1280 /u09/oradata/ord/oe_trans01.dbf
         7        640 /u05/oradata/ord/users02.dbf
         8       1280 /u06/oradata/ord/logmnr_rep01.dbf
         9       1280 /u09/oradata/ord/big_users.dbf

9 rows selected.
```

Suppose you want to analyze datafile #9, the datafile for the bigfile tablespace BIG_USERS. At the Unix command prompt, you can analyze the file with three parallel processes, operating on three different sections of the datafile.

```
$ dbv file=/u09/oradata/ord/big_users.dbf
                        start=1 end=500 &
[1] 11472
$ dbv file=/u09/oradata/ord/big_users.dbf
                        start=501 end=1000 &
[2] 11506
$ dbv file=/u09/oradata/ord/big_users.dbf
                        start=1001 &
[3] 11509
```

Note that if you do not specify the end= keyword in dbv, it is assumed that you will be analyzing the datafile all the way to the end of the datafile. All three instances of dbv run simultaneously. The output from all three commands would look similar to the following:

```
DBVERIFY: Release 10.1.0.2.0 - Production on ➥
Sun Mar 28 15:50:42 2004

Copyright (c) 1982, 2004, Oracle.  All rights reserved.
```

```
DBVERIFY - Verification starting : ➥
FILE = /u09/oradata/ord/big_users.dbf

DBVERIFY - Verification complete

Total Pages Examined         : 280
Total Pages Processed (Data) : 0
Total Pages Failing   (Data) : 0
Total Pages Processed (Index): 0
Total Pages Failing   (Index): 0
Total Pages Processed (Other): 0
Total Pages Processed (Seg)  : 0
Total Pages Failing   (Seg)  : 0
Total Pages Empty            : 280
Total Pages Marked Corrupt   : 0
Total Pages Influx           : 0
```

Temporary Tablespace Groups

In a nutshell, a *temporary tablespace group* is a shortcut or a synonym for a list of temporary tablespaces. A temporary tablespace group can have only temporary tablespaces as members.

A temporary tablespace group consists of at least one temporary tablespace; a temporary tablespace group cannot be empty. After the last member of a temporary tablespace group has been dropped, the temporary tablespace group no longer exists. The temporary tablespace group is created when the first temporary tablespace is added to the group.

Wherever a temporary tablespace can be referenced, a temporary tablespace group can be referenced as well. Therefore, because a temporary tablespace and a temporary tablespace group share the same namespace, a temporary tablespace cannot have the same name as a temporary tablespace group.

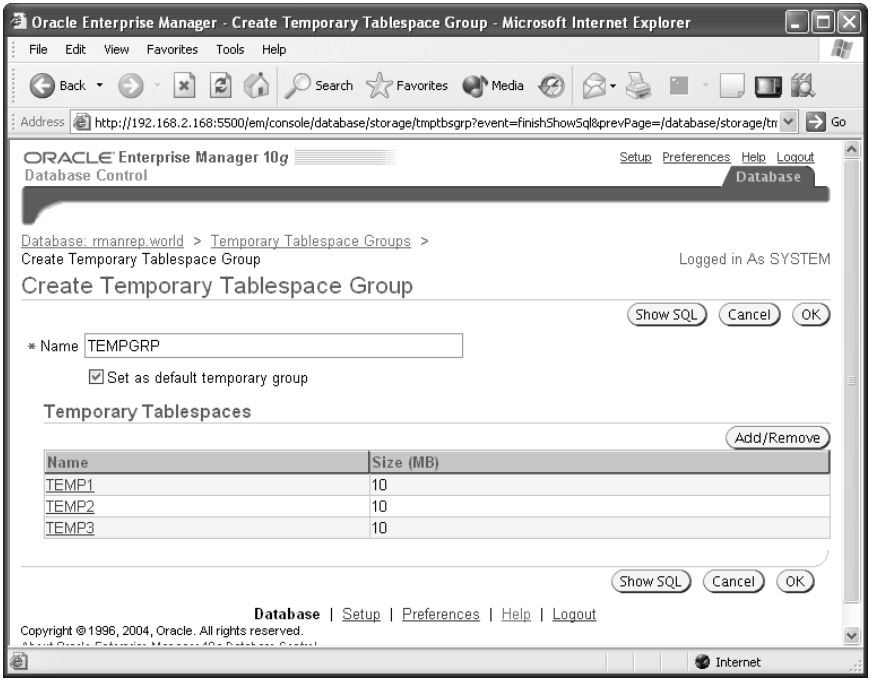
Temporary tablespaces allow a single user with multiple sessions to potentially use a different temporary tablespace in each session. Here is an example of how it works: The user SCOTT is assigned the temporary tablespace group TEMPGRP consisting of temporary tablespaces TEMP1, TEMP2, and TEMP3. The user SCOTT in session #1 may use the actual temporary tablespace TEMP1, and the user SCOTT in session #2 may use the actual temporary tablespace TEMP3. Not only does this prevent large tablespace operations from running out of temporary space, it also allows parallel operations within a single session to potentially use more than one actual temporary tablespace, even though in all the previous scenarios, SCOTT was assigned the TEMPGRP temporary tablespace group. Logically, the same temporary tablespace was used in every session.

In the following sections, we will show you how to create and drop temporary tablespace groups, as well as assigning these groups to users. In addition, we will show the data dictionary views used with temporary tablespaces.

Creating and Dropping Temporary Tablespace Groups

You can use EM Database Control to create temporary tablespace groups, as demonstrated in Figure 4.3.

FIGURE 4.3 Creating temporary tablespace groups using EM Database Control



The equivalent command-line version looks like this:

```
alter tablespace temp1 tablespace group tempgrp;
alter tablespace temp2 tablespace group tempgrp;
alter tablespace temp3 tablespace group tempgrp;
alter database default temporary tablespace tempgrp;
```

Note that along with creating a new temporary tablespace group, you are making the group the default temporary tablespace for the database. You cannot drop the tablespace group unless you change the default temporary tablespace first. You can, however, drop one of the members of the group.

```
SQL> alter tablespace temp3 tablespace group '';

Tablespace altered.
```

When you create a temporary tablespace, you can immediately add it to an existing group, or create a new group with one member as in the following example:

```
SQL> create temporary tablespace temp6
  2       tempfile '/u08/oradata/ord/temp6.dbf'
  3       size 10m
  4       tablespace group tempgrp2;

     Tablespace created.
```

If the group TEMPGRP2 did not exist before creating the TEMP6 tablespace, it is created, otherwise TEMP6 is added to the group. You can also create a temporary tablespace and explicitly assign it to no group using this command:

```
SQL> create temporary tablespace temp7
  2       tempfile '/u08/oradata/ord/temp7.dbf'
  3       size 10m
  4       tablespace group '';

Tablespace created.
```

Assigning Temporary Tablespace Groups to Users

Assigning a temporary tablespace group to a user is identical to assigning a temporary tablespace to a user. The assignment can take place either when the user is created or afterward.

In the following example, you will create a new user OLIVERT with a default permanent tablespace of USERS and a temporary tablespace group of TEMPGRP:

```
SQL> create user olivert identified by wist
  2    default tablespace users
  3    temporary tablespace tempgrp;

User created.
```

Note that if you did not specify a temporary tablespace for OLIVERT, the user would still be assigned TEMPGRP as the temporary tablespace, since it is the default for the database.

Suppose you also want to change the temporary tablespace for SCOTT, so you run the following command:

```
SQL> alter user scott temporary tablespace tempgrp;
```

Tablespace Groups Data Dictionary Views

The views ALL_USERS, USER_USERS, and DBA_USERS still have the column TEMPORARY_TABLESPACE, as in previous versions of Oracle. This column, however, will now contain either the name of the temporary tablespace assigned to the user or the name of a temporary tablespace group.

The new view DBA_TABLESPACE_GROUPS shows the members of each temporary tablespace group.

```
SQL> select group_name, tablespace_name ➥
from dba_tablespace_groups;

GROUP_NAME                     TABLESPACE_NAME
------------------------------ -------------------------
TEMPGRP                        TEMP1
TEMPGRP                        TEMP2
TEMPGRP                        TEMP3

3 rows selected.
```

Other Tablespace Enhancements

A number of other tablespace enhancements can ease your administrative efforts, especially when tablespaces are transported between databases. In addition, you can specify a default permanent tablespace; in previous releases of Oracle, the SYSTEM tablespace was assigned as the user's permanent tablespace if a tablespace was not explicitly assigned when the user was created. You will look at each of these enhancements in the following sections.

Renaming Tablespaces

As transportable tablespaces become more common, so does the potential for naming conflicts. For instance, in previous versions of Oracle, if the target database already had a tablespace called USERS and you wanted to plug in a tablespace named USERS from a different database, the only option available was to create a new tablespace in the source or target database, copy the objects to the new tablespace, and drop the original tablespace.

Oracle 10*g* allows you to rename either one of the tablespaces before unplugging from one database and plugging into another. In the following example, we are renaming the tablespace BIG_USERS to USERS2:

```
SQL> alter tablespace big_users rename to users2;
Tablespace altered.
```

If you are not using OMF to automatically name datafiles, do not rely on naming conventions for datafiles; after a tablespace renaming operation, the name of the datafile may no longer reflect the name of the tablespace containing the datafile.

After the tablespace is renamed, all references to the tablespace name are updated in the data dictionary, control file, and the online datafile headers for the tablespace's datafiles. If you are using an SPFILE to maintain your initialization parameters, all references to the renamed tablespace are updated. If you are still using a text-based initialization parameter file, a message is recorded in the alert log that reminds you to update the initialization file manually.

Of course, a few restrictions exist for tablespace renaming. The SYSTEM and SYSAUX tablespaces cannot be renamed. If any datafile in the tablespace is offline, or if the entire tablespace is offline, the tablespace cannot be renamed. While you can rename a tablespace that is READ ONLY, the datafile headers are not updated until the tablespace is READ WRITE.

Creating a Default Permanent Tablespace

In previous releases of Oracle, the SYSTEM tablespace was designated as the default permanent tablespace if no permanent tablespace was specified in the CREATE USER command. Since you want to reduce the contention as much as possible on the SYSTEM tablespace, it is a bad idea to store user objects in the SYSTEM tablespace. You could specify a default temporary tablespace in Oracle 9*i*, but now in Oracle 10*g* you can specify a *default permanent tablespace*.

You can define the default permanent tablespace in the CREATE DATABASE command or later using ALTER DATABASE.

In the following example, we are changing the default permanent tablespace to the USERS2 tablespace:

```
SQL> alter database default tablespace users2;
Database altered.
```

Similar to how temporary tablespaces are assigned, all users who are not specifically assigned a default permanent tablespace will now use the USERS2 tablespace for permanent objects. The data dictionary view DATABASE_PROPERTIES reflects this new assignment.

```
SQL> select property_name, property_value, description
  2       from database_properties
  3         where property_name =
  4             'DEFAULT_PERMANENT_TABLESPACE';

PROPERTY_NAME     PROPERTY_VALUE  DESCRIPTION
----------------- --------------- --------------------
DEFAULT_PERMANENT USERS2          Name of default
_TABLESPACE                       permanent tablespace

1 row selected.
```

Using the DBCA to create a database, the USERS tablespace is automatically designated as the default permanent tablespace.

The default permanent tablespace does not apply to system users, such as SYS, SYSTEM, and OUTLN; their default tablespace is still SYSTEM. In addition, a tablespace that has been designated as the default permanent tablespace cannot be dropped until a new tablespace has been designated as the default permanent tablespace.

Copying Tablespaces Using the Database Server

As an added convenience to you, and to make application development more seamless by reducing the number of interfaces required to accomplish a given task, Oracle 10*g* now supports copying binary files between directories on the same server or between a remote server and a local server. The package DBMS_FILE_TRANSFER contains three procedures to accomplish these features. Table 4.4 lists the procedures available in DBMS_FILE_TRANSFER.

TABLE 4.4 *DBMS_FILE_TRANSFER* Procedures

Procedure	Description
COPY_FILE	Reads a local file and creates a copy of the file on the local file system; this is the same file system containing the database files.
PUT_FILE	Reads a local file, authenticates with a remote database using a database link, and creates a copy of the file in the remote file system.
GET_FILE	Authenticates with a remote database using a database link to copy a file on the remote file system to the local file system.

While the package DBMS_FILE_TRANSFER is primarily intended to copy Data Pump dump sets and tablespace files between databases, it can be used for any type of file as long as it is a binary file, the file size is a multiple of 512 bytes, and it is no larger than 2TB.

In the next few sections, we will describe how each of the DBMS_FILE_TRANSFER procedures work.

COPY_FILE

The COPY_FILE procedure takes four arguments, as listed in Table 4.5.

The user executing the COPY_FILE procedure must have read permissions in the source directory and write permissions in the destination directory.

In the following example, your goal is to move the datafiles for the EXAMPLE tablespace to a different file system on the server. To accomplish this, you will create two new directories, take the tablespace offline, copy the datafile to the destination directory, change the name of the underlying datafile in the control file, and bring the tablespace back online. To clean up after yourself, you will use UTL_FILE.FREMOVE to remove the original copy of the file.

TABLE 4.5 *COPY_FILE* Parameters

Parameter	Description
source_directory_object	The Oracle directory object from which the binary file will be copied on the local file system.
source_file_name	The name of the file in the local file system in the Oracle directory specified by the first argument.
destination_directory_object	The Oracle directory object into which the binary file will be copied.
destination_file_name	The name of the file in the destination directory; this may or may not be the same as source_file_name, but this file must not already exist in the destination directory.

Here is what you would do to accomplish this:

```
SQL> alter tablespace example offline;
Tablespace altered.

SQL> create directory src_dir as '/u05/oradata/ord';
Directory created.

SQL> create directory tgt_dir as '/u09/oradata/ord';
Directory created.

SQL> begin
  2     dbms_file_transfer.copy_file(
  3          source_directory_object => 'SRC_DIR',
  4          source_file_name => 'example01.dbf',
  5          destination_directory_object => 'TGT_DIR',
  6          destination_file_name => 'example01.dbf');
  7  end;
PL/SQL procedure successfully completed.

SQL> alter database rename file
  2       '/u05/oradata/ord/example01.dbf' to
  3       '/u09/oradata/ord/example01.dbf';
Database altered.

SQL> alter tablespace example online;
```

```
Tablespace altered.

SQL> begin
  2     utl_file.fremove (
  3        location     => 'SRC_DIR',
  4        filename     => 'example01.dbf');
  5  end;
PL/SQL procedure successfully completed.

SQL> ! ls -l /u09/oradata/ord/example*.*
-rw-r-----    1 oracle   oinstall 209723392
          Jul 13 19:07 /u09/oradata/ord/example01.dbf

SQL> select d.name
  2    from v$datafile d join v$tablespace t using(ts#)
  3    where t.name = 'EXAMPLE';

NAME
----------------------------------------
/u09/oradata/ord/example01.dbf
/u06/oradata/example02.dbf

2 rows selected.
```

Notice the two steps at the end of the example: you should verify that the datafile has been actually copied, as well as verifying the copy by using V$DATAFILE.

As with all of the DBMS_FILE_TRANSFER procedures, you can monitor the progress of the file copy by querying the V$SESSION_LONGOPS dynamic performance view.

PUT_FILE

The PUT_FILE procedure is similar to the COPY_FILE procedure, except that the file is transferred to a file system outside the database file system, in other words, a file system on a different server. The PUT_FILE procedure takes five arguments, as listed in Table 4.6.

TABLE 4.6 *PUT_FILE* Parameters

Parameter	Description
source_directory_object	The Oracle directory object from which the binary file will be copied on the local file system.
source_file_name	The name of the file in the local file system in the Oracle directory specified by the first argument.

TABLE 4.6 *PUT_FILE* Parameters *(continued)*

Parameter	Description
`destination_directory_object`	The name of the Oracle directory object in the remote file system into which the binary file will be copied. This directory object must resolve to a valid pathname in the target database's file system.
`destination_file_name`	The name of the file in the destination directory; this may or may not be the same as `source_file_name`, but this file must not already exist in the destination directory.
`destination_database`	The name of a database link to the remote database through which the file is copied to the remote file system.

The user executing the `PUT_FILE` procedure must have read permissions in the source directory, and the connected user defined in the database link must have write permissions in the destination directory. Also, the destination file name must not already exist.

GET_FILE

The `GET_FILE` procedure performs the copy in the opposite direction as `PUT_FILE`; it copies the file from the remote file system to the local file system. The `GET_FILE` procedure takes five arguments, as listed in Table 4.7.

TABLE 4.7 *GET_FILE* Parameters

Parameter	Description
`source_directory_object`	The Oracle directory object from which the binary file will be copied on the remote file system.
`source_file_name`	The name of the file in the remote file system in the Oracle directory specified by the first argument.
`source_database`	The name of a database link to the remote database from which the file is copied to the remote file system.
`destination_directory_object`	The name of the Oracle directory object in the local file system into which the binary file will be copied. This directory object must resolve to a valid pathname in the local database's file system.
`destination_file_name`	The name of the file in the destination directory of the local file system; this may or may not be the same as `source_file_name`, but this file must not already exist in the destination directory.

The parameters are the same as for PUT_FILE, just in a different order, reflecting the different direction of the file copy.

Making Partitioning Enhancements

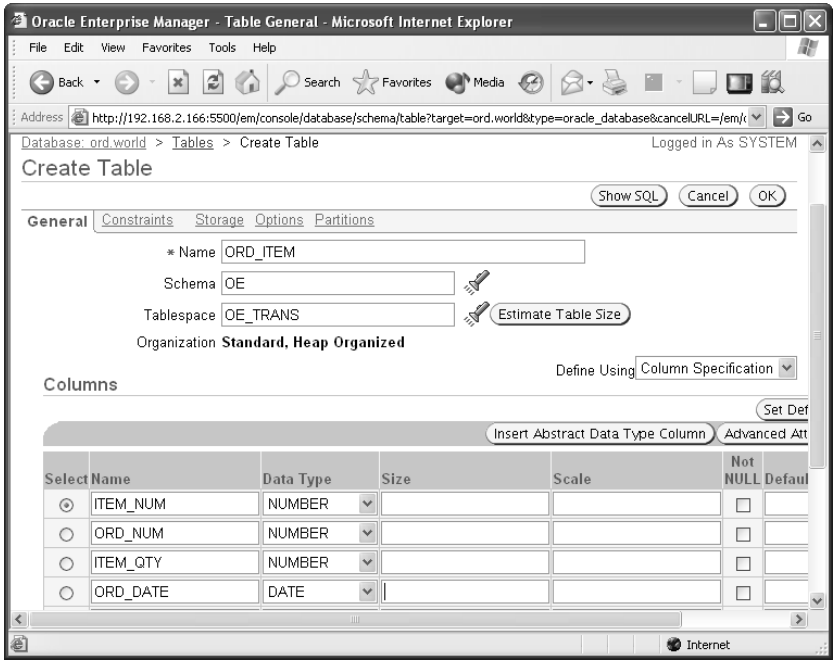
Partitioned tables, available since Oracle 8, have been incrementally enhanced in every version of Oracle including the current version. As with most other database features, partition maintenance is enhanced by the web-based EM Database Control, with wizards and other tips to help you perform the partitioning tasks quickly and accurately.

In addition, IOTs have been enhanced to allow a number of new partitioning options, including list-partitioned IOTs and more robust global index maintenance for partitioned IOTs. We will discuss both of these enhancements in further detail in the next couple of sections.

Partition Maintenance Using EM Database Control

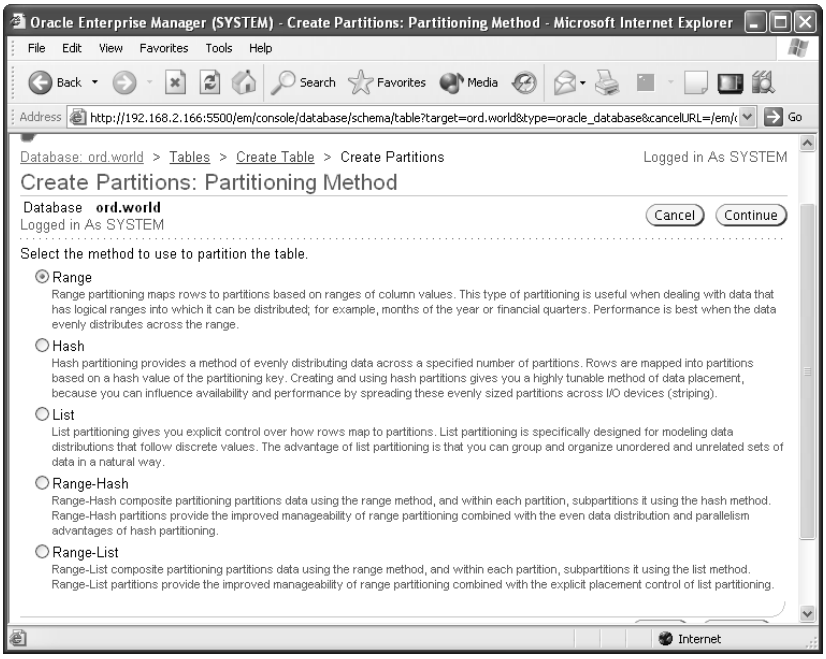
Creating and maintaining partitioned tables using EM Database Control saves you both time and the potential for errors when working with table and index partitions. In Figure 4.4, you can start the process of creating the ORD_ITEM table to support a new order entry system. On this screen, you specify the table name, the schema where it will reside, and the tablespace. You also specify the names, types, and sizes of the columns.

FIGURE 4.4 Creating a table using EM Database Control



Once you have the columns defined, you can define the constraints, storage requirements, and other options, including a partitioning scheme. From the screen shown in Figure 4.4, click the Partitions tab to specify the partitioning method for this table, as shown in Figure 4.5.

FIGURE 4.5 Partitioning methods using EM Database Control



In this particular example, you will choose range partitioning, since you will use the `ORD_DATE` column to put the rows into a specific partition.

Once a partition table has been created, it is easy to maintain the partitioned table using EM Database Control. In Figure 4.6 you can see all the partitions for the table `SH.COSTS` along with the partitioning method and the columns used to partition the table.

To edit the characteristics of a partition, or even to truncate a partition, select the partition and click Advanced Options. Figure 4.7 shows an example of how you can edit some of the advanced storage options for the `COSTS_Q2_1998` partition of the `SH.COSTS` table.

Partitioned Index Organized Tables (IOTs)

In previous releases of Oracle, the partitioning capabilities of IOTs lagged behind the partitioning capabilities of the other table types. Oracle 10*g* has remedied many of these deficiencies, as you will see in the following paragraphs.

List-partitioned IOTs are now fully supported. In Oracle 9*i*, IOTs used either range or hash partitioning, but not list partitioning. Furthermore, the partitioning columns had to be a subset of the primary key columns. In Oracle 10*g*, IOTs can be partitioned by any column.

FIGURE 4.6 Partition maintenance using EM Database Control

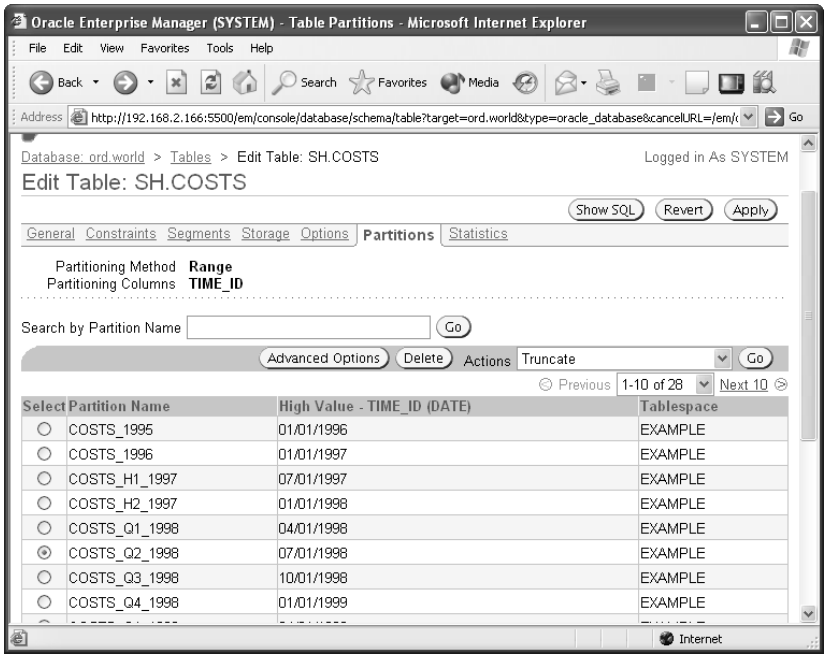
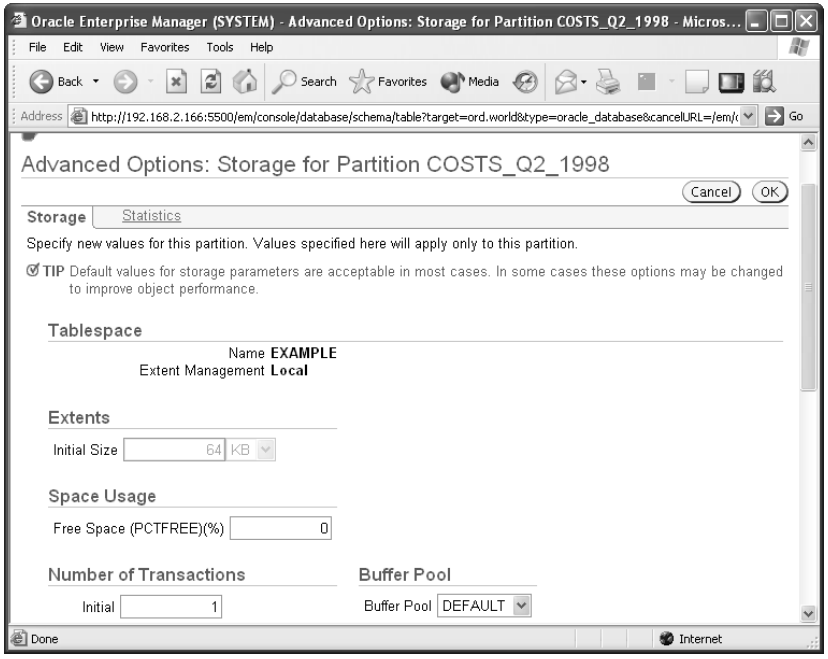


FIGURE 4.7 Advanced partition options using EM Database Control



In previous versions, global indexes were not maintained for most IOT maintenance operations. Global indexes became unusable after dropping, truncating, or exchanging a partition. While other partition maintenance operations such as moving, splitting, or merging partitions did not invalidate the global indexes, performance was degraded because the Guess-Data Block Access (Guess-DBA) values became inaccurate over time, requiring a primary key lookup to locate the actual row in the IOT. While the command `ALTER INDEX ... UPDATE BLOCK REFERENCES` fixed the problems with the Guess-DBAs, this command had to be run after every move, split, or merge partition maintenance operation. In Oracle 10*g*, the block references are kept up-to-date automatically when any partition maintenance operation occurs.

Local partitioned bitmap indexes are now available for IOTs if a mapping table is created. Mapping tables are heap organized, and they map local-to-physical `ROWID`s for an IOT. The mapping table is partitioned with the same name and physical attributes of the IOT partitions. In previous versions of Oracle, mapping tables were only available for nonpartitioned IOTs.

Finally, LOB columns are supported for IOTs partitioned by any method. Previously, LOBs were supported only in range-partitioned IOTs.

Local-Partitioned Index Enhancements

Improvements in Oracle 10*g* maintain local-partitioned indexes when you use partition DDL commands such as the following:

- `ADD PARTITION`
- `SPLIT PARTITION`
- `MERGE PARTITION`
- `MOVE PARTITION`

In addition, the associated indexes no longer have to be stored in the same tablespace as the table.

In the following example, we are merging two of the partitions in the `SH.COSTS` table, maintaining the local indexes, and relocating the index into the `USERS2` tablespace:

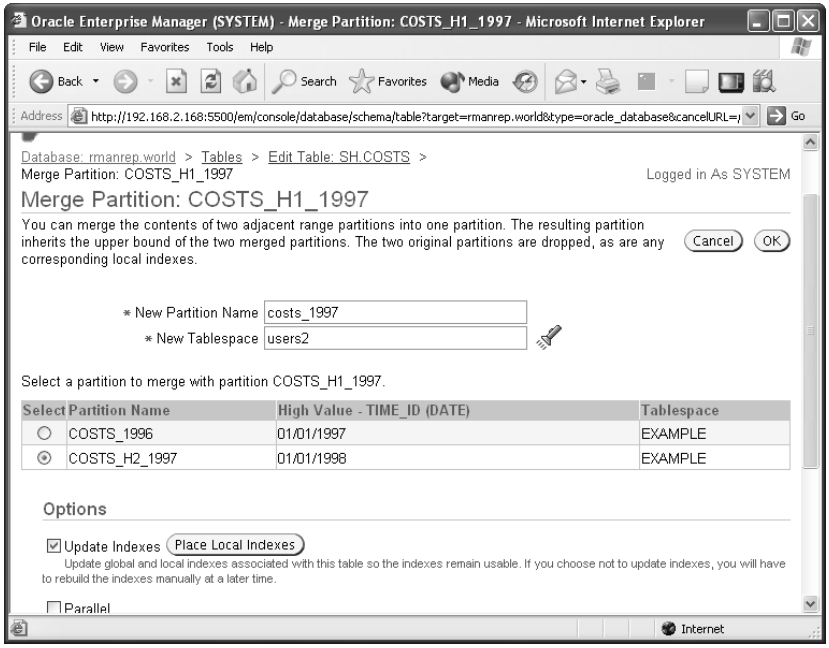
```
SQL> alter table sh.costs
  2     merge partitions costs_h1_1997, costs_h2_1997
  3          into partition costs_1997
  4     update indexes (
  5         sh.costs_prod_bix
  6            (partition costs_1997 tablespace users2),
  7         sh.costs_time_bix
  8            (partition costs_1997 tablespace users2));

Table altered.
```

Looking at the data dictionary view DBA_IND_PARTITIONS, you can see that the index partition is still valid.

```
SQL> select index_name, partition_name,
 2     tablespace_name, status
 3  from dba_ind_partitions
 4  where index_name = 'COSTS_PROD_BIX';

INDEX_NAME      PARTITION_NAME  TABLESPACE_NAME   STATUS
--------------- --------------- ----------------- --------
COSTS_PROD_BIX  COSTS_1995      EXAMPLE           USABLE
COSTS_PROD_BIX  COSTS_1996      EXAMPLE           USABLE
COSTS_PROD_BIX  COSTS_1997      USERS2            USABLE
COSTS_PROD_BIX  COSTS_Q1_1998   EXAMPLE           USABLE
. . .
COSTS_PROD_BIX  COSTS_Q4_2003   EXAMPLE           USABLE

27 rows selected.
```

As with most every other enhancement in Oracle 10*g*, this operation is also available via EM Database Control, as you can see in Figure 4.8.

FIGURE 4.8 Merging partitions using EM Database Control



Leveraging Index Enhancements

The enhancements to indexes in Oracle 10*g* improve both the availability and the performance of global indexes. Invalid global partition indexes can be skipped instead of generating an ORA- message; new clauses in the index maintenance commands can prevent the global indexes from becoming invalid in the first place.

In the following sections, we will also discuss how hash-partitioned global indexes can improve query processing times by increasing the number of parallel processes that can access each partition in a hash-partitioned index. In addition, a hash-partitioned global index can further reduce hotspots in global indexes by spreading the creation of new index leaf nodes among all partitions in the index.

Bitmap indexes have also been improved in Oracle 10*g*, with major improvements in performance because of reduced fragmentation of bitmap indexes in environments with heavy DML activity.

Skipping Unusable Indexes

In previous versions of Oracle, when an index partition became unusable because of partition maintenance commands such as `ADD PARTITION`, `SPLIT PARTITION`, `MERGE PARTITION`, or `MOVE PARTITION`, any SQL `SELECT` statements that attempted to use the unusable index returned an ORA-01502 "index '*schema.indexname*' or partition of such index is in unusable state" error message. At the session level, the user was able to direct the optimizer to skip the unusable index by issuing this command:

```
SQL> alter session set skip_unusable_indexes = true;
Session altered.
```

This parameter was also modifiable at the system level, but it was not dynamic. In Oracle 10*g*, this parameter is not only dynamic but defaults to `TRUE` at both the system level and the session level. The optimizer automatically skips any unusable indexes when constructing a query plan.

While setting `SKIP_UNUSABLE_INDEXES` can avoid ORA-01502 errors, and the query still runs, the optimizer may choose a suboptimal execution plan since one of the indexes is not available. To monitor the database for unusable indexes, you should monitor the data dictionary view `DBA_IND_PARTITIONS` for invalid indexes; in addition, the alert log records an event when a local index partition becomes invalid. In addition, a user can reanalyze the query with `EXPLAIN PLAN` to see if an index is suddenly unavailable and rebuild the relevant indexes.

Maintaining Index Partition Storage Characteristics

Range-partitioned global indexes are no longer the only type of global indexes available in Oracle 10*g*. *Hash-partitioned global indexes* add new DDL options for partition maintenance,

along with increased availability and performance, by eliminating index hotspots in heavy OLTP environments. Both `ADD PARTITION` and `COALESCE PARTITION` are available for both range-partitioned and hash-partitioned global indexes.

Range-partitioned global indexes can cause a performance issue during `INSERT` operations whose inserted rows contain a primary key generated from an Oracle sequence; this creates a hotspot in a small number of index leaf blocks in one of the index partitions. While using a reverse-key global index alleviates this problem somewhat using range partitioning, the problem is alleviated in only one index partition. Using hash-partitioned global indexes, the index entries are spread out not only to different leaf nodes within an index partition but also to different partitions.

In the next few sections, we'll review the typical maintenance activities you'd perform on any index: creating and maintaining hash-partitioned global indexes. We'll also show how you can leverage the parallel processing advantages of hash-partitioned global indexes.

Creating Hash-Partitioned Global Indexes

Creating a hash-partitioned index is just as easy as creating a range-partitioned index; in fact, you have two different ways to create the index. In the `CREATE INDEX` command, you can specify the name of each partition individually with the associated tablespace, or you can specify the number of partitions and the list of the partitions. A couple of examples will demonstrate the two different syntax options.

In the first example, we will create a global hash-partitioned index on the `HIRE_DATE` column of the `HR.EMPLOYEES` table, naming each partition and associating the partition with a tablespace to store the index partition.

```
SQL> create index emp_id_ix2 on hr.employees(hire_date)
  2       global partition by hash(hire_date)
  3       (partition p1 tablespace idx_1,
  4        partition p2 tablespace idx_2,
  5        partition p3 tablespace idx_3,
  6        partition p4 tablespace idx_4,
  7        partition p5 tablespace idx_5);

Index created.
```

Alternatively, you can create the index more easily if you do not need to assign partition names.

```
SQL> create index emp_id_ix2 on hr.employees(hire_date)
  2       global partition by hash(hire_date)
  3       partitions 5
  4       store in (idx_1, idx_2, idx_3, idx_4, idx_5);

Index created.
```

The data dictionary table DBA_IND_PARTITIONS reveals how Oracle automatically assigns names to the partitions using the second format.

```
SQL> select index_name, partition_name,
  2      tablespace_name, status
  3  from dba_ind_partitions
  4  where index_name = 'EMP_ID_IX2';

INDEX_NAME   PARTITION_NAME   TABLESPACE_NAME   STATUS
------------ ---------------- ----------------- --------
EMP_ID_IX2   SYS_P185         IDX_1             USABLE
EMP_ID_IX2   SYS_P186         IDX_2             USABLE
EMP_ID_IX2   SYS_P187         IDX_3             USABLE
EMP_ID_IX2   SYS_P188         IDX_4             USABLE
EMP_ID_IX2   SYS_P189         IDX_5             USABLE

5 rows selected.
```

Using EM Database Control, creating hash-partitioned indexes is even easier. Figure 4.9 shows how you can create a hash-partitioned global index using the first method.

When you click on the Show SQL button, you can see the SQL command that will be executed to create the new index as follows:

```
CREATE INDEX "SYS"."EMP_ID_IX2" ON "HR"."EMPLOYEES" ("HIRE_DATE")
TABLESPACE "USERS" PCTFREE 10 INITRANS 2 MAXTRANS 255
STORAGE ( FREELISTS 1 FREELIST GROUPS 1
          BUFFER_POOL DEFAULT) NOLOGGING
GLOBAL PARTITION BY HASH ("HIRE_DATE")
(PARTITION "EMP_ID_IX2_P1" TABLESPACE "IDX_1",
 PARTITION "EMP_ID_IX2_P2" TABLESPACE "IDX_2",
 PARTITION "EMP_ID_IX2_P3" TABLESPACE "IDX_3",
 PARTITION "EMP_ID_IX2_P4" TABLESPACE "IDX_4",
 PARTITION "EMP_ID_IX2_P5" TABLESPACE "IDX_5")
```

Maintaining Hash-Partitioned Global Indexes

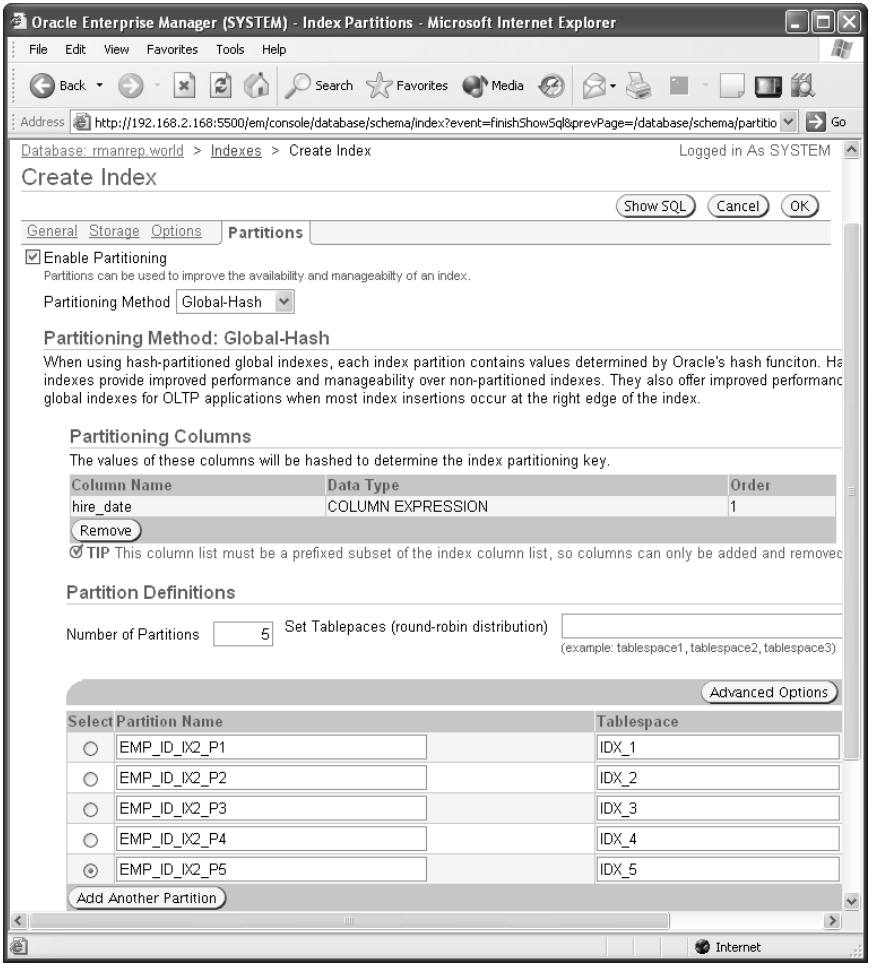
As with other types of partitions, you can use ADD PARTITION to create additional partitions to a hash-partitioned global index, or you can remove partitions by using COALESCE PARTITION.

Following the example from the previous section, suppose you have a global hash-partitioned index on the HIRE_DATE column with five partitions defined. Oracle recommends that the number of partitions be a power of two to more evenly spread the index entries among the partitions;

as a result, you will want to either drop the partitions back down to four (2^2) or increase it to eight (2^3). In the first attempt, we will try to optimize the performance of the index by using the COALESCE PARTITION option to redistribute the contents of one of the partitions to the remaining partitions and drop the partition.

```
SQL> alter index emp_id_ix2 coalesce partition;

Index altered.
```

FIGURE 4.9 Using EM Database Control to create global indexes



Oracle chooses which index partition is the best candidate, redistributes its contents to the remaining partitions, and drops the partition. Looking at the DBA_IND_PARTITIONS data dictionary view, you see that the index now has only four partitions

```
SQL> select index_name, partition_name,
  2     tablespace_name, status
  3  from dba_ind_partitions
  4  where index_name = 'EMP_ID_IX2';

INDEX_NAME    PARTITION_NAME    TABLESPACE_NAME  STATUS
------------- ----------------- ---------------- --------
EMP_ID_IX2    P1                IDX_1            USABLE
EMP_ID_IX2    P2                IDX_2            USABLE
EMP_ID_IX2    P3                IDX_3            USABLE
EMP_ID_IX2    P4                IDX_4            USABLE

4 rows selected.
```

After a few weeks, the performance of the index does not meet your service-level agreements, so you decide that it would be better to have eight partitions instead of four; therefore, you use the ADD PARTITION command four times.

```
SQL> alter index emp_id_ix2 add partition p5
  2    tablespace idx_5;
Index altered.
SQL> alter index emp_id_ix2 add partition p6
  2    tablespace idx_6;
Index altered.
SQL> alter index emp_id_ix2 add partition p7
  2    tablespace idx_7;
Index altered.
SQL> alter index emp_id_ix2 add partition p8
  2    tablespace idx_8;
Index altered.

SQL> select index_name, partition_name,
  2    tablespace_name, status
  3  from dba_ind_partitions
  4  where index_name = 'EMP_ID_IX2';
```

```
INDEX_NAME     PARTITION_NAME     TABLESPACE_NAME  STATUS
-------------- ------------------ ---------------- --------
EMP_ID_IX2     P1                 IDX_1            USABLE
EMP_ID_IX2     P2                 IDX_2            USABLE
EMP_ID_IX2     P3                 IDX_3            USABLE
EMP_ID_IX2     P4                 IDX_4            USABLE
EMP_ID_IX2     P5                 IDX_5            USABLE
EMP_ID_IX2     P6                 IDX_6            USABLE
EMP_ID_IX2     P7                 IDX_7            USABLE
EMP_ID_IX2     P8                 IDX_8            USABLE

8 rows selected.
```

In both cases, Oracle automatically redistributes and balances the index entries to maximize performance. Looking at the data dictionary view DBA_IND_PARTITIONS, you can see by the leaf block count that the index entries have been evenly distributed to all eight of the partitions:

```
SQL> select index_name, partition_name, leaf_blocks
  2     from dba_ind_partitions
  3  where index_name = 'EMP_ID_IX3';

INDEX_NAME             PARTITION_NAME         LEAF_BLOCKS
---------------------- ---------------------- -----------
EMP_ID_IX3             EMP_ID_IX3_P1                    2
EMP_ID_IX3             EMP_ID_IX3_P2                    2
EMP_ID_IX3             EMP_ID_IX3_P3                    2
EMP_ID_IX3             EMP_ID_IX3_P4                    2
EMP_ID_IX3             EMP_ID_IX3_P5                    2
EMP_ID_IX3             EMP_ID_IX3_P6                    2
EMP_ID_IX3             EMP_ID_IX3_P7                    2
EMP_ID_IX3             EMP_ID_IX3_P8                    2

8 rows selected.
```

As expected, a few operations available for range-partitioned indexes are not available for hash-partitioned global indexes, such as SPLIT INDEX PARTITION and MERGE INDEX PARTITION. Hash-partitioned indexes can be rebuilt but only on a partition-by-partition basis. The only modification you can make with ALTER INDEX MODIFY PARTITION is to manually mark the partition UNUSABLE.

Using Hash-Partitioned Global Indexes

Paradoxically, hash-partitioned indexes have another distinct advantage over range-partitioned indexes when performing parallel long-running queries with range predicates: While some of the partitions can be pruned given the range specified, the degree of parallelism is limited to the number of partitions in the index. For example, even if you specify a SELECT query with a degree of eight for a table with a global range-partitioned index containing only four partitions, the degree of parallelism is limited to four. With hash-partitioned global indexes, however, multiple parallel processes can access each pruned partition in the global index.

Using the earlier global partition example with eight index partitions, run the following query:

```
SQL> select /* parallel_index(emp,emp_id_ix2,16) */
  2     employee_id, email from employees emp
  3     where hire_date between '1-jan-1990' and '31-dec-2004';
```

Up to two parallel query processes will be assigned to each of the eight partitions in the EMP_ID_IX2 index.

Bitmap Index Storage Enhancements

Under certain DML situations, the performance of bitmap indexes may deteriorate over time, requiring a rebuild of the index. Improvements in Oracle 10*g* to the internal structure of bitmap indexes reduce the impact of frequent single-row DML operations against the table containing the bitmap index.

To take advantage of any of these improvements, the COMPATIBLE parameter must be set to 10.0.0.0 or greater. Some bitmap indexes that performed poorly before adjusting the COMPATIBLE parameter should be rebuilt; bitmap indexes that performed adequately before upgrading the COMPATIBLE parameter will enjoy some of the benefits of the new bitmap structure. Any new indexes created after the COMPATIBLE parameter is raised to 10.0.0.0 will take advantage of all improvements.

Ideally, all bitmap indexes created with lower COMPATIBLE values should eventually be rebuilt to take advantage of the new bitmap index functionality.

Summary

In this chapter we covered all the general storage enhancements in Oracle 10*g*. We started with the new SYSAUX tablespace: how it is created, either during a database upgrade or as part of a new database. We reviewed what applications use the SYSAUX tablespace and how the SYSAUX tablespace improves the performance of the database by taking some of the contention away from the SYSTEM tablespace. We showed you how to move some of the applications out of SYSAUX and into another tablespace when the SYSAUX tablespace itself gets too big. Finally, we provided some tips on how to manage the SYSAUX tablespace and some of its restrictions: While you can add datafiles to the SYSAUX tablespace, you cannot take it offline, you cannot rename it, and you cannot drop it.

Real World Scenario

Bitmap Index Performance

On one of our production Oracle servers, we maintain several databases containing the Enterprise Data Warehouse plus several data marts. Because of the inherent benefits of bitmap indexes in data warehouse environments, where typically there are few updates and many indexed columns in a star schema, most every column used in a join with low cardinality had a bitmap index. An earlier analysis revealed that, for some tables, using a tradition B-tree index would take almost as much disk space as the tables themselves!

A few weeks after the successful implementation of one of the data marts, some of the analysts started to complain that their queries were starting to run slowly, sometimes taking twice as long as they did a month earlier. However, the amount of data did not double in the last month, so some analysis was warranted.

As it turns out, one of the developers changed the load scripts so that some of the tables were being updated from the OLTP system in real time, instead of being updated at night in a batch run. As a result, the continual updates increased the size of the bitmap index dramatically and reduced the efficiency of the queries using the bitmap index.

Until the daily updates were turned off, we rebuilt the index nightly to address the performance issue. With the enhancements to bitmap index maintenance in Oracle 10*g*, we will be setting the `COMPATIBLE` parameter to 10.0.0.0, rebuilding the bitmap indexes in our data warehouse once, and we can reconsider turning the daily updates back on without affecting query performance.

Bigfile tablespaces provide a number of benefits to a busy DBA. Because a bigfile tablespace consists of only one datafile, the management of bigfile tablespaces moves from the datafile level to the tablespace level; in fact, many operations once reserved for datafiles can now be performed on bigfile tablespaces. Furthermore, we discussed how the `ROWID` format changes for bigfile tablespaces, along with the changes to the initialization parameters and data dictionary. Finally, we showed how several instances of the `DBVERIFY` utility can run in parallel to analyze different sections of a bigfile datafile.

Temporary tablespace groups improve the concurrency and performance of multiple sessions logged in with the same account, reducing the possibility that temporary sort operations may run out of temporary space. We reviewed how temporary tablespace groups are created and assigned to users; we also reviewed the data dictionary view related to temporary tablespace groups: `DBA_TABLESPACE_GROUPS`.

Various other tablespace enhancements can help save you time and potentially reduce the possibility of human error. Renaming tablespaces can save some of the extra steps required in previous versions of Oracle when the source and the target database have tablespaces with the same name. Specifying a default permanent tablespace is another enhancement to Oracle 10*g* that can prevent permanent objects from being created in the `SYSTEM` tablespace, further enhancing the reliability and response time for objects that must reside in the `SYSTEM` tablespace.

Finally, we reviewed one of the new packages available in Oracle 10*g*: DBMS_FILE_TRANSFER. The procedures COPY_FILE, PUT_FILE, and GET_FILE can copy binary files, usually tablespace datafiles and Data Pump files, between directories on the same server or between local and remote servers using a database link.

Partitioning support has been enhanced dramatically, for both tables and indexes. The partitioning capabilities of Index Organized Tables (IOTs) have been expanded to include list partitioning; in addition, local bitmap indexes are available for IOTs if a mapping table is created. LOB columns can be stored in IOTs partitioned by any method.

Index enhancements in Oracle 10*g* increase the availability of the database in a number of ways. The initialization parameter SKIP_UNUSABLE_INDEXES is now a dynamic parameter and performs the same function as in previous releases: to direct the optimizer to skip unusable index partitions and avoid ORA-01502 errors. Hash-partitioned global indexes go beyond the capabilities of range-partitioned global indexes by expanding the number of parallel query processes that can access an index partition in a SELECT query. Bitmap indexes are enhanced to prevent performance degradation because of frequent single-row DML statements against a table with a bitmap index.

Exam Essentials

Understand the purpose and usage of the SYSAUX tablespace. Be able to create a SYSAUX tablespace for both a new database and an upgrade to a database at a previous version of Oracle. Identify the contents of the SYSAUX tablespace, and be able to identify the procedure needed to move the contents of a particular application out of the SYSAUX tablespace.

Describe how bigfile tablespaces are created, maintained, and used. Know how to create a bigfile tablespace, and understand the differences in ROWID format between a smallfile and a bigfile tablespace. Be able to use DBVERIFY to check the validity of a bigfile datafile using parallel operating system processes.

Understand the concept of temporary tablespace groups and their performance and availability benefits. Describe how temporary tablespace groups are created, dropped, and assigned to users.

Enumerate the miscellaneous tablespace enhancements in Oracle 10*g*. Be able to rename a tablespace and define a default permanent tablespace.

Describe the new packages and procedures for tablespace maintenance. Understand how to use the DBMS_FILE_TRANSFER package to copy files between directories on the local server and between servers.

Understand the index enhancements in Oracle 10*g*. Be able to specify that unusable indexes should be skipped instead of generating an error message.

List the new data dictionary and dynamic performance views related to storage management. Identify the new columns in data dictionary views related to bigfile tablespaces, new rows in `DATABASE_PROPERTIES`, and new views identifying the members of temporary tablespace groups.

Be able to take advantage of partitioning enhancements for both IOTs and partitioned indexes. Create and maintain hash-partitioned indexes using both EM Database Control and SQL*Plus, as well as constructing parallel queries to take advantage of hash-partitioned global indexes.

Review Questions

1. Which of the following ALTER commands is supported for hash-partitioned indexes?
   - **A.** `ALTER INDEX REBUILD`
   - **B.** `ALTER INDEX MODIFY PARTITION`
   - **C.** `ALTER TABLE SPLIT INDEX PARTITION`
   - **D.** `ALTER TABLE MERGE INDEX PARTITIONS`
   - **E.** None of the above

2. Which of the following recommended practices should a DBA implement to take advantage of bitmap index storage enhancements? (Choose all that apply.)
   - **A.** Rebuilding all bitmap indexes manually after adjusting the `COMPATIBLE` parameter
   - **B.** Raising the `COMPATIBLE` parameter to at least 10.0.0.0
   - **C.** Considering rebuilding bitmap indexes when large volumes of single-row DML operations occur on a table
   - **D.** Rebuilding bitmap indexes that exhibit a slowdown after adjusting the `COMPATIBLE` parameter
   - **E.** Raising the `COMPATIBLE` parameter to at least 9.2.0.0

3. What is the maximum number of bytes that can be stored in a bigfile tablespace with a database block size of 16KB?
   - **A.** 8 exabytes
   - **B.** 8,000,000 terabytes
   - **C.** 8 petabytes
   - **D.** 64 terabytes

4. Which of the following commands creates a temporary tablespace group `TMPGRP1` and adds a temporary tablespace named `TMPMEMB1`? (Choose two.)
   - **A.** `CREATE TEMPORARY TABLESPACE GROUP TMPGRP1 MEMBERS (TMPMEMB1);`
   - **B.**
     ```
     ALTER TEMPORARY TABLESPACE GROUP TMPGRP1
       ADD TEMPORARY TABLESPACE TMPMEMB1
       TEMPFILE 'tmpmem1.dbf' SIZE 100M;
     ```
   - **C.** ALTER TABLESPACE TMPMEMB1 TABLESPACE GROUP TMPGRP1;
   - **D.**
     ```
     CREATE TEMPORARY TABLESPACE TMPMEMB1
       TEMPFILE 'tmpmem1.dbf' SIZE 100M
       TABLESPACE GROUP TMPGRP1;
     ```
   - **E.** None of the above

5. With a non-SYSTEM default permanent tablespace, which users still have SYSTEM as their default permanent tablespace? (Choose all that apply.)
   - **A.** SYSMAN
   - **B.** SYS
   - **C.** OUTLN
   - **D.** SYSTEM
   - **E.** DBSNMP
   - **F.** SCOTT

6. Which of the following statement(s) are not true about default permanent tablespaces?
   - **A.** The default permanent tablespace cannot be dropped until another tablespace is defined as the default permanent tablespace.
   - **B.** EM Database Control can be used to change the default permanent tablespace.
   - **C.** The Database Configuration Assistant defines the USERS tablespace as the default permanent tablespace.
   - **D.** In the CREATE DATABASE command, you use the DEFAULT PERMANENT TABLESPACE to assign the default permanent tablespace for users that are not otherwise assigned a default tablespace.
   - **E.** The data dictionary view DATABASE_PROPERTIES can be used to retrieve the name of the default permanent tablespace.

7. Which of the following applications can be moved out of the SYSAUX tablespace?
   - **A.** Automatic Workload Repository
   - **B.** Oracle Streams
   - **C.** StatsPack
   - **D.** Job Scheduler
   - **E.** LogMiner

8. Which data dictionary or dynamic performance view(s) indicates whether a tablespace is a bigfile or smallfile tablespace? (Choose all that apply.)
   - **A.** V$TABLESPACE
   - **B.** V$DATABASE
   - **C.** V$DATAFILE
   - **D.** DBA_TABLESPACES
   - **E.** DATABASE_PROPERTIES

9. Which of the following is not true about the initialization parameter SKIP_UNUSABLE_INDEXES?
   A. SKIP_UNUSABLE_INDEXES is a dynamic parameter.
   B. Even if set to TRUE, a user may still get ORA-01502 messages if UPDATE INDEXES was not specified in partition maintenance.
   C. The default value is TRUE at the session and system level.
   D. Even if set to TRUE, the optimizer may choose a suboptimal execution plan.
   E. The data dictionary view DBA_IND_PARTITIONS can be monitored to see if a local index partition has become invalid.

10. Identify the new partitioning method available for global indexes.
   A. Range partitioned
   B. Range-hash partitioned
   C. Hash partitioned
   D. List-hash partitioned

11. Identify the main differences between the procedures COPY_FILE and PUT_FILE in the DBMS_FILE_TRANSFER package. (Choose all that apply.)
   A. COPY_FILE copies a file to a destination on the same server, and PUT_FILE copies a file to a remote server.
   B. PUT_FILE copies a file to a destination on the same server, and COPY_FILE copies a file to a remote server.
   C. PUT_FILE can copy only binary files; COPY_FILE can copy binary and Unicode files.
   D. The PUT_FILE procedure requires a destination server name.

12. Which of the following operations is not supported for hash-partitioned global indexes?
   A. `DROP INDEX IX_ORD;`
   B. `ALTER INDEX IX_ORD REBUILD;`
   C. `ALTER INDEX IX_ORD UNUSABLE;`
   D. `ALTER INDEX IX_ORD MODIFY PARTITION IX_ORD_P1 UNUSABLE;`
   E. `ALTER INDEX IX_ORD REBUILD PARTITION IX_ORD_P2;`

13. Given the commands

```
CREATE TEMPORARY TABLESPACE PRDTTS1
TEMPFILE 'prdtts1.dbf' SIZE 100M
TABLESPACE GROUP PRDTMP;

CREATE TEMPORARY TABLESPACE PRDTTS2
TEMPFILE 'prdtts2.dbf' SIZE 100M
TABLESPACE GROUP PRDTMP;
```

which command does not assign the temporary tablespace group PRDTMP to a user?

A.
```
CREATE USER KELLYM IDENTIFIED BY TJPO
  DEFAULT TABLESPACE USERS
  TEMPORARY TABLESPACE PRDTMP;
```

B.
```
ALTER USER KELLYM TEMPORARY TABLESPACE GROUP PRDTMP;
```

C.
```
ALTER DATABASE DEFAULT TEMPORARY TABLESPACE PRDTMP;
```

D.
```
CREATE USER KELLYM IDENTIFIED BY TJPO
  TEMPORARY TABLESPACE PRDTMP;
```

14. Given a hash-partitioned global index `IX_ORD` on the table `ORD`, with four partitions, and the following `SELECT` statement:

```
SELECT /*+ PARALLEL_INDEX(ORD,IX_ORD,12) */
  ORDER_ID, ORDER_DATE FROM ORD
  WHERE ORDER_ID BETWEEN 110000 AND 190000;
```

which of the following is true about the number of processes used to execute the query?

A. Only one process is spawned since the index is hash-partitioned, and the `WHERE` clause uses a range.

B. After pruning the partitions down to those having the range of order IDs in the `WHERE` clause, the 12 processes are divided equally among the remaining partitions.

C. If the number of remaining partitions after pruning is fewer than 12, then not all 12 query processes are spawned; a maximum of one query process per partition is allowed for hash-partitioned global indexes.

D. The number of parallel query processes can only be a power of two, therefore, as many as 16 processes may be spawned.

15. Which of the following are true about renaming tablespaces? (Choose all that apply.)

A. Tablespaces that are `READ ONLY` cannot be renamed and must be changed to `READ WRITE` before renaming.

B. When a tablespace is renamed, all references to the tablespace name in the data dictionary, control file, online datafile headers, and initialization parameter files are updated.

C. You cannot rename the `SYSTEM` or `SYSAUX` tablespaces.

D. The tablespace must be online to be renamed.

E. Temporary tablespaces, undo tablespaces, and permanent tablespaces can be renamed.

16. Which of the following is a benefit of hash-partitioned global indexes?

A. Contention for the same index leaf blocks is reduced in an OLTP environment.

B. Indexes are smaller in a DSS environment because hash partitioning compresses duplicate entries for dimension keys in a star schema.

C. Hash-partitioned global indexes do not become invalid when partition maintenance occurs on the table partitions.

D. The application developer no longer needs to use a reverse-key index to optimize the updates to the index.

17. Identify the way(s) a DBA can find out if a suboptimal execution plan is being used for a query because a local partitioned index has become invalid and the `SKIP_UNUSABLE_INDEXES` parameter is set to `TRUE`. (Choose all that apply.)

A. Monitoring the data dictionary view `DBA_IND_PARTITIONS` for invalid indexes

B. Monitoring the alert log

C. Using `EXPLAIN PLAN` to preview the execution plan used for all queries

D. Monitoring user trace files

E. All of the above

18. Under which of the following conditions is the tablespace `SYSAUX` created? (Choose all that apply.)

A. When the database is created

B. When you need to use features such as Ultra Search or the EM Repository

C. When the `SYSTEM` tablespace can no longer autoextend

D. When the database is upgraded from a previous version of Oracle

E. You do not need the `SYSAUX` tablespace; it is optional

19. Which of the following operations are allowed on the SYSAUX tablespace?

    A. Transporting the SYSAUX tablespace to another database

    B. Renaming the SYSAUX tablespace

    C. Adding a datafile to the SYSAUX tablespace

    D. Dropping the SYSAUX tablespace

    E. Changing the SYSAUX tablespace from SEGMENT SPACE AUTO to SEGMENT SPACE MANUAL

20. Which of the following methods can be used to verify the bigfile tablespace bfile.dbf with the DBVERIFY utility and enable parallel processing?

    A.
    ```
    $ dbv FILE=bfile.dbf START=1 END=25000 &
    $ dbv FILE=bfile.dbf START=25000 END=50000 &
    $ dbv FILE=bfile.dbf START=50001 &
    ```

    B.
    ```
    $ dbv FILE=bfile.dbf PARALLEL=3
    ```

    C. Parallel processing is automatically enabled for DBVERIFY depending on the value of PARALLEL_MAX_SERVERS.

    D. Since a bigfile tablespace has only one datafile, parallel processing cannot be enabled.

    E. Parallel processing is automatically enabled for offline datafiles only.

    F.
    ```
    $ dbverify FILE=bfile.dbf START=1 END=25000 &
    $ dbverify FILE=bfile.dbf START=25000
      END=50000 &
    $ dbverify FILE=bfile.dbf START=50001 &
    ```

Answers to Review Questions

1. B. None of the choices contain an ALTER command that is allowed for hash-partitioned indexes, except for the ALTER INDEX MODIFY PARTITION command with the UNUSABLE option—in other words, marking a partition of a hash-partitioned index as unusable.

2. B, D. Not all bitmap indexes need to be rebuilt after the COMPATIBLE parameter is adjusted, unless they still exhibit a slowdown or get worse. The COMPATIBLE parameter should be set to 10.0.0.0 to take advantage of all enhancements.

3. D. Bigfile tablespaces increase the maximum size of a tablespace to 128TB with a block size of 32KB; therefore, with a block size of 16KB, a bigfile tablespace can be 64TB.

4. C, D. A temporary tablespace group is created when the first temporary tablespace member is added and is deleted when the last member is removed from the group. If a temporary tablespace already exists, it can be added to an existing group with the ALTER TABLESPACE command.

5. B, C, D. Only the system users SYS, SYSTEM, and OUTLN still use the SYSTEM tablespace as their default permanent tablespace.

6. D. In the CREATE DATABASE command, you can only specify DEFAULT TABLESPACE; the PERMANENT keyword is not required nor allowed in the command.

7. E. Of the available answers, only LogMiner can be relocated out of the SYSAUX tablespace.

8. A, D. Both V$TABLESPACE and DBA_TABLESPACES contain a new column called BIGFILE to indicate if the tablespace is a bigfile tablespace. V$DATABASE has no tablespace-specific information; V$DATAFILE contains only information relevant to the datafiles of the tablespace; and DATABASE_PROPERTIES has a row indicating the default tablespace type for the database.

9. B. By setting SKIP_UNUSABLE_INDEXES to TRUE either at the system level or the session level, the optimizer may choose a suboptimal execution plan, but the query will not return an ORA-01502 error message.

10. C. Oracle 10*g* now supports hash-partitioned global indexes; each partition contains values derived from an internal hash function based on the partitioning key or keys and the number of partitions defined for the global index. Range partitioned global indexes are not new to Oracle 10*g*. There is no such partitioning method known as global list-hash partitioning.

11. A, D. COPY_FILE copies files on the same server; PUT_FILE copies files to a remote server. Both procedures can copy only binary files. Since PUT_FILE copies to a remote server, it requires a destination server name, unlike COPY_FILE, which copies to a destination on the same server.

12. B. For hash-partitioned indexes, each individual index must be rebuilt individually. Other operations not supported for hash-partitioned indexes are ALTER TABLE SPLIT INDEX PARTITION and ALTER INDEX MODIFY PARTITION.

13. B. Logically, a temporary tablespace group is equivalent to an individual temporary tablespace. If a user is not assigned a default temporary tablespace, they are assigned the database's default temporary tablespace.

14. B. With range-partitioned indexes, partition pruning occurs, but only one parallel query process is spawned per partition whereas multiple query processes may be spawned for each pruned partition in a hash-partitioned global index.

15. C, D, E. Tablespaces that are `READ ONLY` can be renamed, but the datafile header is not changed. References to the tablespace are updated in an SPFILE if necessary, but a text-based initialization parameter file is not changed.

16. A. Hash partitioning spreads the activity to more leaf blocks and therefore reduces the contention for a given leaf block in an OLTP environment.

17. A, B. The DBA can monitor the view `DBA_IND_PARTITIONS` to see if index partitions become invalid; in addition, the alert log will contain messages when an index has been marked unusable. While `EXPLAIN PLAN` may alert a user that the index is not being chosen to run the query, it is impractical for the DBA to run the `EXPLAIN PLAN` command for all user queries. User trace files will not contain messages regarding invalid indexes.

18. A, D. The `SYSAUX` tablespace is required for all new Oracle 10*g* database installations, as well as upgrading a previous version of Oracle to Oracle 10*g*. The `SYSAUX` table must exist, even if the applications that use the `SYSAUX` table are not installed.

19. C. A datafile can be added to the `SYSAUX` tablespace, just as any other tablespace, as long as it is a smallfile tablespace. All the other operations listed are not allowed on the `SYSAUX` tablespace.

20. A. The `DBVERIFY` utility, invoked as `dbv` on every platform, can be spawned multiple times, with each instance of `DBVERIFY` accessing a different portion of the datafile. No `PARALLEL` clause exists for `DBVERIFY`. Since the `DBVERIFY` utility is an external utility, it does not use database initialization parameters such as `PARALLEL_MAX_SERVERS`.

Chapter 5

Automated Storage Management

ORACLE DATABASE 10*g* NEW FEATURES FOR ADMINISTRATORS EXAM OBJECTIVES OFFERED IN THIS CHAPTER:

- ✓ **Space Management**
  - Reduce space related error conditions through proactively managing tablespace usage
  - Reclaim wasted space from tables and indexes using the segment shrink functionality
  - Use the Segment Advisor
  - Use the Undo Advisor
  - Use sorted hash clusters
- ✓ **General Storage Enhancement**
  - Use the Redo Logfile Size Advisor
- ✓ **Automatic Storage Management**
  - Describe Automatic Storage Management
  - Set up initialization parameter files for ASM and database instances
  - Execute SQL commands with ASM file names
  - Start up and shut down ASM instances
  - Administer ASM disk groups
  - Use RMAN to migrate your database to ASM

Exam objectives are subject to change at any time without prior notice and at Oracle's sole discretion. Please visit Oracle's training and certification website (`http://www.oracle.com/education/certification/`) for the most current exam objectives listing.

Oracle Database 10*g* (Oracle 10*g*) provides a number of automated enhancements to help you manage the disk space in the database.

Proactive tablespace monitoring uses the `DBMS_SERVER_ALERT PL/SQL` package to set up thresholds at which you are notified of a potential space issue; ideally, this happens long before a user calls you because they cannot create a table because of lack of space in a tablespace.

To make table access more space efficient and reduce the amount of I/O needed to access a table, Oracle provides segment shrink functionality to compress a table whose data blocks are sparsely populated. The Segment Advisor notifies you of segments, either table or index segments, that would benefit from a segment shrink operation.

Other automated advisors introduced in Oracle 10*g* include the Undo Advisor and the Redo Logfile Size Advisor. The Undo Advisor collects statistics on an ongoing basis to help you size the undo tablespace so that DML transactions can complete successfully while at the same time allowing `SELECT` statements to complete successfully without receiving the all-too-familiar "Snapshot too old" error.

One of the biggest automated storage enhancements introduced in Oracle 10*g* is Automatic Storage Management (ASM). ASM is a cluster file system that can be used either with standalone Oracle instances or with Oracle Real Application Clusters (RAC) to provide a vertically integrated subsystem encapsulating a file system, a volume manager, and a fault-tolerant environment specifically designed for Oracle databases. It works in concert with other Oracle features such as Oracle Managed Files (OMF) to not only make disk space management easier but also to enhance the performance of the database by automatically spreading the I/O load across all available hardware devices.

In all of these cases, the Oracle Enterprise Manager (EM) Database Control provides wizards and a graphical interface for these enhancements, making it easy to leverage these enhancements when the command-line syntax is unfamiliar or difficult to remember.

In this chapter, we will review how to set up server alerts, both with the PL/SQL interface and the EM Database Control. We will also show how to identify segments that can benefit from space reclamation using the Segment Advisor and how to shrink these segments with segment shrink operations. We will present a few other enhancements such as sorted hash clusters. Finally, we will provide an in-depth look at ASM along with some comprehensive examples of how it can be used to both ease administrative effort and enhance I/O performance.

Enhancing Space Management

The space management enhancements in Oracle 10*g* fall into the following four general categories:

- Tablespace management
- Segment optimization
- Undo tablespace sizing
- Redo logfile sizing

Oracle 10*g* introduces the package `DBMS_SERVER_ALERT` to set thresholds at which you'll be notified when the space usage exceeds one of the thresholds. Segment optimization includes the Segment Advisor and segment shrink functionality; segments that inefficiently utilize space are detected with the Segment Advisor and compacted with segment shrink. Finally, the Automatic Workload Repository accumulates information about undo and redo usage to allow the Undo Advisor and the Redo Logfile Size Advisor to provide optimal sizing information for the undo tablespace and redo log files, respectively.

Proactive Tablespace Monitoring

Oracle Database 10*g* manages the disk space in two ways: reactively and proactively. Through database alerts, you are notified of tablespace disk space usage at two different levels: at a warning level and at a critical level. By default, the warning level is 85 percent, and the critical level is 97 percent. While these levels are by definition reactive, they can arguably be considered proactive in that you will have an opportunity to increase the amount of space in the tablespace before it runs out of space.

In a truly proactive manner, Oracle Database 10*g* collects statistics on space usage in the *Automatic Workload Repository (AWR)* at 30-minute intervals to assist you with tablespace and segment growth trend analysis and capacity planning. The AWR collects vital statistics and workload information, including CPU usage, user sessions, I/O usage, and many other metrics at 30-minute intervals and stores them in the SYSAUX tablespace for later analysis.

In the following sections, we will go into some of the details of how Oracle monitors tablespace usage. In addition, we will show you how you can view and modify the alert thresholds, both for an individual tablespace as well as for the database default, via the EM Database Control interface as well as via the PL/SQL package `DBMS_SERVER_ALERT`. We will also touch upon a special case of tablespace monitoring: undo tablespace monitoring.

Space Usage Monitoring

If a tablespace does not have specific percentage thresholds defined, the database default of 85 percent for the warning level and 97 percent for the critical level apply. You can also change these default thresholds, as you will see in the next couple of sections.

The background process *MMON* checks for tablespace space problems every 10 minutes; alerts are triggered both when a threshold is exceeded and once again when the space usage for a tablespace falls back below the threshold. For example, assume that the default thresholds of 85 percent and 97 percent are in effect. Within a five-minute period, the USERS tablespace reaches 86 percent full, and MMON generates an alert. Fifteen minutes later, the USERS tablespace passes the 97 percent mark and finally reaches 99 percent full, and MMON signals a second alert, this time a critical alert. You allocate a new datafile to the USERS tablespace to bring the overall space usage to 92 percent. The next time MMON checks for space problems in the USERS tablespace, the space usage has fallen back below the 97 percent threshold, and a third alert is sent to denote that the critical alert has been cleared.

For Oracle databases that have been upgraded from a previous version to Oracle 10*g*, all tablespace alerts are off by default.

Alerts are not necessary under a few conditions. For example, tablespaces that are read-only or are offline do not need thresholds defined, as their contents will not increase or decrease while they are read-only or offline.

Some tablespaces are defined as autoextensible; this presents a challenge to tablespace threshold monitoring because even though the space usage of the datafile at a particular point in time may be at a warning or critical level, the datafile will automatically autoextend when it runs out of space. To avoid generating false alerts, thresholds on these tablespaces are computed in one of two ways: based on the maximum size specified when the tablespace was created or the maximum operating system file size, whichever is smaller.

Dictionary-managed tablespaces do not support server-generated alerts, which is yet another good reason to convert tablespaces from a previous version of Oracle to locally managed and to create all new tablespaces as locally managed.

Editing Thresholds with the Enterprise Manager Database Control

You can edit space usage thresholds for tablespaces in one of two ways via the EM Database Control, one from an overall threshold perspective and the other from an individual tablespace perspective.

To access the thresholds from a database-wide point of view, click the Manage Metrics link at the bottom of the EM Database Control database Home tab, and you'll see all possible database alerts listed as in Figure 5.1.

Clicking the Edit Thresholds button brings up the Edit Thresholds screen, where you can change one or more of these thresholds, as you can see in Figure 5.2.

As the tip on the screen indicates, some metrics allow different thresholds for different objects of the same type, such as tablespaces. For instance, if you select the Tablespace Space Used (%) metric (see Figure 5.3) and then click the Specify Multiple Thresholds on the Edit Thresholds screen, you arrive at the Specify Multiple Thresholds: Tablespace Space Used (%) screen, as shown in Figure 5.4.

FIGURE 5.1 All database thresholds

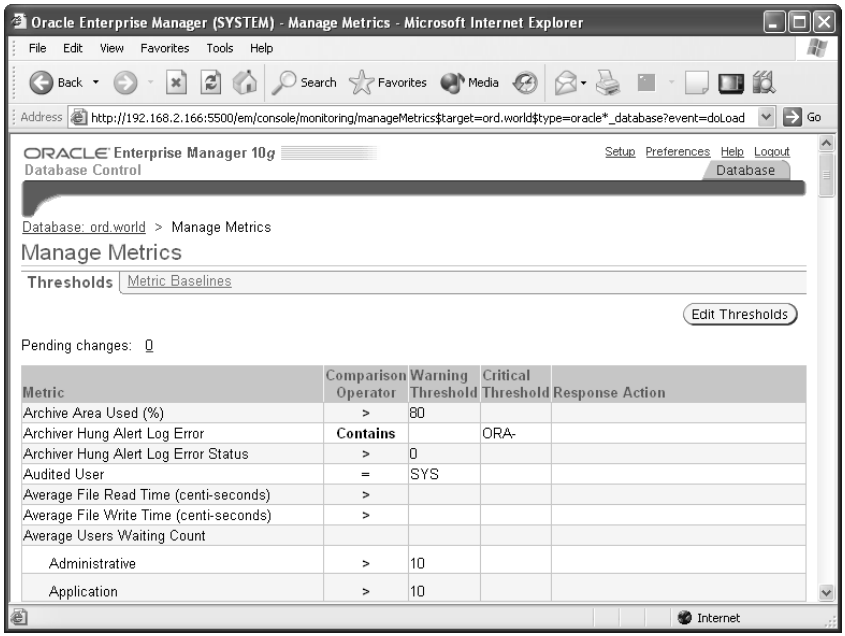


FIGURE 5.2 Editing thresholds

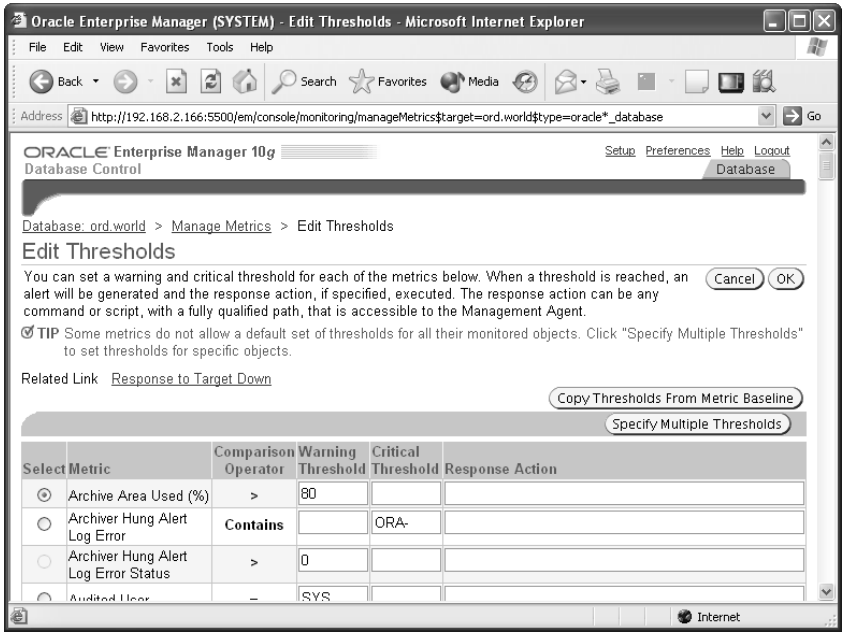


FIGURE 5.3 Selecting the Tablespace Space Used (%) metric

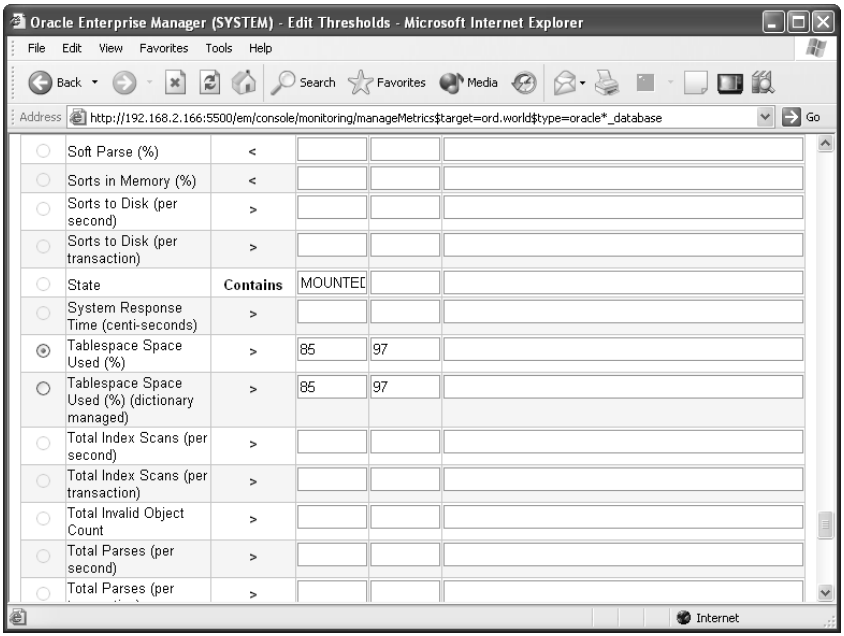
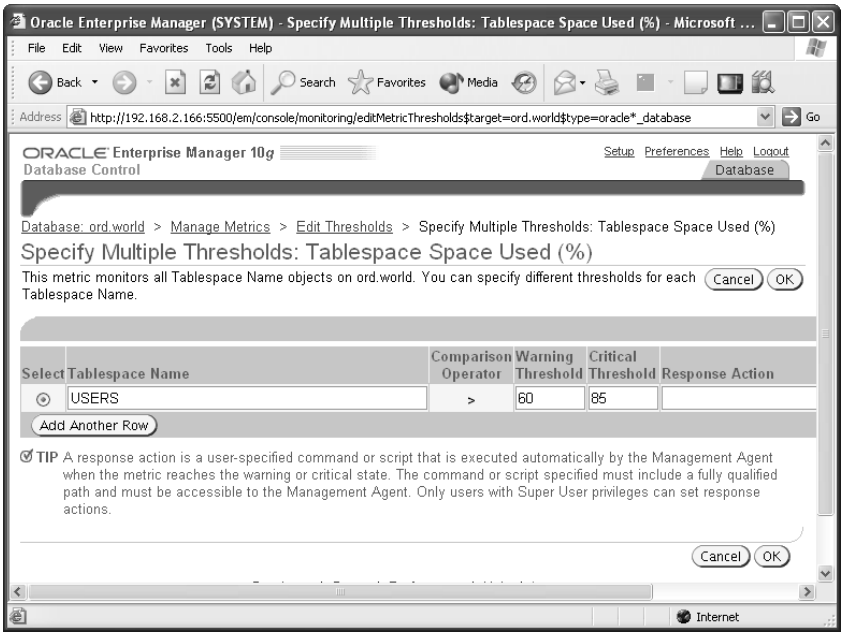


FIGURE 5.4 Altering specific tablespace thresholds



Because the USERS tablespace tends to grow quickly, notice in Figure 5.4 you set the thresholds for the tablespace at 60 percent and 85 percent, a bit lower than the default, so that you will have more time to allocate the space for the USERS tablespace when the alert is generated. Also, note that this screen has a place for a response action: it can range from a script containing a SQL command to automatically freeing up the space in the tablespace or adding a new datafile to the tablespace.

You can also edit the thresholds for a tablespace by clicking the Tablespaces link from the Administration tab on the EM Database Control database Administration page. Clicking the link for the USERS tablespace, you see the general characteristics of the tablespace in Figure 5.5.

Clicking the Thresholds link brings you to the Edit Tablespace: USERS screen (see Figure 5.6). Here, you can see the current space usage for the USERS tablespace and change the thresholds for the warning and critical levels. As with the previous example, the thresholds for the USERS tablespace were changed to 60 percent and 85 percent.

On this same screen, you have the option to change the database-wide defaults by clicking the Modify Database Defaults button, which opens the Modify Database Defaults screen (see Figure 5.7). Using this screen, you can edit the database's default thresholds or disable them completely.

FIGURE 5.5 Tablespace general characteristics

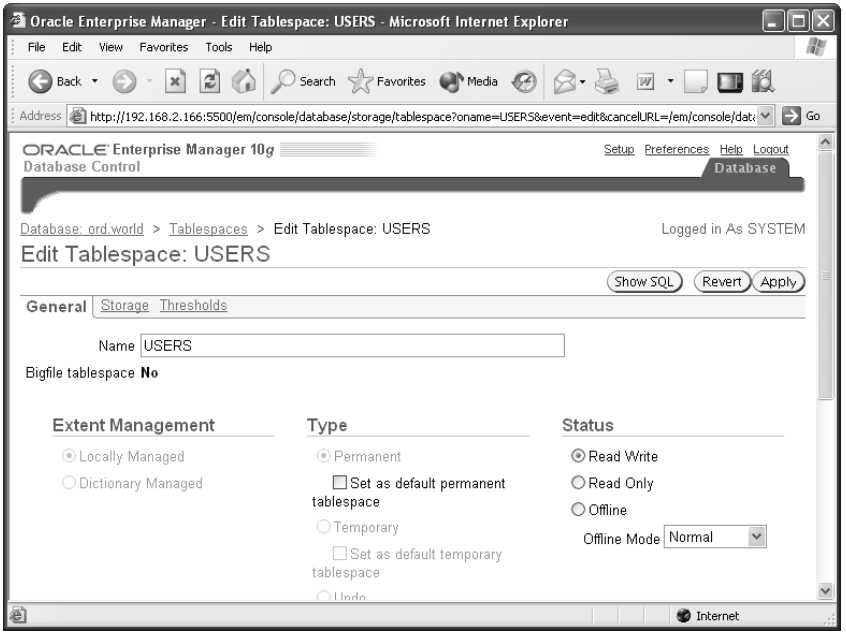


FIGURE 5.6 Editing tablespace thresholds

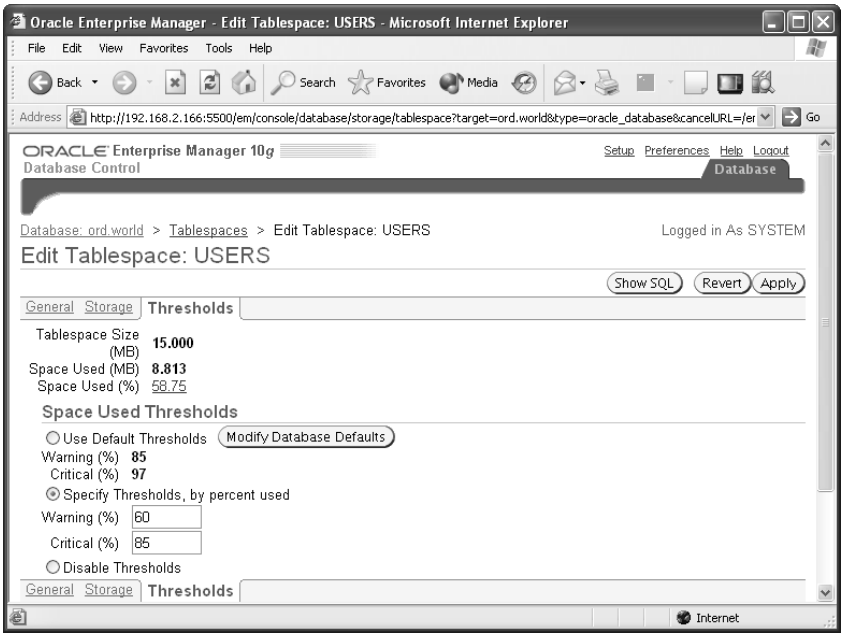
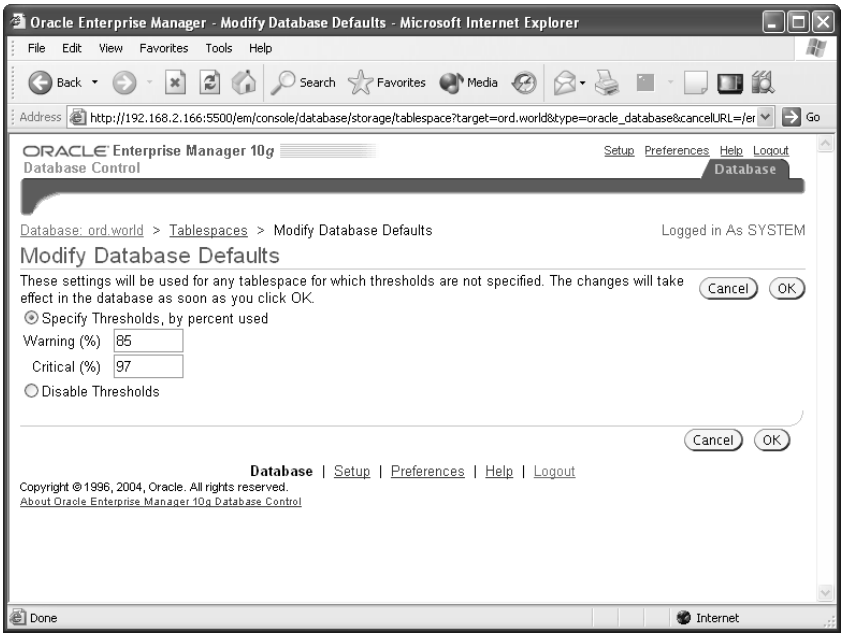


FIGURE 5.7 Editing database default thresholds



Referring to the Edit Tablespace: USERS screen (shown earlier in Figure 5.6), you want to apply your changes for the USERS tablespace thresholds. But before you do, you want to look at the SQL commands that will be executed by clicking the Show SQL button. As with most EM Database Control screens, you can brush up on the command-line syntax while enjoying the ease of use of a GUI. Figure 5.8 shows the command that will be run when you click the Apply button.

Referring to Figure 5.6, note that the USERS tablespace is already at 58.75 percent full. Let's see what happens when you add a few more segments to the USERS tablespace.

```
SQL> create table oe.customers_archive
  2       tablespace users
  3       as select * from oe.customers;
Table created.
```

The thresholds screen for the USERS tablespace in Figure 5.9 shows that you have not only exceeded the warning level but also the critical level.

Within 10 minutes, the MMON process will notify you of the critical tablespace problem in one of three ways: via the EM Database Control Home tab, via an e-mail message sent to the e-mail address configured when the database was created, or using the script in the Response Action column, if one was specified, shown in Figure 5.4 when the tablespace thresholds were modified.

FIGURE 5.8 Showing SQL for tablespace thresholds

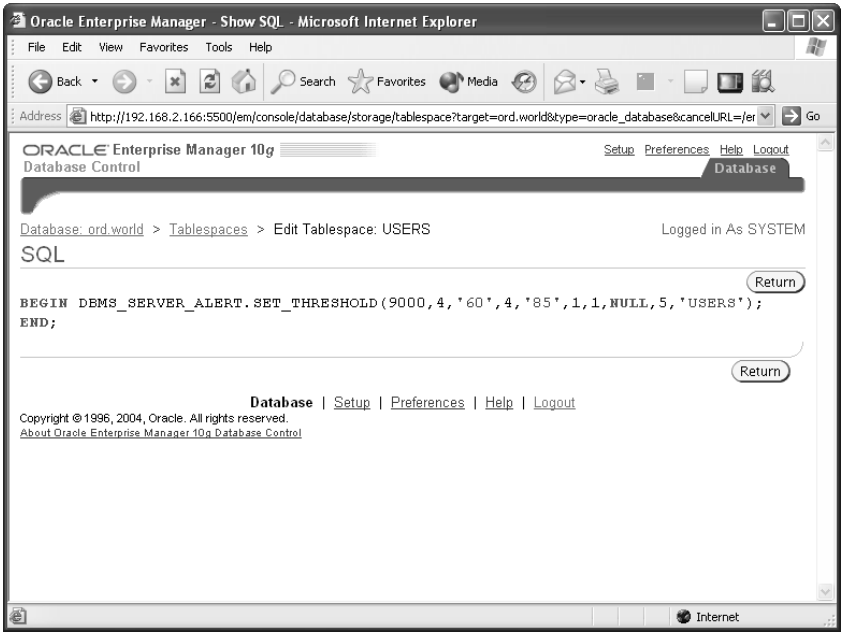
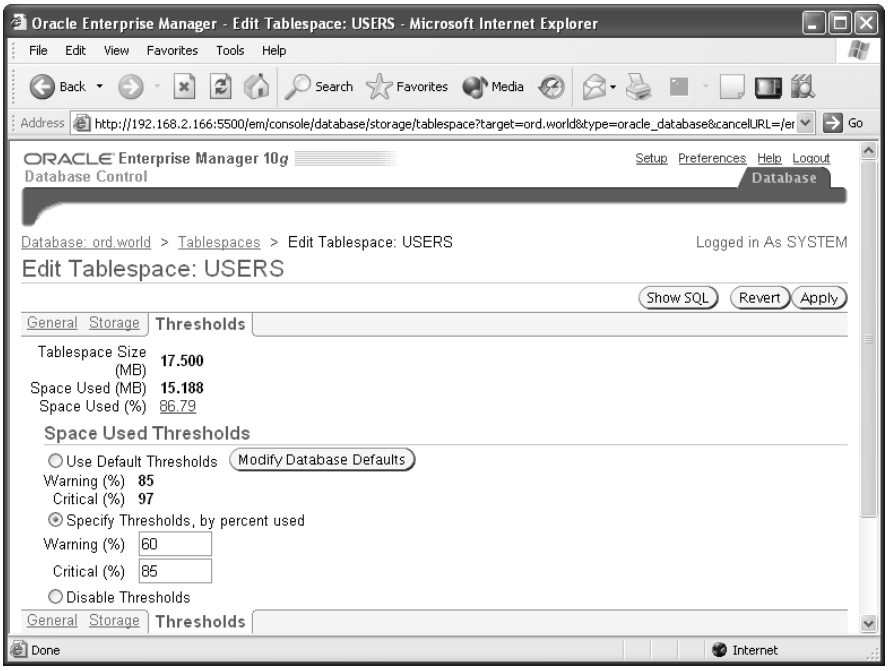


FIGURE 5.9 Viewing current tablespace usage



Using *DBMS_SERVER_ALERT*

In the previous section, we demonstrated how you could view the actual SQL commands that the EM Database Control uses to add, change, or modify space usage thresholds. In the following sections, we will go into more detail on how the DBMS_SERVER_ALERT package works. The DBMS_SERVER_ALERT package contains a number of procedures that allows you to set, view, and modify a variety of alert conditions.

For managing space usage alerts, as with every other type of alert, the three procedures available are as follows:

- SET_THRESHOLD
- GET_THRESHOLD
- EXPAND_MESSAGE

SET_THRESHOLD

As the name implies, the SET_THRESHOLD procedure sets the threshold for a particular alert type. Table 5.1 describes the parameters for SET_THRESHOLD.

TABLE 5.1 *SET_THRESHOLD* Parameters

Parameter Name	Description
METRICS_ID	The name of the metric, using an internally defined constant
WARNING_OPERATOR	The comparison operator for comparing the current value with the warning threshold value
WARNING_VALUE	The warning threshold or NULL if no warning threshold exists
CRITICAL_OPERATOR	The comparison operator for comparing the current value with the warning threshold value
CRITICAL_VALUE	The critical threshold or NULL if no critical threshold exists
OBSERVATION_PERIOD	The timer period at which the metrics are computed against the threshold; the valid range is 1 to 60 minutes
CONSECUTIVE_OCCURRENCES	How many times the threshold needs to be exceeded before the alert is issued
INSTANCE_NAME	The name of the instance for which the threshold applies; this value is NULL for all instances in a RAC database and is NULL for database-wide alerts
OBJECT_TYPE	The type of object—for example, a tablespace, session, or service—using a set of internally defined constants
OBJECT_NAME	The name of the object, such as the tablespace name

For monitoring tablespace space usage, only one metric object type is available: the TABLESPACE_PCT_FULL metric. The operators for exceeding a threshold are either OPERATOR_GE or OPERATOR_GT. OPERATOR_GE indicates that the current value of the metric is compared to the WARNING_VALUE or CRITICAL_VALUE using the greater than or equal to operator (>=); similarly, OPERATOR_GT indicates that the current value of the metric is compared to the WARNING_VALUE or the CRITICAL_VALUE using the greater than operator (>). The object type is always OBJECT_TYPE_TABLESPACE.

Because the USERS2 tablespace in the database is an infrequently used tablespace and not part of the production environment, you want to raise the alert thresholds for space usage to reduce the total number of alerts you receive every day. In the following example, we are changing the warning threshold to 90 percent and the critical threshold to 99 percent. These thresholds

will be compared to the percentage of space used in the USERS2 tablespace every minute, causing an alert the first time the threshold is exceeded for the tablespace USERS2.

```
SQL> execute
  2    dbms_server_alert.set_threshold(
  3    dbms_server_alert.tablespace_pct_full,
  4    dbms_server_alert.operator_ge, 90,
  5    dbms_server_alert.operator_ge, 99,
  6    1, 1, null,
  7    dbms_server_alert.object_type_tablespace,'USERS2');
PL/SQL procedure successfully completed.
```

The new threshold goes into effect immediately. The next time MMON runs, an alert will be generated if the space usage on the USERS2 tablespace is at 90 percent or higher.

GET_THRESHOLD

Similarly, GET_THRESHOLD retrieves the values of a defined alert. Table 5.2 describes the parameters for GET_THRESHOLD.

TABLE 5.2 *GET_THRESHOLD* Parameters

Parameter Name	Description
METRICS_ID	The name of the metric, using an internally defined constant
WARNING_OPERATOR	The comparison operator for comparing the current value with the warning threshold value
WARNING_VALUE	The warning threshold or NULL if no warning threshold exists
CRITICAL_OPERATOR	The comparison operator for comparing the current value with the warning threshold value
CRITICAL_VALUE	The critical threshold or NULL if no critical threshold exists
OBSERVATION_PERIOD	The timer period at which the metrics are computed against the threshold; the valid range is 1 to 60 minutes
CONSECUTIVE_OCCURRENCES	How many times the threshold needs to be exceeded before the alert is issued
INSTANCE_NAME	The name of the instance for which the threshold applies; this value is NULL for all instances in a RAC database

TABLE 5.2 *GET_THRESHOLD* Parameters *(continued)*

Parameter Name	Description
OBJECT_TYPE	The type of object—for example, a tablespace, session, or service—using a set of internally defined constants
OBJECT_NAME	The name of the object, such as the tablespace name

Not surprisingly, the parameters for GET_THRESHOLD are identical to SET_THRESHOLD, except that the values of WARNING_OPERATOR through CONSECUTIVE_OCCURENCES are OUT parameters instead of IN. In the following example, you will retrieve the threshold values you set for the USERS tablespace earlier in this chapter:

```
SQL> begin
  2    dbms_server_alert.get_threshold(
  3     dbms_server_alert.tablespace_pct_full,
  4     :warn_oper, :warn_value, :crit_oper, :crit_value,
  5     :obs_per, :cons_oc, null,
  6     dbms_server_alert.object_type_tablespace,'USERS');
  7  end;
  8  /

PL/SQL procedure successfully completed.

SQL> print warn_value

WARN_VALUE
--------------------------------
60

SQL> print crit_value

CRIT_VALUE
--------------------------------
85
```

Setting the last parameter to NULL instead of the tablespace name will retrieve the database-wide default values instead of the values for a particular tablespace.

EXPAND_MESSAGE

The EXPAND_MESSAGE procedure is very straightforward, translating a numeric message number to a text format. Table 5.3 describes the parameters for EXPAND_MESSAGE.

TABLE 5.3 *EXPAND_MESSAGE* Parameters

Parameter Name	Description
USER_LANGUAGE	The current session's language
MESSAGE_ID	The alert message ID number
ARGUMENT_1	The first argument returned in the alert message
ARGUMENT_2	The second argument returned in the alert message
ARGUMENT_3	The third argument returned in the alert message
ARGUMENT_4	The fourth argument returned in the alert message
ARGUMENT_5	The fifth argument returned in the alert message

If additional values are returned along with the alert code number, they are specified using ARGUMENT_1 through ARGUMENT_5 and are substituted into the alert message as needed. For server alert message number 6, you can retrieve the text of the message as follows:

```
SQL> select dbms_server_alert.expand_message
  2       (null,6,null,null,null,null,null) alert_msg
  3  from dual;

ALERT_MSG
----------------------------------
Read and write contention on database
blocks was consuming significant
database time. However, no single
object was the predominant cause for
this contention.
```

Rarely will you have to call EXPAND_MESSAGE; it is primarily used for third-party applications that read alert messages from the alert queue. The EM Database Control automatically retrieves the text of all alert messages.

Undo Tablespace Monitoring

Undo tablespaces are monitored just like any other tablespace: if a specific set of space thresholds is not defined, the database default values are used; otherwise a specific set of thresholds can be assigned.

Running out of space in an undo tablespace, however, may also trigger an "ORA-01555: Snapshot too old" error. Long-running queries that need a read-consistent view of one or more tables can be at odds with ongoing transactions that need undo space. Unless the undo tablespace is defined with the `RETENTION GUARANTEE` parameter, ongoing DML can use undo space that may be needed for long-running queries. As a result, a "Snapshot too old" error is returned to the user executing the query, and an alert is generated. This alert is also known as a *long query warning alert*.

This alert may be triggered independently of the space available in the undo tablespace if the `UNDO_RETENTION` initialization parameter is set too low.

Regardless of how often the "Snapshot too old" error occurs, the alert is generated at most once per a 24-hour period. Increasing the size of the undo tablespace or changing the value of `UNDO_RETENTION` does not reset the 24-hour timer: For example, an alert is generated at 10 a.m. and you add undo space at 11 a.m. The undo tablespace is still too small, and users are still receiving "Snapshot too old" errors at 2 p.m. You will not receive a long query warning alert until 10 a.m. the next day, but chances are you will get a phone call before then!

Segment Management

Oracle 10*g* provides a number of new ways to manage segments in the database. To use disk space more efficiently and to reduce the I/O required to access a segment, segment shrink functionality will compact the space within a segment and optionally move the high watermark (HWM), freeing up space for other segments.

The Segment Advisor, one of many advisors in Oracle 10*g*, can analyze one segment or all the segments within a tablespace and determine if a segment is a good candidate for a segment shrink operation.

Finally, sorted hash clusters is a new way to manage a segment, expanding upon the space efficiency of hash clusters by adding the capability to maintain the sort order of hash table entries, reducing the need for additional sorts and disk space in a query that retrieves rows from a sorted hash cluster in a first-in, first-out (FIFO) manner.

Segment Shrink

If rows were added only to tables, then segment shrink would not be needed; however, deletes and updates to a table, and ultimately the index, leave many blocks with fewer or no rows. While this space can be used by future inserts or updates, you have no guarantee that the space will be reused, if ever. In addition, since the HWM only stays the same or gets larger, full table scans must read every block whether or not it is empty.

In the following sections, we will discuss the benefits of segment shrink; we will also cover a few of the restrictions regarding the types of segments you can shrink and where the segments must reside. Finally, we will provide some practical examples of how segment shrink works, both using the command line and the EM Database Control.

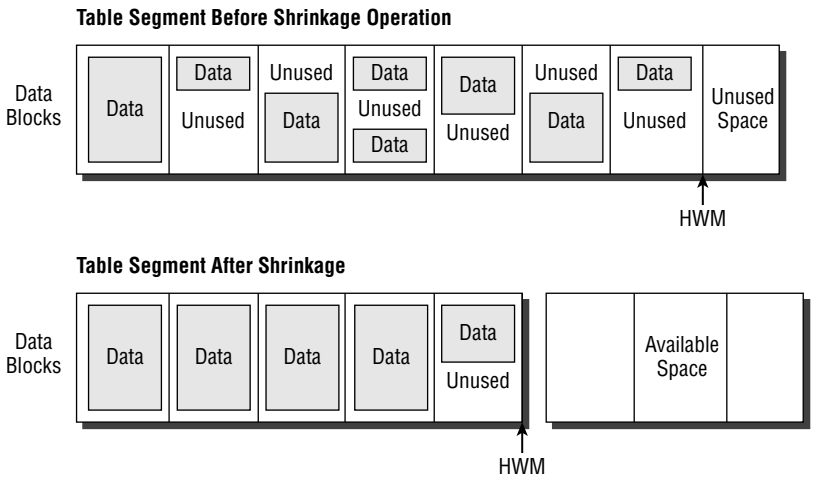
Overview of Segment Shrink

Segment shrink compresses the data blocks in a table or index and optionally moves the HWM down, making the unused space available for other segments in the tablespace. In addition to making full table scans more efficient, a shrunken segment makes even single I/Os for individual data blocks more efficient, since more rows are retrieved for each I/O. Indexes that are shrunk are also more efficient for the same reason: during an index range scan operation, more index entries are read for each I/O, reducing overall I/O for the query.

While chained rows may be eliminated by performing a segment shrink operation, it is not guaranteed that all chained rows will be repaired because not all blocks may be accessed in a segment shrink operation.

Figure 5.10 shows a sparsely populated table segment before and after a shrink operation.

FIGURE 5.10 Segment before and after shrink



Before Oracle 10*g*, the HWM could be moved down only if the segment was moved or truncated. While online table redefinition or Create Table As Select (CTAS) operations can provide similar results to segment shrink, those methods must temporarily provide double the amount of space occupied by the table. Segment shrink is online and in place, requiring a negligible amount of extra space and remaining available during the entire operation except for a brief period when the HWM is moved.

Segment Shrink Restrictions and Considerations

Segment shrink operations have one major restriction: Segments managed with freelists cannot be shrunk; in other words, the tablespace containing the segment must be defined with automatic segment space management.

The most common types of segments can be shrunk:

- Heap-organized and index-organized tables
- Indexes
- Partitions and subpartitions
- Materialized views and materialized view logs

Other segment types or segment with specific characteristics cannot be shrunk:

- Clustered tables
- Tables with LONG columns
- Tables with on-commit or ROWID-based materialized views
- LOB segments
- IOT mapping tables or overflow segments
- Tables with function-based indexes

During a segment shrink operation, the ROWID may change for a row when it moves between blocks. Therefore, segments that rely on ROWIDs being constant, such as an application that maintains ROWIDs as pointers in another table, cannot be shrunk. In any case, `ROW MOVEMENT` must be enabled for table segments that are candidates for shrink operations.

All indexes are maintained and useable both during and after the shrink operation.

Performing Segment Shrink

To perform segment shrink, you can use either SQL commands or the EM Database Control. If you have hundreds of segments to shrink, a series of batch jobs with SQL commands submitted overnight is most likely the best way to perform the operation. For only one or two shrink operations on an occasional basis, the EM Database Control is probably the fastest and easiest to use.

SQL COMMANDS AND SEGMENT SHRINK

As mentioned previously, segment shrink operations may change the ROWID of one or more rows of a table segment. Therefore, row movement on the segment must be enabled before the segment can be shrunk. In the following example, you'll enable row movement for the `HR.EMPLOYEES` table:

```
SQL> alter table hr.employees enable row movement;
Table altered.
```

The `ROW MOVEMENT` capability appeared in Oracle 8*i* to allow rows to move between partitions of a partitioned table.

Shrinking the space in a segment is performed as an extension to the ALTER TABLE or ALTER INDEX command, with the SHRINK SPACE clause, as shown here:

```
SQL> alter table hr.employees shrink space;
Table altered.
```

In this example, the table HR.EMPLOYEES is shrunk, and the HWM is moved in the same operation.

Although the table is available for use by all users while the shrink operation is in progress, the I/O throughput may be decreased. Therefore, it may be advantageous to split the operation into two commands using the COMPACT clause to compress the rows without moving the HWM, as shown here:

```
SQL> alter table hr.employees shrink space compact;
Table altered.
```

At a later time, when the database is not as busy, you can complete the rest of the operation by omitting the COMPACT clause.

```
SQL> alter table hr.employees shrink space;
Table altered.
```

Any fragmentation that has occurred in the meantime is addressed, and the HWM is moved. Whether the operation is performed all at once or in two steps, only a small number of rows are locked at any given time. Conversely, a user DML command may lock one or more rows and temporarily prevent segment shrink from completing compaction of the rows. When the HWM is moved, the entire table is locked for a brief amount of time.

Another potential benefit of splitting the operation into two parts is based on PL/SQL code that may have cursors open while the segment is being accessed: with the COMPACT option, all cursors defined on the segment remain valid; without the COMPACT option, all cursors on the segment are invalidated.

Another option available with the ALTER TABLE . . . SHRINK SPACE command is the CASCADE keyword. When CASCADE is specified, all dependent objects, such as indexes, are also shrunk. In the following example, you'll use the CASCADE example to shrink all the indexes defined on the HR.EMPLOYEES table:

```
SQL> alter table hr.employees shrink space cascade;
Table altered.
```

Without the CASCADE keyword, you would have to identify all the indexes defined on the table and execute a series of commands instead of just one command.

```
SQL> select index_name from dba_indexes where
  2      table_name = 'EMPLOYEES' and owner = 'HR';
```

```
INDEX_NAME
------------------------------
EMP_EMAIL_UK
EMP_EMP_ID_PK
EMP_DEPARTMENT_IX
EMP_JOB_IX
EMP_MANAGER_IX
EMP_NAME_IX

6 rows selected.

SQL> alter index hr.emp_email_uk shrink space;
Index altered.

SQL> alter index hr.emp_emp_id_pk shrink space;
Index altered.

SQL> alter index hr.emp_department_ix shrink space;
Index altered.

SQL> alter index hr.emp_job_ix shrink space;
Index altered.

SQL> alter index hr.emp_manager_ix shrink space;
Index altered.

SQL> alter index hr.emp_name_ix shrink space;
Index altered.
```

THE EM DATABASE CONTROL AND SEGMENT SHRINK

Performing segment shrink with the EM Database Control is even easier. From the Administration tab on the EM Database Control database Home tab, click the Tables link under the Schema heading. Search for the tables you want to shrink, and select the Shrink Segment action, as shown in Figure 5.11.

The EM Database Control screen gives you all the options that are available on the command line, including the `COMPACT` and the `CASCADE` options (see Figure 5.12).

Another benefit to using the EM Database Control is that the segment shrink operation will be submitted as a job and run in the background, allowing you to immediately perform other tasks with the EM Database Control.

FIGURE 5.11 Selecting tables for segment shrink

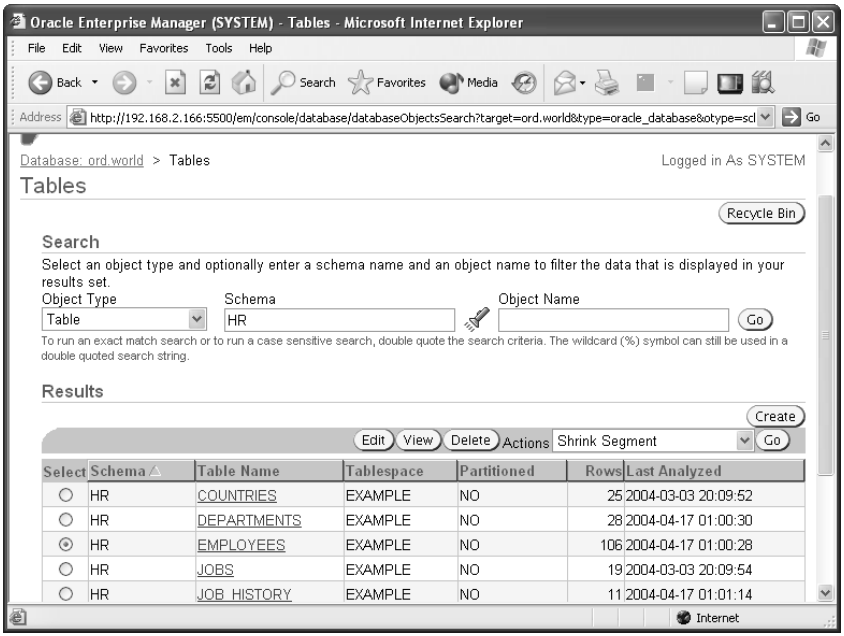
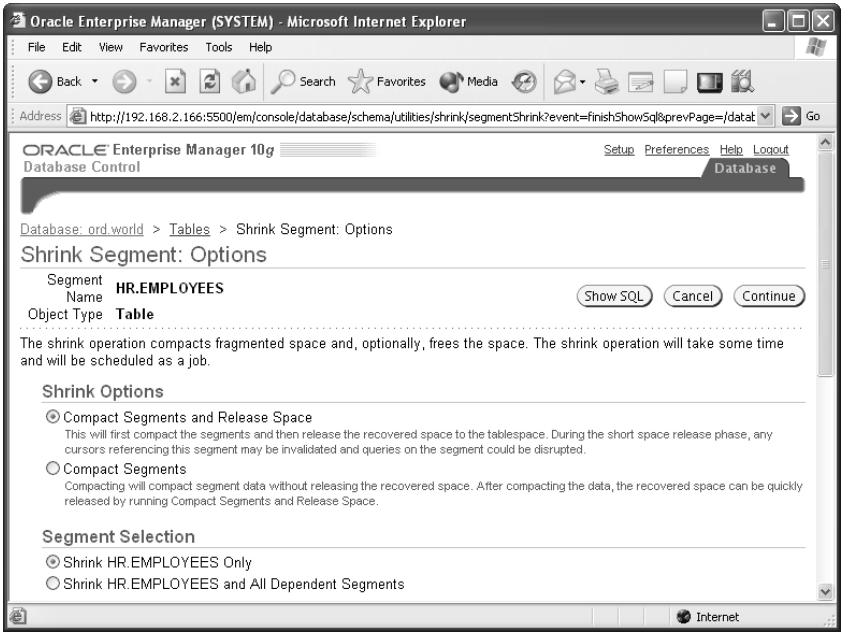


FIGURE 5.12 The EM Database Control segment shrink options



Segment Advisor

Oracle's *Segment Advisor* provides several types of functionality to manage the space occupied by database segments, such as tables and indexes. This functionality is available through both the EM Database Control and PL/SQL procedures.

The Segment Advisor can provide advice regarding a particular table, schema, or tablespace that contains segments that are good candidates for shrink operations; in addition, using the data collected within the AWR, the Growth Trend Report can help predict how much space a segment will occupy based on previous growth patterns. Finally, Segment Resource Estimation can help make preliminary sizing estimates for a table given the column datatypes and the estimated number of rows in the table.

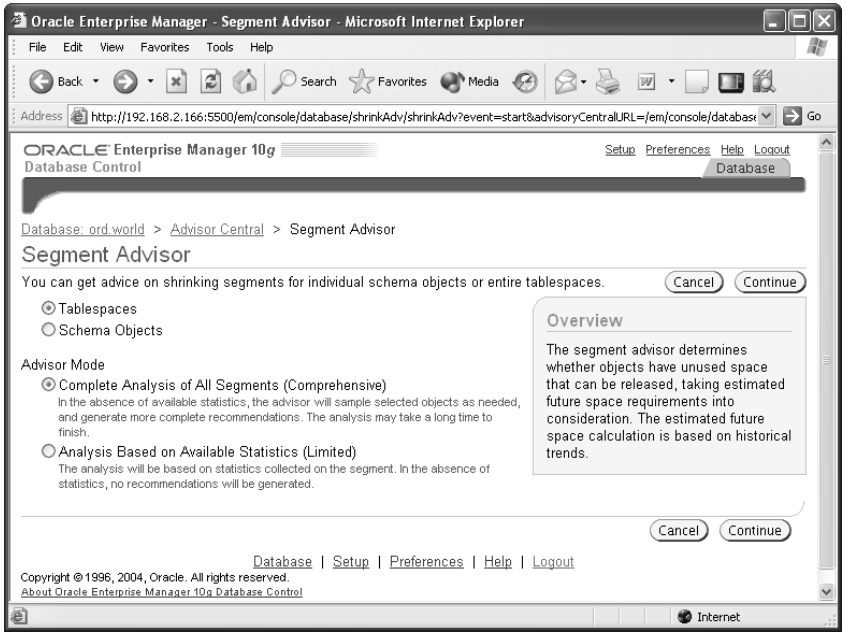
EM Database Control and Segment Advisor

As with nearly all Oracle Database 10*g* features, the EM Database Control provides an intuitive graphical interface to make the most common segment analysis tasks easy to perform. In addition to the ability to perform a complete analysis on all segments within a tablespace, the EM Database Control can use data in the AWR to use segment growth patterns to predict future space usage needs. Plus, the EM Database Control provides a segment resource estimation tool to help size a table's space usage needs even before it is created.

SEGMENT ADVISOR

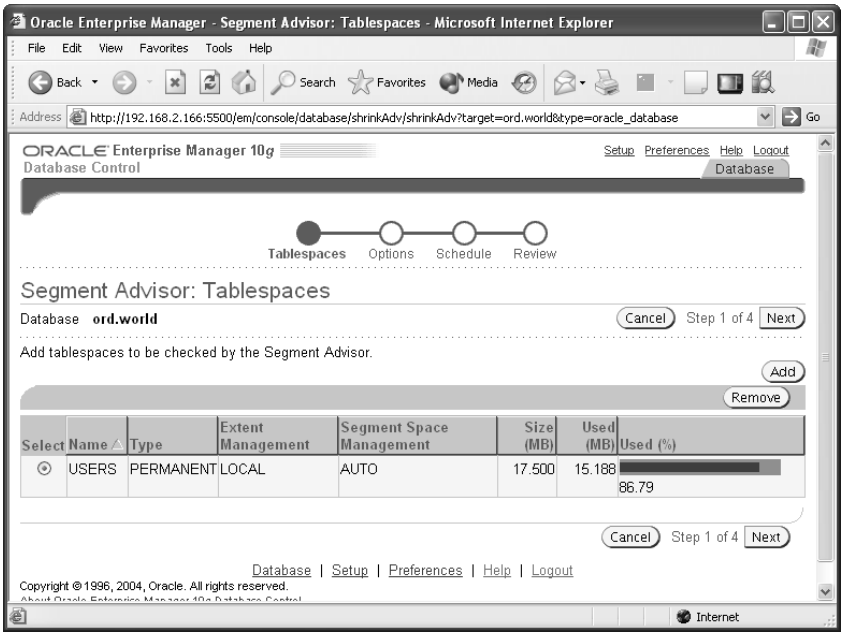
To use the Segment Advisor, select the Advisor Central link under any tab. Click Segment Advisor, which brings you to the Segment Advisor (see Figure 5.13).

FIGURE 5.13 Segment Advisor



Click Continue, which brings you to the Segment Advisor: Tablespaces screen, where you select the tablespaces to be analyzed (see Figure 5.14). In this example, the USERS tablespace is added to the list.

FIGURE 5.14 Selecting tablespaces for the Segment Advisor



Clicking Next, you can specify how long to run the analysis on the Segment Advisor: Options screen (see Figure 5.15). Since the USERS tablespace is relatively small, you will not specify a time limit; but for much larger tablespaces, you may want to prevent I/O contention, even during a nonpeak time interval, and settle for a limited analysis. In Figure 5.15, the results of the analysis are to be retained for 30 days.

Clicking Next will open the Segment Advisor: Schedule screen (see Figure 5.16). Here, you can set up the task name and the scheduling options; in this example, the job will run immediately.

In the last screen of the Segment Advisor—Segment Advisor: Review—you have one more chance to review the analysis options and to review the SQL commands that will be submitted to perform the analysis. Figure 5.17 shows the summary.

FIGURE 5.15 Segment Advisor options

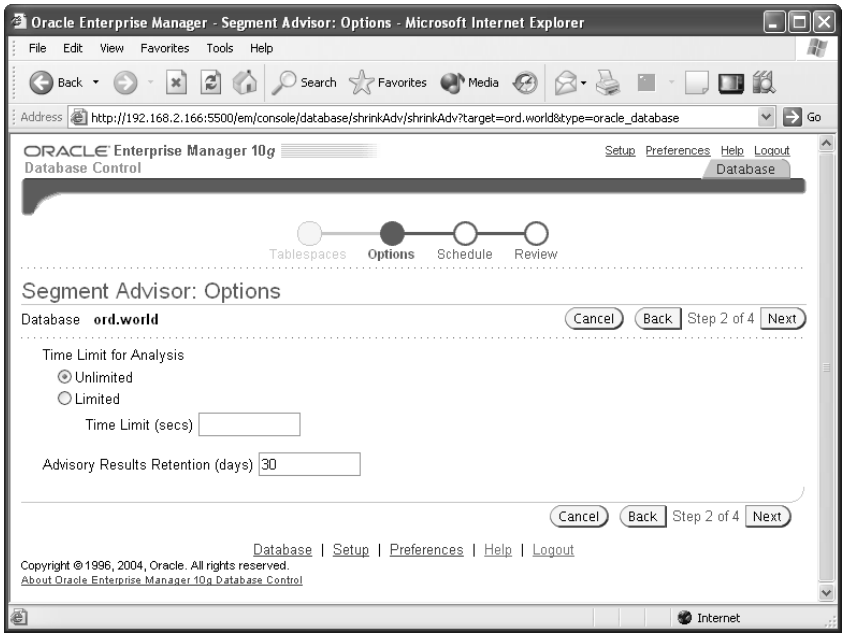


FIGURE 5.16 Task scheduling options

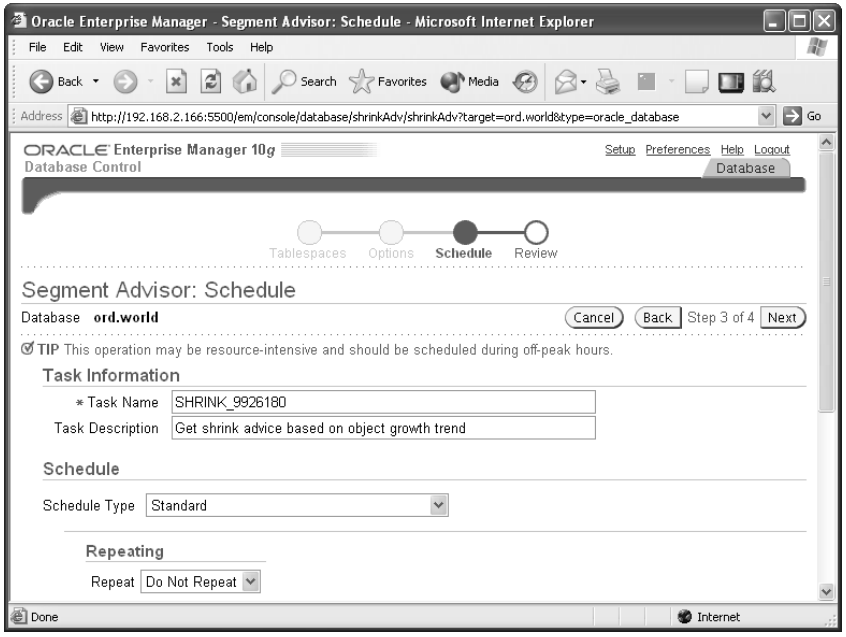
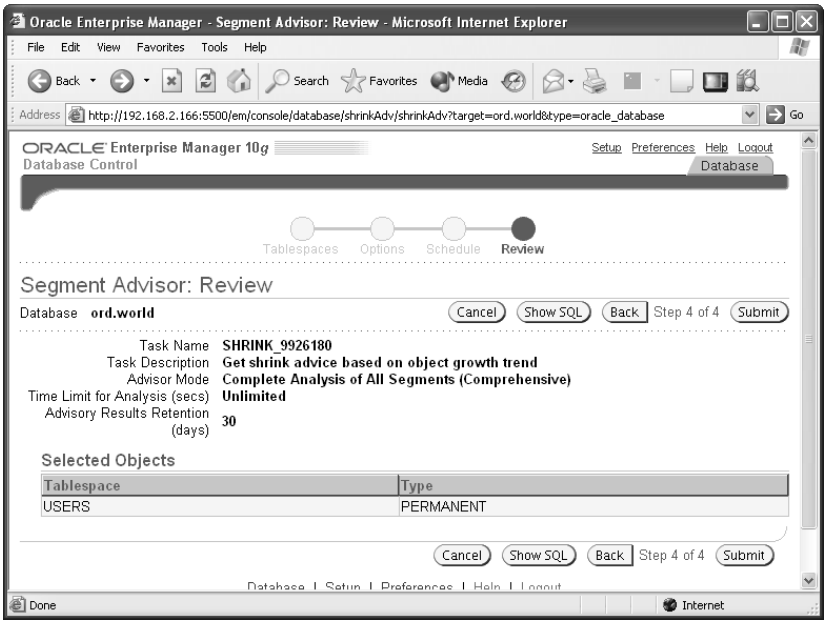


FIGURE 5.17 Segment Advisor task summary



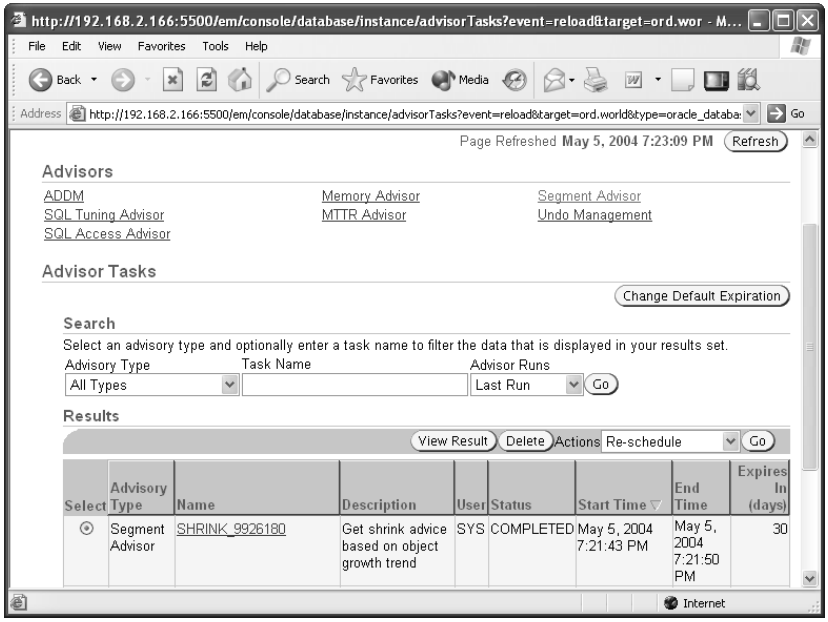
Clicking the Show SQL button, you can review the anonymous PL/SQL procedures that will perform the tasks just configured.

```
DECLARE
taskname varchar2(100);
taskdesc varchar2(128);
task_id number;
object_id number;
advMode varchar2(25);
timeLimit varchar2(25);
numDaysToRetain varchar2(25);
objectName varchar2(100);
objectType varchar2(100);
BEGIN
taskname := 'SHRINK_9926180';
taskdesc :='Get shrink advice based on object
      growth trend';
advMode :='COMPREHENSIVE';
numDaysToRetain :='30';
dbms_advisor.create_task('Segment Advisor',?,
       taskname,taskdesc,NULL);
dbms_advisor.create_object(taskname, 'TABLESPACE',
```

```
       'USERS', ' ', ' ', NULL, object_id);

dbms_advisor.set_task_parameter(taskname,
       'MODE', advMode);
dbms_advisor.set_task_parameter(taskname,
       'RECOMMEND_ALL', 'TRUE');
dbms_advisor.set_task_parameter(taskname,
       'DAYS_TO_EXPIRE',  numDaysToRetain);

END;

DECLARE
taskname varchar2(100);
BEGIN
taskname := 'SHRINK_9926180';
dbms_advisor.reset_task(taskname);
dbms_advisor.execute_task(taskname);
END;
```

Clicking Submit submits the SQL commands to be run. A few moments later, click the Refresh button on the Advisor Central screen. In Figure 5.18, notice that the Segment Advisor task has completed.

FIGURE 5.18 Advisor Central Task Completion



Click the link containing the job name of the task you just ran—in this case, SHRINK_9926180—to see that there are no segments in the USERS tablespace that can benefit from a shrink operation early in the evening (see Figure 5.19).

Emphasizing the dynamic nature of space management in any database, you may run the analysis again and find that there is now a table that can benefit from a shrink operation: the HR.EMPLOYEES_HIST table. You can shrink the HR.EMPLOYEES_HIST table by selecting one of the recommendations on the bottom of the results screen for task name SHRINK_6871100 in Figure 5.20. These options are identical to those used in Figures 5.11 and 5.12, except that you can perform a shrink operation on more than one table at a time.

GROWTH TREND REPORT

The *Growth Trend Report*, based on the AWR data collected at 30-minute intervals or when space-related server-generated alerts are triggered, helps to predict future growth trends for selected segments. Given the predicted growth pattern, you know when space will need to be added to support segment growth.

To access the Growth Trend Report, start at the Administration tab, and click the Tables link under the Schema heading. In Figure 5.21, you want to predict the growth of the HR.EMPLOYEES_HIST table.

Clicking the table name, select the Segments tab and enter a future date to see when more space should be allocated to the segment. In the example, enter **5/16/04** and click the Refresh button. Figure 5.22 shows the results of the analysis.

FIGURE 5.19 Segment Advisor recommendations at 7:21 p.m.

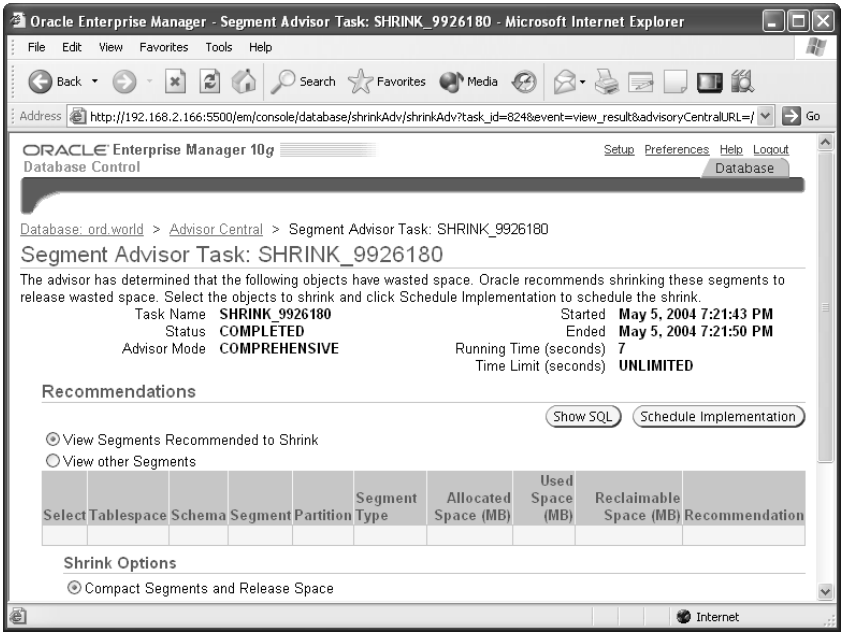


FIGURE 5.20 Segment Advisor recommendations at 11:12 p.m.

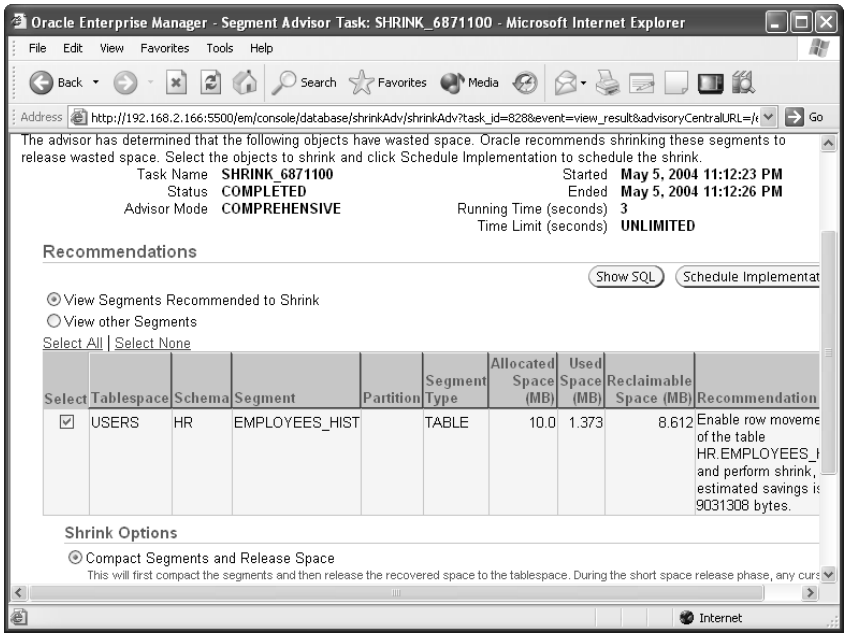


FIGURE 5.21 Growth Trend Report segment selection

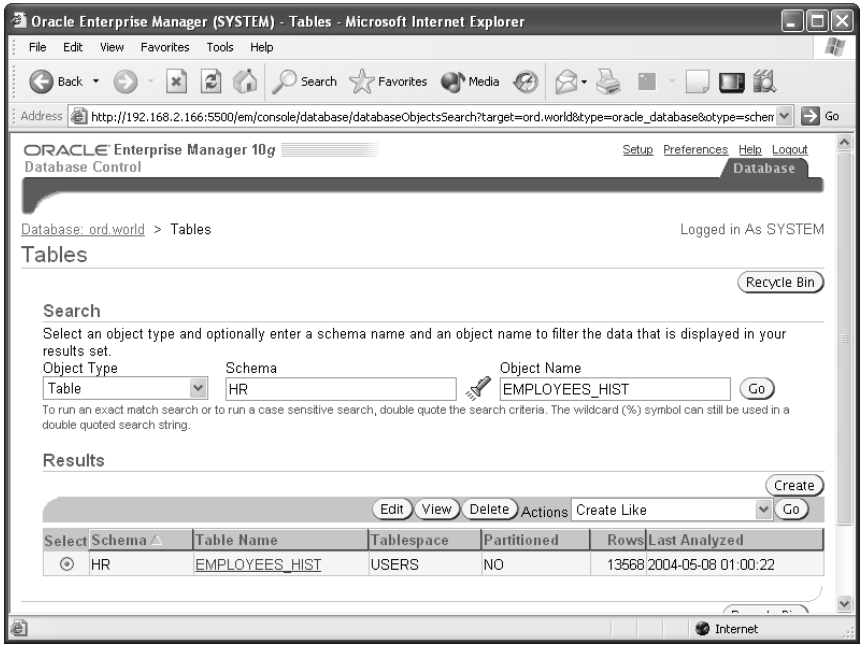
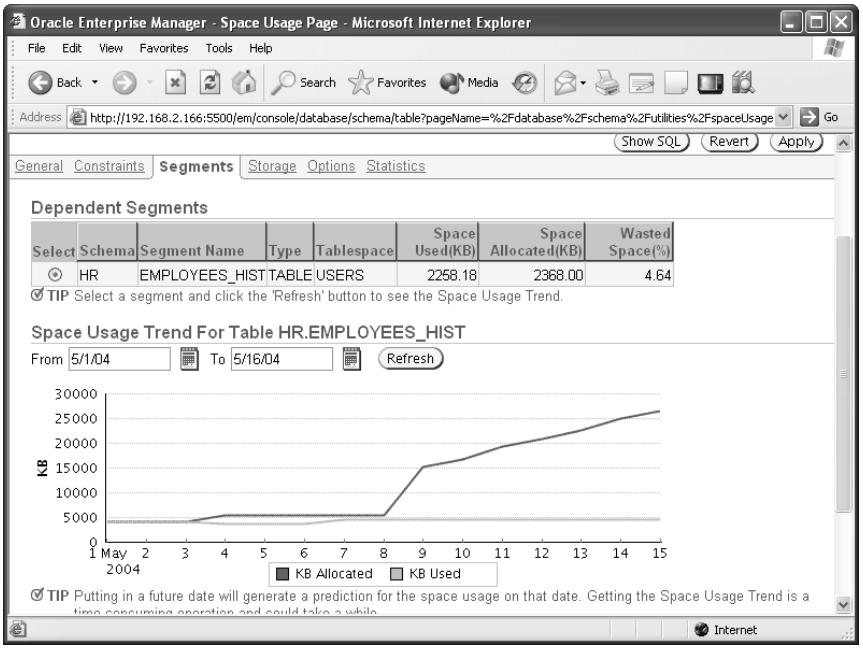


FIGURE 5.22 Growth Trend Report segment analysis



This report was run on May 8, 2004, and although the overall usage is predicted to be relatively flat, the Segment Advisor has predicted that amount of space allocated for the segment will rise dramatically within the next week.

As with the Segment Advisor, the Growth Trend Report is supported only for locally managed tablespaces.

SEGMENT RESOURCE ESTIMATION

The *Segment Resource Estimation* tool gives you a good estimate of how much disk space a new segment will require. While it is not directly a part of the Segment Advisor, it is a point-in-time analysis tool to give you sizing advice so you can estimate space usage for a new segment given the columns, datatypes, sizes, and PCTFREE for the segment.

To use Segment Resource Estimation, start at the Administration tab from the EM Database Control home page, and click the Tables link. Instead of searching for an existing table, click the Create link. In Figure 5.23, a table called `HR.EMPLOYEE_REVIEW` with three columns is created.

Clicking the Estimate Table Size link, enter an estimated row count of **5000** for the first year, and click the Estimated Table Size link again. In Figure 5.24, see that 5,000 rows of the table will occupy just more than 13MB, with the allocated space at 14MB.

FIGURE 5.23 EM Database Control: Create Table

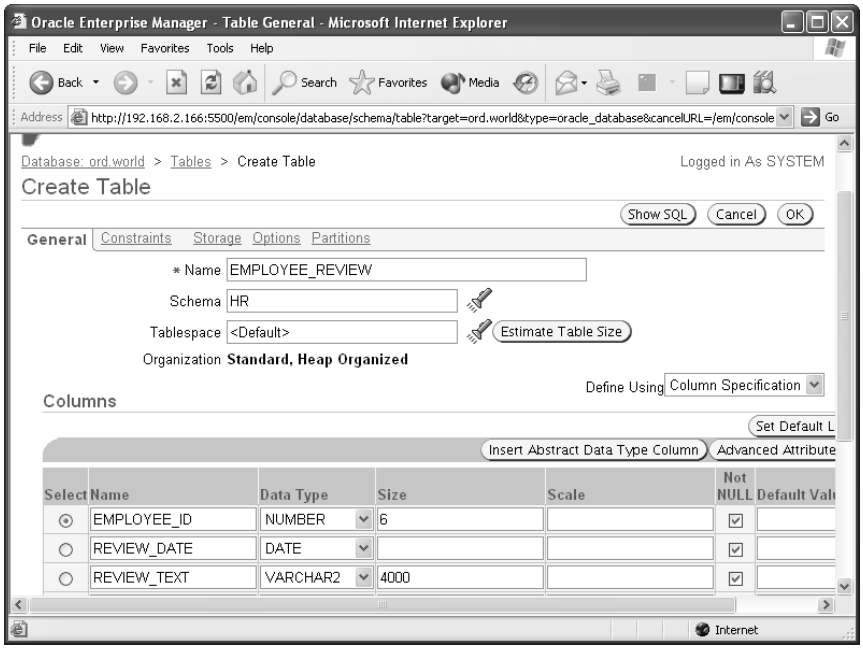
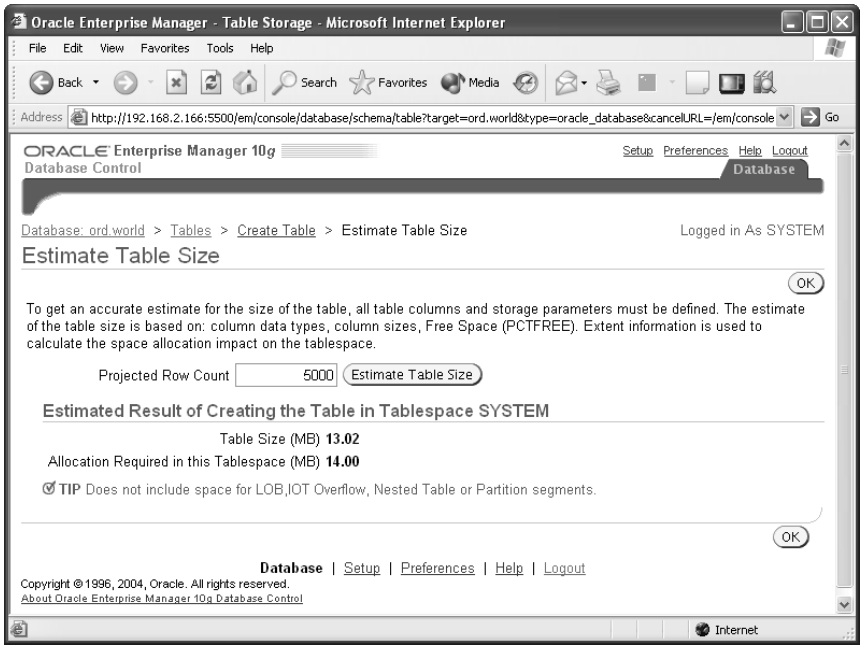


FIGURE 5.24 Estimating table size



Segment Advisor within *PL/SQL*

Although the Segment Advisor is easy to use from the EM Database Control, sometimes you may want to perform some of these operations from within a PL/SQL procedure. You may want to automate the advisors in a nightly batch job, for example.

To access Segment Advisor functionality within PL/SQL, use the package `DBMS_ADVISOR`. Since `DBMS_ADVISOR` is used with the AWR for all advisors within the Oracle 10*g* advisory framework, not all procedures within `DBMS_ADVISOR` are applicable to all advisors, and the parameters for a particular procedure will also vary depending on the advisor. For the Segment Advisor, you typically use the following procedures:

- `CREATE_TASK`
- `CREATE_OBJECT`
- `SET_TASK_PARAMETER`
- `EXECUTE_TASK`
- `DELETE_TASK`
- `CANCEL_TASK`

We will explain each of these procedures in the following sections, as well as provide two examples of analyzing a table using the Segment Advisor and implementing Segment Advisor recommendations.

CREATE_TASK

As the name implies, `CREATE_TASK` creates a new advisor task. For the Segment Advisor, the procedure requires the text string `Segment Advisor`, a variable to contain the assigned task number, a task name, and a description. Here is an example:

```
dbms_advisor.create_task
        ('Segment Advisor', :task_id, task_name,
            'Free space in OE.CUSTOMERS', NULL);
```

After the task is created, the assigned task number is stored in the SQL*Plus variable `task_id`. The unique task name is automatically generated if you leave `task_name` null; otherwise Oracle will use the task name specified. In both cases, the task name must be unique among all tasks created by a particular user. Assigning a task name or description can help identify the results when querying the advisor-related data dictionary views.

CREATE_OBJECT

The `CREATE_OBJECT` procedure specifies an object to be analyzed within the task. For the Segment Advisor, the object to be analyzed is typically a table or index; for other advisors, such as the SQL Access Advisor, the object to be analyzed is a SQL statement. To create a task object that will analyze the `OE.CUSTOMERS` table, use the following:

```
dbms_advisor.create_object
        (task_name, 'TABLE', 'OE', 'CUSTOMERS',
           NULL, NULL, object_id);
```

The PL/SQL variable object_id is assigned a unique identifier for this object. The NULL parameters are not needed for advisor objects within the Segment Advisor.

SET_TASK_PARAMETER

The SET_TASK_PARAMETER procedure allows you to specify any additional parameters needed to run the analysis for the database objects specified with CREATE_OBJECT. In the case of the Segment Advisor, you have a Boolean parameter called RECOMMEND_ALL that you set to TRUE for the analysis on the table.

```
dbms_advisor.set_task_parameter
     (task_name, 'RECOMMEND_ALL', 'TRUE');
```

When set to TRUE, the parameter RECOMMEND_ALL provides recommendations for all objects specified by the user, not just the objects eligible for segment shrink. Objects not eligible for segment shrink include objects such as tables that don't have ROW MOVEMENT enabled or tables that reside in tablespaces that do not have automatic segment space management enabled.

EXECUTE_TASK

Once all the tasks are created and their parameters specified, EXECUTE_TASK performs the analysis. The only parameter specified is the task name generated in a previous step in your code by the CREATE_TASK procedure.

```
dbms_advisor.execute_task(task_name);
```

To view the status of the executing task, especially for a long-running task such as a full tablespace analysis, the data dictionary view DBA_ADVISOR_LOG contains the task name, the start and stop time, the current status, and estimated percent complete for the task.

DELETE_TASK

The DELETE_TASK procedure removes a single Advisor task from the AWR, even if the task has not been executed yet.

```
dbms_advisor.delete_task(task_name);
```

CANCEL_TASK

CANCEL_TASK will terminate a currently executing task. Because all Advisor procedures are synchronous, the CANCEL_TASK procedure must be called from a different session for the same user account.

```
dbms_advisor.cancel_task(task_name);
```

In the next section, we will put all these procedures together in two anonymous PL/SQL blocks.

ANALYZING A TABLE USING SEGMENT ADVISOR

The code examples that follow call these procedures to determine if the table OE.CUSTOMERS needs to be shrunk.

The last change to the table OE.CUSTOMERS added a field called CUST_COMMENTS to contain any suggestions, complaints, or information about the customer.

```
SQL> alter table oe.customers
           add (cust_comments varchar2(2000));
Table altered.
```

After a number of months using this new field, you realize that the comments should be broken out by date and decide to create a new table to hold a time stamp and a comment for that particular date and time. After the new table is implemented and the comments moved to the new table, drop the column from the OE.CUSTOMERS table.

```
SQL> alter table oe.customers drop (cust_comments);
Table altered.
```

You realize that this table may be a good candidate for segment shrink and decide to use a PL/SQL procedure to analyze the table.

```
-- SQL*Plus variable to contain the task ID
variable task_id number

-- PL/SQL block follows
declare
    task_name  varchar2(100);
    task_descr varchar2(100);
    object_id  number;
begin
    task_name := ''; -- unique name generated
                     -- by create_task
    task_descr := 'Free space in OE.CUSTOMERS';
    dbms_advisor.create_task
        ('Segment Advisor', :task_id, task_name,
           task_descr, NULL);
    dbms_advisor.create_object
        (task_name, 'TABLE', 'OE', 'CUSTOMERS',
             NULL, NULL, object_id);
    dbms_advisor.set_task_parameter
         (task_name, 'RECOMMEND_ALL', 'TRUE');
    dbms_advisor.execute_task(task_name);
end;

PL/SQL procedure successfully completed.
```

Using the SQL*Plus PRINT command, you will identify the task ID number to use in your data dictionary queries.

```
SQL> print task_id

   TASK_ID
----------
       680
```

Using this task number, you can query the data dictionary view DBA_ADVISOR_FINDINGS to see the recommendations:

```
SQL> select owner, task_id, task_name, type,
  2         message, more_info from dba_advisor_findings
  3         where task_id = 680;

OWNER         TASK_ID TASK_NAME    TYPE
---------- ---------- ------------ -----------
SYS               680 TASK_680     INFORMATION

MESSAGE
------------------------------------------------------------
Enable row movement of the table OE.CUSTOMERS and perform
shrink, estimated savings is 775878 bytes.

MORE_INFO
------------------------------------------------------------
Allocated Space:983040: Used Space:205110:
Reclaimable Space :775878:


1 row selected.
```

Note that the Segment Advisor reminds you to enable row movement for the table; it is a required prerequisite before a shrink can be performed. The space in each block occupied by the CUST_COMMENTS column is unused, and by compacting this table you can reclaim almost 80 percent of the allocated space.

IMPLEMENTING SEGMENT ADVISOR RECOMMENDATIONS

To shrink the table OE.CUSTOMERS, you need to enable row movement.

```
SQL> alter table oe.customers enable row movement;
Table altered.
```

Because you have no applications or triggers that depend on the ROWIDs of this table, you will leave row movement enabled.

Next, perform the shrink operation; the data dictionary view DBA_ADVISOR_ACTIONS provides the SQL for the shrink operation.

```
SQL> select task_id, task_name, command, attr1 from
  2       dba_advisor_actions where task_id = 680;

   TASK_ID TASK_NAME    COMMAND
---------- ------------ ---------------
       680 TASK_680     SHRINK SPACE

ATTR1
--------------------------------------------------------
alter table "OE"."CUSTOMERS" shrink space

1 row selected.

SQL> alter table "OE"."CUSTOMERS" shrink space;
Table altered.
```

The shrink operation requires a negligible amount of disk space, and the table is available to other users during the shrink operation except for a short period of time at the end of the shrink operation to move the HWM. Because this table is relatively large, you may consider performing this operation in two steps, the first time with the COMPACT option to free the space and the second time without the COMPACT option to move the HWM.

Finally, remove this task from the AWR, as you have no need to retain this information once the segment has been shrunk.

```
SQL> execute dbms_advisor.delete_task('TASK_680');

PL/SQL procedure successfully completed.
```

Sorted Hash Clusters

Sorted hash clusters extend the functionality of hash clusters that have been available since Oracle 8*i* by maintaining a sort order for rows that are retrieved by the same cluster key. In heap-organized tables and traditional hash clusters, the order in which rows are returned is not under user control and depends on internal algorithms and the relative physical location of data blocks on disk. For each hash cluster key, Oracle maintains a list of rows sorted by one or more sort columns.

Maintaining the sort order of rows upon insert incurs minimal overhead but provides a tangible benefit when the data is updated or queried: CPU time and private memory requirements are reduced because no additional sorts are required, as long as the ORDER BY clause references the sort key columns or the sort key columns prefix; in fact, the ORDER BY clause is not required

if you are only retrieving rows for a single hash cluster key and want to order the rows by the sort key columns. This processing implies another valuable benefit of sorted hash clusters in that it supports FIFO processing: the sort order within each cluster key guarantees that rows are returned in the same order in which they were inserted.

For queries with an `ORDER BY` using nonprefixed sort key columns, you can use a traditional index to maintain the performance of queries on the table in the cluster.

A couple of examples will help demonstrate the value of sorted hash clusters. In the sample order entry system, you want to make sure to process the customer orders for a given customer in the order in which the orders were received without the extra overhead of sorting on the time stamp of the order.

The first step is to create a single table sorted hash cluster, as follows:

```
create cluster order_cluster
   (customer_number       number,
    order_timestamp       timestamp sort)
hashkeys 10000000
single table hash is customer_number
size 500;
```

You expect at most 10 million unique customer numbers, and the average size of the row in your cluster will be 500 bytes. The next step is to create the order table itself.

```
create table orders
   (cust_number      number,
    order_date       timestamp,
    order_number     number,
    spec_instr       varchar2(1000))
cluster order_cluster(cust_number, order_date);
```

Note that the names of the cluster keys do not have to match as long as the relative positions match and the datatypes are compatible.

Next, add a few orders with the following `INSERT` statements. Depending on when the orders were submitted and the locations where the orders are placed, the orders may not necessarily be inserted in chronological order:

```
insert into orders values(3045,
     timestamp'2004-05-05 15:04:14',
     405584,'Reorder from last month');
insert into orders values(1958,
     timestamp'2004-05-05 15:05:01',
     348857,'New customer');
insert into orders values(3045,
     timestamp'2004-05-04  9:26:59',
```

```
     938477,'GGT Promotion');
insert into orders values(3045,
     timestamp'2004-05-07 12:33:23',
     703749,'');
insert into orders values(3045,
     timestamp'2004-05-02 19:47:09',
     389233,'Needs order in time for Mothers Day');
```

However, because you are storing the orders in a sorted hash cluster, they are automatically maintained in the order of the sort key columns for each customer without specifying an ORDER BY clause:

```
SQL> select cust_number,
  2     to_char(order_date,'yyyy-mm-dd hh:mi pm')
  3               order_date,
  4     order_number, spec_instr
  5  from orders where cust_number = 3045;

CUST_NUMBER ORDER_DATE          ORDER_NUMBER SPEC_INSTR
----------- ------------------- ------------ -------------
       3045 2004-05-02 07:47 pm       389233 Needs order i
                                             n time for Mo
                                             thers Day
       3045 2004-05-04 09:26 am       938477 GGT Promotion
       3045 2004-05-05 03:04 pm       405584 Reorder from
                                             last month
       3045 2004-05-07 12:33 pm       703749

4 rows selected.

Execution Plan
----------------------------------------------------------
   0      SELECT STATEMENT Optimizer=ALL_ROWS
             (Cost=0 Card=4 Bytes=2164)
   1    0   TABLE ACCESS (HASH) OF 'ORDERS'
                       (CLUSTER (HASH))
```

Even though you had no ORDER BY clause, all rows selected using a specific customer number (in this case, customer number 3045) will automatically return the rows ordered by the sort keys because the sorted hash cluster maintains the order within the customer number cluster key.

To make sure that the new access path is used, you must ensure that the cost-based optimizer is enabled and statistics are gathered for the table. An `EXPLAIN PLAN` of any query on a sorted hash cluster will show an access method of `TABLE ACCESS HASH` without a sort operation. Also, any queries must use an equality predicate; if the previous query was instead written as follows, then an `ORDER BY` clause would be necessary to keep the rows in the desired sequence:

```
SQL> select cust_number,
  2     to_char(order_date,'yyyy-mm-dd hh:mi pm')
  3            order_date,
  4     order_number, spec_instr
  5  from orders where cust_number >= 3045;

CUST_NUMBER ORDER_DATE          ORDER_NUMBER SPEC_INSTR
----------- ------------------- ------------ -------------
       3045 2004-05-05 03:04 pm       405584 Reorder from
                                             last month
       3045 2004-05-04 09:26 am       938477 GGT Promotion
       3045 2004-05-07 12:33 pm       703749
       3045 2004-05-02 07:47 pm       389233 Needs order i
                                             n time for Mo
                                             thers Day

4 rows selected.
```

Similarly, if you accessed the table using a reference to only the `SPEC_INSTR` column in the `WHERE` clause, a sort would be necessary to return the rows in the desired order.

To make further improvements in performance, you may consider creating a multitable hash cluster to hold both the orders and the order items, but for now the improvements in processing orders alone will help you avoid new hardware acquisitions for a few months.

Miscellaneous Space Management Features

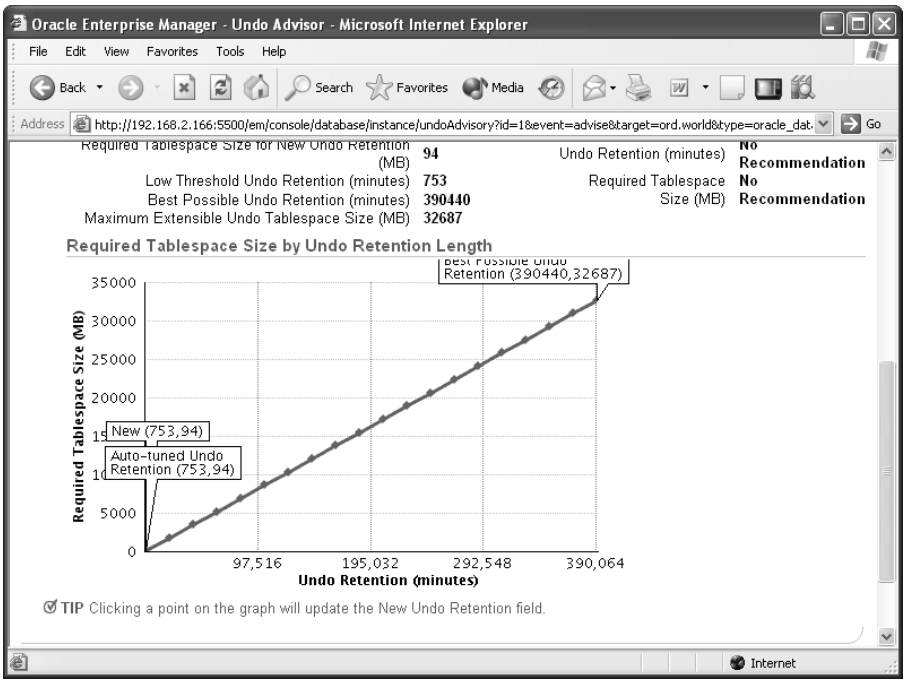
Two other automated space management features fall into the advisor category: the Undo Advisor and the Redo Logfile Size Advisor. In both cases, Oracle collects statistics on a continuous basis to help you size the undo tablespace and the size of the online redo logs to enhance both performance and availability.

Undo Advisor

The EM Database Control *Undo Advisor* helps you determine how large of an undo tablespace is necessary given adjustments to the undo retention setting.

In Figure 5.25, the Undo Advisor screen shows the autotuned undo retention of 753 minutes and an undo tablespace size of 94MB. If you don't expect your undo usage to increase or you don't expect to need to retain undo information longer than 753 minutes, you can drop the size of the undo tablespace if it is significantly more than 94MB.

FIGURE 5.25 Autotuned undo retention settings



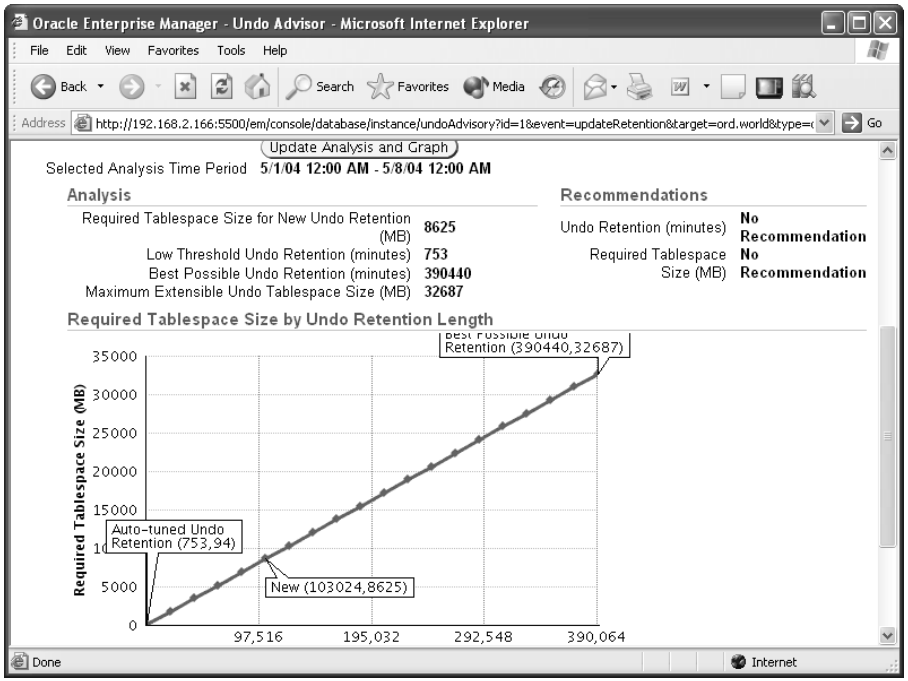
On the other hand, if you expect to need undo information for longer than 753 minutes, you can see the impact of this increase by either entering a new value for undo retention and refreshing the page or by clicking a point on the graph corresponding to the estimated undo retention. Figure 5.26 shows the results of increasing the undo retention to 103,204 minutes.

To support an undo retention setting of 103,204 minutes given the current undo usage, the undo tablespace will have to be increased in size to 8,625MB, or 8.625GB.

Redo Logfile Size Advisor

The *Redo Logfile Size Advisor* provides an automatic method for sizing redo log files. In general, redo logs should be sized large enough so that checkpoints do not occur too frequently; if the logs switch more often than every 20 minutes, performance of the database may be affected. On the other hand, redo logs that are too big may impact disk space usage without a measurable benefit.

FIGURE 5.26 Specifying new undo retention settings



In addition to the amount of redo generated, the other factor that directly affects the proper sizing of the redo logs is the initialization parameter FAST_START_MTTR_TARGET. A parameter available since Oracle 9*i*, FAST_START_MTTR_TARGET indicates the time, in seconds, that instance recovery should take after a crash or instance failure. For the Redo Logfile Size Advisor to provide a value for the optimal log file size, this parameter must be nonzero. As one of Oracle's automated advisors, statistics for optimizing the redo log file size are collected automatically and continually.

The initialization parameters FAST_START_IO_TARGET and LOG_CHECKPOINT_INTERVAL can still be specified to control instance recovery, but setting either of these parameters disables FAST_START_MTTR_TARGET.

In the sample order database, the redo log files are sized as follows:

```
SQL> select member from v$logfile;

MEMBER
---------------------------------------
```

```
/u07/oradata/ord/redo03.log
/u07/oradata/ord/redo02.log
/u07/oradata/ord/redo01.log
/u08/oradata/ord/redo01.log
/u08/oradata/ord/redo02.log
/u08/oradata/ord/redo03.log

6 rows selected.

SQL> !ls -l /u07/oradata/ord/redo03.log
-rw-r-----    1 oracle   oinstall 10486272 Apr 20 14:01
                            /u07/oradata/ord/redo03.log
```

The redo log files are sized at 10MB each, the default size for redo log files when the database was created. The parameter FAST_START_MTTR_TARGET is set for 30 seconds; in other words, you don't want instance recovery to take more than 30 seconds after a crash or instance failure.

```
SQL> show parameter fast_start_mttr_target

NAME                         TYPE        VALUE
---------------------------- ----------- ---------------
fast_start_mttr_target       integer     30
SQL>
```

You have two ways to retrieve the optimal log file size calculated by the Redo Logfile Size Advisor: using a new column in the view V$INSTANCE_RECOVERY or using the EM Database Control. The view V$INSTANCE_RECOVERY contains a new column, OPTIMAL_LOGFILE_SIZE, which recommends a minimum size for the redo logfiles.

```
SQL> select optimal_logfile_size from v$instance_recovery;
OPTIMAL_LOGFILE_SIZE
--------------------
                  49

1 row selected.
```

Given the current log file size of 10MB, you should probably increase the log file size to at least 49MB to reduce the number of log file switches.

Using the EM Database Control, you can retrieve the same information via a graphical interface. In Figure 5.27, review the Redo Log Groups screen containing the number and size of each redo log file.

In the drop-down list on the right, select Sizing Advice, and click Go. Figure 5.28 shows the recommendation for the redo log file size, which coincidentally corresponds with the information obtained from the view V$INSTANCE_RECOVERY.

FIGURE 5.27 Redo Log Groups screen

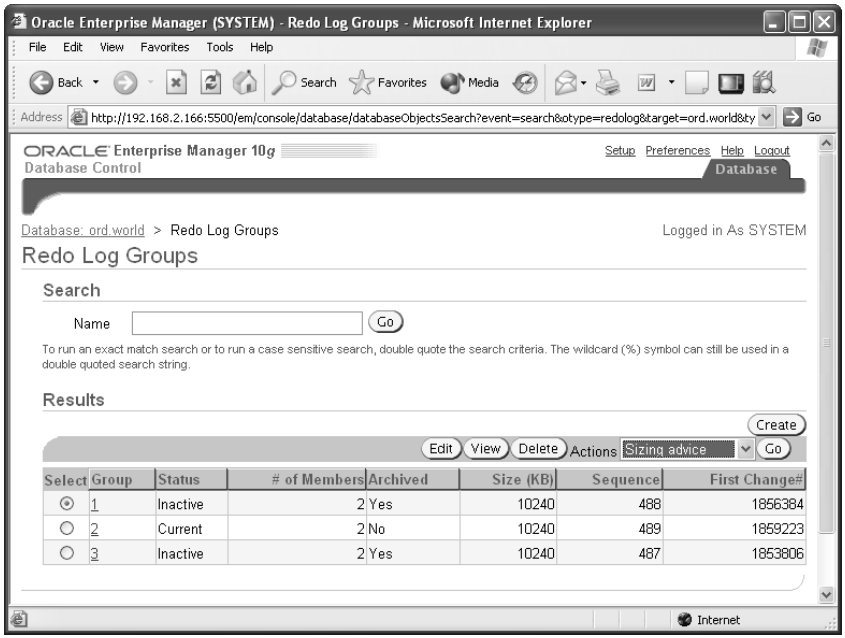
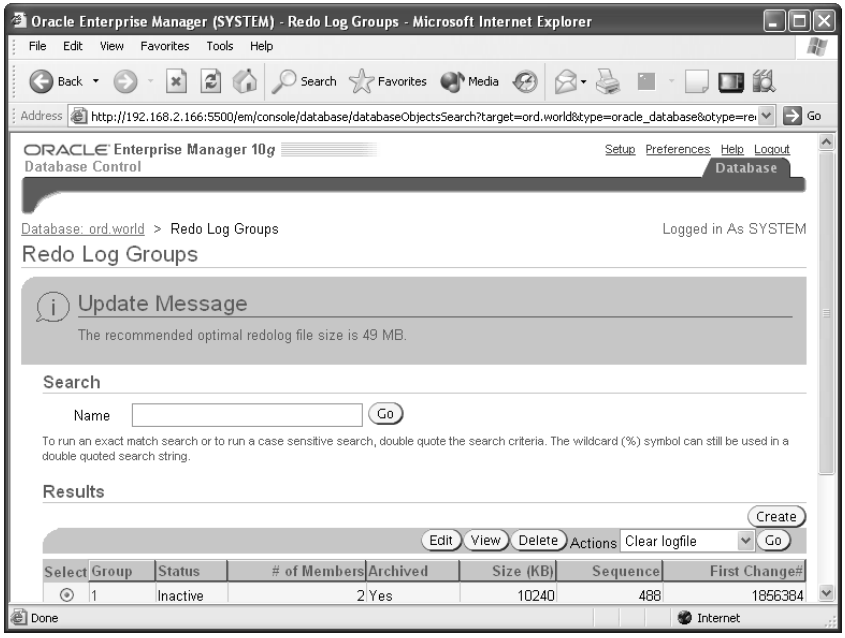


FIGURE 5.28 Redo log group sizing advice



Automatic Storage Management

While this entire chapter focuses on the new automated storage features in Oracle 10*g*, the most automated storage feature, *ASM*, eases the administrative burden of managing potentially thousands of database files by instead creating *disk groups*, composed of disk devices and the files that reside on the disk devices managed as a logical unit.

When creating a new tablespace or other database structure such as a control file or redo log file, you can specify a disk group as the storage area for the database structure instead of an operating system file. ASM takes the ease of use of OMF and combines it with mirroring and striping features to provide a robust file system and logical volume manager that can even support multiple nodes in an Oracle RAC. ASM eliminates the need to purchase a third-party logical volume manager. To provide further benefits beyond a typical third-party logical volume manager, ASM stripes files, not logical volumes.

In addition, ASM not only enhances performance by automatically spreading database objects over multiple devices but increases availability by allowing new disk devices to be added to the database without shutting down the database; ASM automatically rebalances the distribution of files with minimal intervention.

In the following sections, we will delve further into the architecture of ASM. In addition, we will show how you create a special type of Oracle instance to support ASM as well as how to start up and shut down an ASM instance. We will review the new initialization parameters related to ASM and the existing initialization parameters that have new values to support an ASM instance. Finally, we will use some raw disk devices on a development Unix server to demonstrate how disk groups are created and maintained.

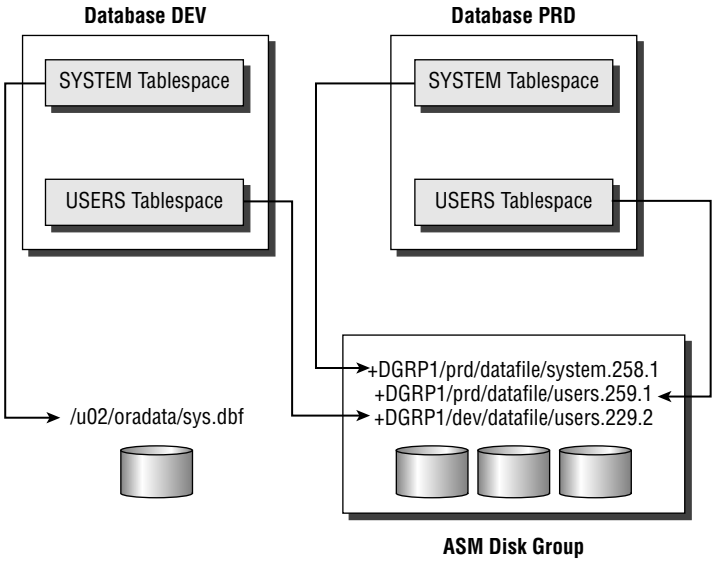
ASM Architecture

ASM divides the datafiles and other database structures into extents and divides the extents among all the disks in the disk group to enhance both performance and reliability. Instead of mirroring entire disk volumes, ASM mirrors the database objects to provide the flexibility to mirror or stripe the database objects differently depending on their type. Optionally, the objects may not be striped at all if the underlying disk hardware is already RAID enabled, for example.

Automatic rebalancing is another key feature of ASM. When you need an increase in disk space, you can add disk devices to a disk group, and ASM moves a proportional number of files from one or more existing disks to the new disks to maintain the overall I/O balance across all disks. This happens in the background while the database objects contained in the disk files are still online and available to users. If the impact to the I/O subsystem is high during a rebalance operation, the speed at which the rebalance occurs can be reduced using an initialization parameter.

As mentioned earlier in the chapter, ASM supports virtually all Oracle object types as well as RAC, eliminating the need to use any other logical volume manager or cluster file system. Figure 5.29 shows an example of a database that contains tablespaces consisting of files both from a traditional file system and from an ASM disk group and another database that allocates all datafiles from an ASM disk group.

FIGURE 5.29 Tablespaces using ASM and traditional datafiles



Note that the example in Figure 5.29 shows that more than one database may allocate files from the same ASM disk group. An ASM file is always spread over all ASM disks in the ASM group; an ASM disk belongs to only one ASM disk group.

ASM disks are partitioned in units of 1MB each.

ASM requires a special type of Oracle instance to provide the interface between a traditional Oracle instance and the file system; the ASM software components are shipped with the database and are always available as a selection when choosing the storage type for the SYSTEM, SYSAUX, and other default tablespaces when the database is created.

We'll show how an ASM instance is created in the next section.

Using ASM does not, however, preclude you from mixing ASM disk groups with manual Oracle datafile management techniques, but the ease of use and performance of ASM makes a strong case for eventually converting all your storage to ASM disk groups.

Two new background processes support ASM instances: *RBAL* and *ORBn*. RBAL coordinates the disk activity for disk groups, and ORB*n*, where *n* can be from 0 to 9, performs the actual extent movement between disks in the disk groups.

For databases that use ASM disks, two new background processes also exist: OSMB and RBAL. OSMB performs the communication between the database and the ASM instance, and RBAL performs the open and close of the disks in the disk group on behalf of the database.

Creating an ASM Instance

ASM requires a dedicated instance to manage the disk groups. An ASM instance generally has a smaller memory footprint in the range of 60MB to 100MB and is automatically configured when ASM is specified as the database's file storage option when installing the Oracle software and an existing ASM instance does not already exist (see Figure 5.30).

As an example, suppose your Linux server has a number of raw disk devices with the capacities listed in Table 5.4.

You will use these raw devices to create, alter, and delete ASM disk groups throughout the rest of this chapter.

Configure the first disk group within the Oracle Universal Installer (OUI), as shown in Figure 5.31.

The name of the first disk group is `DATA1`, and you will be using `/dev/raw/raw1` and `/dev/raw/raw2` to create the normal redundancy disk group. After the database is created, both the regular instance and the ASM instance are started.

FIGURE 5.30 Specifying ASM for database file storage

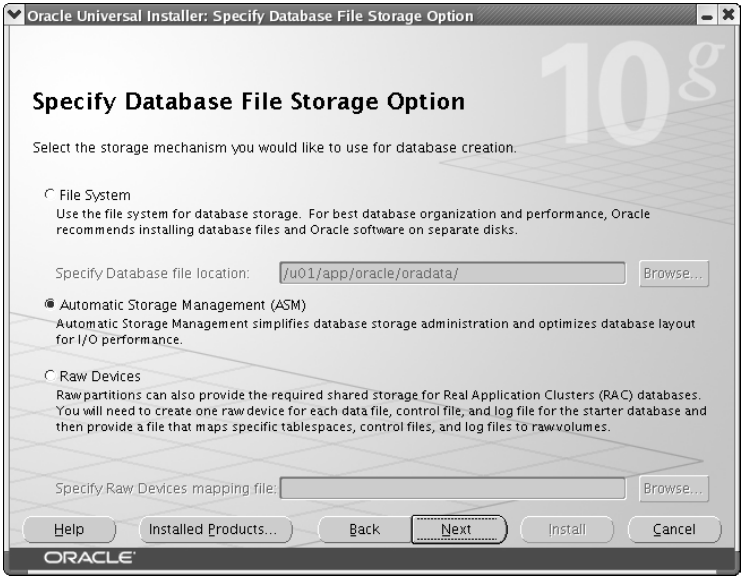
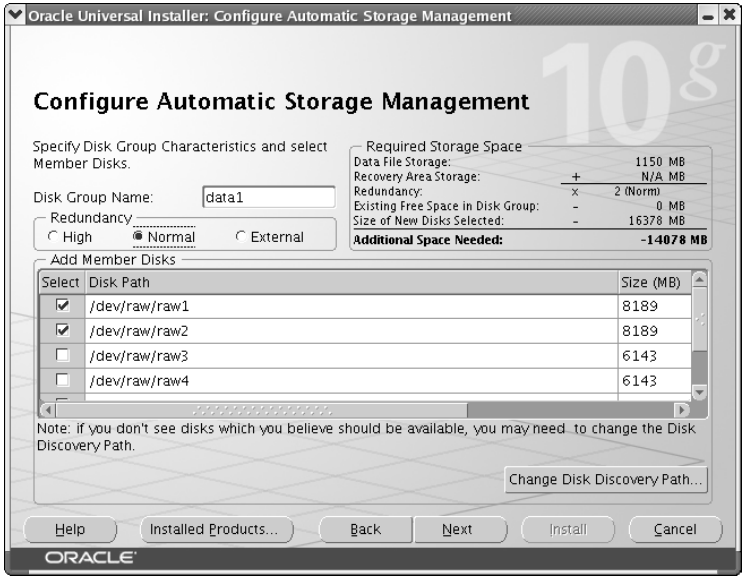


TABLE 5.4 Sample Raw Devices and Capacities

Device Name	Capacity
/dev/raw/raw1	8GB
/dev/raw/raw2	8GB
/dev/raw/raw3	6GB
/dev/raw/raw4	6GB
/dev/raw/raw5	6GB
/dev/raw/raw6	6GB

An ASM instance has a few other unique characteristics. While it does have an initialization parameter file and a password file, it has no data dictionary, and therefore all connections to an ASM instance are via SYS and SYSTEM using operating system authentication only. Disk group commands such as CREATE DISKGROUP, ALTER DISKGROUP, and DROP DISKGROUP are valid only from an ASM instance. Finally, an ASM instance is always in a NOMOUNT state, since it does not have a control file.

FIGURE 5.31 Specifying disk group member disks



ASM Instance Characteristics

ASM instances cannot be accessed using the variety of methods available with a traditional database. In the following sections, we will talk about the privileges available to you that connect with SYSDBA and SYSOPER privileges. We will also distinguish an ASM instance by the new and expanded initialization parameters available only for an ASM instance. Finally, we will present the procedures for starting and stopping an ASM instance along with the dependencies between ASM instances and the database instances they serve.

Accessing an ASM Instance

As mentioned earlier in the chapter, an ASM instance does not have a data dictionary, so access to the instance is restricted to users who can authenticate with the operating system—in other words, connecting as SYSDBA or SYSOPER by an operating system user that is in the dba group.

Users who connect to an ASM instance as SYSDBA can perform all ASM operations, such as creating and deleting disk groups as well as adding and removing disks from disk groups.

The SYSOPER users have a much more limited set of commands available in an ASM instance. In general, the commands available to SYSOPER commands give only enough privileges to perform routine operations for an already configured and stable ASM instance. The list that follows contains the operations available as SYSOPER:

- Starting up and shutting down an ASM instance
- Mounting or dismounting a disk group
- Altering a disk group's disk status to ONLINE or OFFLINE
- Rebalancing a disk group
- Performing an integrity check of a disk group
- Accessing V$ASM_* dynamic performance views

ASM Initialization Parameters

A number of initialization parameters either are specific to ASM instances or have new values within an ASM instance. An SPFILE is highly recommended over an initialization parameter file for an ASM instance: for example, parameters such as ASM_DISKGROUPS will automatically be maintained when a disk group is added or dropped, potentially freeing you from ever having to manually change this value.

We will discuss the various parameters in the following sections.

INSTANCE_TYPE

For an ASM instance, the INSTANCE_TYPE parameter has a value of ASM. The default, for a traditional Oracle instance, is RDBMS.

DB_UNIQUE_NAME

The default value for the DB_UNIQUE_NAME parameter is +ASM and is the unique name for a group of ASM instances within a cluster or on a single node; the default value needs to be modified only if you're trying to run multiple ASM instances on a single node.

ASM_POWER_LIMIT

To ensure that rebalancing operations do not interfere with ongoing user I/O, the ASM_POWER_LIMIT parameter controls how fast rebalance operations occur. The values range from 1 to 11, with 11 being the highest possible value; the default value is 1 (low I/O overhead). Since this is a dynamic parameter, you may set this to a low value during the day and set it higher overnight whenever a disk rebalancing operation must occur.

ASM_DISKSTRING

The ASM_DISKSTRING parameter specifies one or more strings, which are operating system dependent, to limit the disk devices that can be used to create disk groups. If this value is NULL, all disks visible to the ASM instance are potential candidates for creating disk groups.

Here is the value for the development server:

```
SQL> show parameter asm_diskstring

NAME                 TYPE        VALUE
-------------------- ----------- ------------------
asm_diskstring       string      /dev/raw/*
```

When creating disk groups, the only disks available on this server are raw disks.

ASM_DISKGROUPS

The ASM_DISKGROUPS parameter specifies a list containing the names of the disk groups to be automatically mounted by the ASM instance at startup or by the ALTER DISKGROUP ALL MOUNT command. Even if this list is empty at instance startup, any existing disk group can be manually mounted.

LARGE_POOL_SIZE

The LARGE_POOL_SIZE parameter is useful for both regular and ASM instances; however, this pool is used differently for an ASM instance. All internal ASM packages are executed from this pool, so this parameter should be set to at least 8MB.

ASM Instance Startup and Shutdown

An ASM instance is started much like a database instance, except that the STARTUP command defaults to STARTUP MOUNT. Since there is no control file, database, or data dictionary to mount, the ASM disk groups are mounted instead of a database. STARTUP NOMOUNT starts up the instance but does not mount any ASM disks. In addition, you can specify STARTUP RESTRICT to temporarily prevent database instances from connecting to the ASM instance to mount disk groups.

Performing a SHUTDOWN command on an ASM instance performs the same SHUTDOWN command on any database instances using the ASM instance; before the ASM instance finishes a shutdown, it waits for all dependent databases to shut down. The only exception to this is if you use the SHUTDOWN ABORT command on the ASM instance, the ASM instance does not pass the ABORT command to the dependent databases; however, all dependent databases immediately perform a SHUTDOWN ABORT because there is no longer an ASM instance available to manage the database's storage.

For multiple ASM instances sharing disk groups, such as in a RAC environment, the failure of an ASM instance does not cause the database instances to fail. Instead, another ASM instance performs a recovery operation for the failed instance.

ASM Dynamic Performance Views

A few new dynamic performance views are associated with ASM instances. The contents of these views varies depending on whether they are displaying data for an ASM instance or a standard, non-ASM (RDBMS) instance. Table 5.5 contains the common ASM-related dynamic performance views.

We'll provide further explanation where appropriate later in this chapter for some of these views.

TABLE 5.5 ASM Dynamic Performance Views

View Name	Contents In ASM Instance	Contents In RDBMS Instance
V$ASM_DISK	One row for each disk discovered by an ASM instance, whether used by a disk group or not.	One row for each disk in use by the instance.
V$ASM_DISKGROUP	One row for each disk group containing general characteristics of the disk group.	One row for each disk group in use whether mounted or not.
V$ASM_FILE	One row for each file in every mounted disk group.	Not used.
V$ASM_OPERATION	One row for each executing long running operation in the ASM instance.	Not used.
V$ASM_TEMPLATE	One row for each template in each mounted disk group in the ASM instance.	One row for each template for each mounted disk group.
V$ASM_CLIENT	One row for each database using disk groups managed by the ASM instance.	One row for the ASM instance if any ASM files are open.
V$ASM_ALIAS	One row for every alias in every mounted disk group.	Not used.

ASM Filenames

All ASM files are OMF, so the details of the actual filename within the disk group is not needed for most administrative functions. When an object in an ASM disk group is dropped, the file is automatically deleted. Certain commands will expose the actual filenames, such as `ALTER DATABASE BACKUP CONTROLFILE TO TRACE`, as well as some data dictionary views. For example, the data dictionary view `V$DATAFILE` shows the actual filenames within each disk group.

```
SQL> select file#, name, blocks from v$datafile;

  FILE# NAME                                      BLOCKS
------- ---------------------------------------- ---------
      1 +DATA1/rac0/datafile/system.256.1          57600
      2 +DATA1/rac0/datafile/undotbs1.258.1         3840
      3 +DATA1/rac0/datafile/sysaux.257.1          44800
      4 +DATA1/rac0/datafile/users.259.1             640
      5 +DATA1/rac0/datafile/example.269.1         19200
      6 +DATA2/rac0/datafile/users3.256.1          12800

6 rows selected.
```

ASM filenames can be one of six different formats. In the sections that follow, we'll give an overview of the different formats and the context where they can be used: either as a reference to an existing file, during a single-file creation operation, or during a multiple-file creation operation.

Fully Qualified Names

Fully qualified ASM filenames are used only when referencing an existing file. A fully qualified ASM filename has the format

+group/dbname/file type/tag.file.incarnation

where *group* is the disk group name, *dbname* is the database to which the file belongs, *file type* is the Oracle file type, *tag* is the type-specific information about the specific file type, and the *file.incarnation* pair ensures uniqueness. An example of an ASM file for the `USERS3` tablespace is as follows:

```
+DATA2/rac0/datafile/users3.256.1
```

The disk group name is `+DATA2`, the database name is `rac0`, it's a datafile for the `USERS3` tablespace, and the file number/incarnation pair `256.1` ensures uniqueness if you decide to create another ASM datafile for the `USERS3` tablespace.

Numeric Names

Numeric names are used only when referencing an existing ASM file. It allows you to refer to an existing ASM file by only the disk group name and the file number/incarnation pair. The numeric name for the ASM file in the previous section is as follows:

```
+DATA2.256.1
```

Alias Names

You can use an alias either when referencing an existing object or when creating a single ASM file. Using the `ALTER DISKGROUP ADD ALIAS` command, you can create a more user-friendly name for an existing or a new ASM file; they are distinguishable from regular ASM filenames because they do not end in a dotted pair of numbers (the file number/incarnation pair). In the following example, we create a directory object to the `data2` diskgroup, then we use the `ALTER DISKGROUP ADD ALIAS` command to create a more user-friendly alias in the newly created directory object to point to a fully qualified datafile name.

```
SQL> alter diskgroup data2
  2     add directory '+data2/redempt';

Diskgroup altered.
SQL> alter diskgroup data2
  2     add alias '+data2/redempt/users.dbf'
  3     for '+data2/rac0/datafile/users3.256.1';

Diskgroup altered.

SQL>
```

Alias with Template Names

You can use an alias with a template only when creating a new ASM file. Templates provide a shorthand way of specifying a file type and a tag when creating a new ASM file.

The "ASM File Types and Templates" section covers default ASM templates.

An example of an alias using a template for a new tablespace in the `+DATA2` disk group is as follows:

```
SQL> create tablespace users4 datafile
  2     '+data2/uspare(datafile)';
Tablespace created.
```

Incomplete Names

You can use an incomplete filename format either for single file or for multiple file creation operations. You specify only the disk group name, and you use a default template depending on the type of file, as shown here:

```
SQL> create tablespace users5 datafile '+data1';
Tablespace created.
```

Incomplete Names with Template

As with incomplete ASM filenames, you can use an incomplete filename with a template for single-file or multiple-file creation operations. Regardless of the actual file type, the template name determines the characteristics of the file.

Even though you are creating a tablespace, the characteristics of a `tempfile` are used instead as the attributes for the datafile, as shown here:

```
SQL> create tablespace users6 datafile '+data1(tempfile)';
Tablespace created.
```

ASM File Types and Templates

ASM supports all types of files used by the database except for files such as operating system executables. Table 5.6 contains the complete list of ASM file types; *`File Type`* and *`Tag`* are those presented previously for ASM filenaming conventions.

TABLE 5.6 ASM File Types

Oracle File Type	File Type	Tag	Default Template
Control files	`controlfile`	`cf` (control file) or `bcf` (backup control file)	`CONTROLFILE`
Datafiles	`datafile`	*`tablespace name.file#`*	`DATAFILE`
Online logs	`online_log`	`log_`*`thread#`*	`ONLINELOG`
Archive logs	`archive_log`	parameter	`ARCHIVELOG`
Temp files	`temp`	*`tablespace name.file#`*	`TEMPFILE`
RMAN datafile backup piece	`backupset`	Client specified	`BACKUPSET`

TABLE 5.6 ASM File Types *(continued)*

Oracle File Type	File Type	Tag	Default Template
RMAN incremental backup piece	backupset	Client specified	BACKUPSET
RMAN archivelog backup piece	backupset	Client specified	BACKUPSET
RMAN datafile copy	datafile	*tablespace name.file#*	DATAFILE
Initialization parameters	init	spfile	PARAMETERFILE
Broker config	drc	drc	DATAGUARDCONFIG
Flashback logs	rlog	*thread#_log#*	FLASHBACK
Change tracking bitmap	ctb	bitmap	CHANGETRACKING
Auto backup	autobackup	Client specified	AUTOBACKUP
Data Pump dumpset	dumpset	dump	DUMPSET
Cross-platform datafiles			XTRANSPORT

Table 5.7 presents the default ASM file templates referenced in the Default Template column of Table 5.6.

TABLE 5.7 ASM File Templates

System Template	External Redundancy	Normal Redundancy	High Redundancy	Striping
CONTROLFILE	Unprotected	Two-way mirroring	Three-way mirroring	Fine
DATAFILE	Unprotected	Two-way mirroring	Three-way mirroring	Coarse
ONLINELOG	Unprotected	Two-way mirroring	Three-way mirroring	Fine
ARCHIVELOG	Unprotected	Two-way mirroring	Three-way mirroring	Coarse

TABLE 5.7 ASM File Templates *(continued)*

System Template	External Redundancy	Normal Redundancy	High Redundancy	Striping
TEMPFILE	Unprotected	Two-way mirroring	Three-way mirroring	Coarse
BACKUPSET	Unprotected	Two-way mirroring	Three-way mirroring	Coarse
XTRANSPORT	Unprotected	Two-way mirroring	Three-way mirroring	Coarse
PARAMETERFILE	Unprotected	Two-way mirroring	Three-way mirroring	Coarse
DATAGUARDCONFIG	Unprotected	Two-way mirroring	Three-way mirroring	Coarse
FLASHBACK	Unprotected	Two-way mirroring	Three-way mirroring	Fine
CHANGETRACKING	Unprotected	Two-way mirroring	Three-way mirroring	Coarse
AUTOBACKUP	Unprotected	Two-way mirroring	Three-way mirroring	Coarse
DUMPSET	Unprotected	Two-way mirroring	Three-way mirroring	Coarse

The mirroring options in the High Redundancy column of Table 5.7 are discussed in the next section under Disk Group Architecture.

When a new disk group is created, a set of ASM file templates copied from the default templates in Table 5.4 is saved with the disk group; as a result, individual template characteristics can be changed and apply only to the disk group where they reside. In other words, the DATAFILE system template in disk group +DATA1 may have the default coarse striping, but the DATAFILE template in disk group +DATA2 may have fine striping. You can create your own templates in each disk group as needed.

When an ASM datafile is created with the DATAFILE template, by default the datafile is 100MB, the datafile is autoextensible, and the maximum size is unlimited.

Administering ASM Disk Groups

Using ASM disk groups benefits you in a number of ways: I/O performance is improved, availability is increased, and the ease with which you can add a disk to a disk group or add an entirely new disk group enables you to manage many more databases in the same amount of time. Understanding the components of a disk group as well as correctly configuring a disk group is an important goal for a successful DBA.

In the following sections we will delve more deeply into the details of the structure of a disk group. Also, we will review the different types of administrative tasks related to disk groups and show how disks are assigned to failure groups, how disk groups are mirrored, and how disk groups are created, dropped, and altered. We will also briefly review the EM Database Control interface to ASM.

Disk Group Architecture

As defined earlier in this chapter, a *disk group* is a collection of physical disks managed as a unit. Every ASM disk, as part of a disk group, has an ASM disk name that is either assigned by the DBA or automatically assigned when it is assigned to the disk group.

Files in a disk group are striped on the disks using either coarse striping or fine striping. *Coarse striping* spreads files in units of 1MB each across all disks. Coarse striping is appropriate for a system with a high degree of concurrent small I/O requests, such as an OLTP environment. Alternatively, *fine striping* spreads files in units of 128KB and is appropriate for traditional data warehouse environments or OLTP systems with low concurrency and maximizes response time for individual I/O requests.

Failure Groups and Disk Group Mirroring

Before defining the type of mirroring within a disk group, you must group disks into failure groups. A *failure group* is one or more disks within a disk group that share a common resource, such as a disk controller, whose failure would cause the entire set of disks to be unavailable to the group. In most cases, an ASM instance does not know the hardware and software dependencies for a given disk. Therefore, unless you specifically assign a disk to a failure group, each disk in a disk group is assigned to its own failure group.

Once the failure groups have been defined, you can define the mirroring for the disk group; the number of failure groups available within a disk group can restrict the type of mirroring available for the disk group. The following three types of mirroring are available:

External redundancy *External redundancy* requires only one failure group and assumes that the disk is not critical to the ongoing operation of the database or that the disk is managed externally with high-availability hardware such as a RAID controller.

Normal redundancy *Normal redundancy* provides two-way mirroring and requires at least two failure groups within a disk group. The failure of one of the disks in a failure group does not cause any downtime for the disk group or any data loss other than a slight performance hit for queries against objects in the disk group.

High redundancy *High redundancy* provides three-way mirroring and requires at least three failure groups within a disk group. The failure of disks in two out of the three failure groups is for the most part transparent to the database users as in normal redundancy mirroring.

Mirroring is managed at a very low level; extents, not disks, are mirrored. In addition, each disk will have a mixture of both primary and mirrored (secondary and tertiary) extents on each disk. While there is a slight overhead incurred for managing mirroring at the extent level, it provides the advantage of spreading the load from the failed disk to all other disks instead of a single disk.

Disk Group Dynamic Rebalancing

Whenever the configuration of a disk group changes, whether it is adding or removing a failure group or a disk within a failure group, *dynamic rebalancing* occurs automatically to proportionally reallocate data from other members of the disk group to the new member of the disk group. This rebalance occurs while the database is online and available to users; any impact to ongoing database I/O can be controlled by adjusting the value of the initialization parameter `ASM_POWER_LIMIT` to a lower value.

Not only does dynamic rebalancing free you from the tedious and often error-prone task of identifying hot spots in a disk group, it also provides an automatic way to migrate an entire database from a set of slower disks to a set of faster disks while the entire database remains online during the entire operation. The faster disks are added as two or more new failure groups in an existing disk group and the automatic rebalance occurs. The failure groups containing the slower disks are dropped, leaving a disk group with only fast disks. To make this operation even faster, both the `ADD` and `DROP` operations can be initiated within the same `ALTER DISKGROUP` command.

Creating and Deleting Disk Groups

Sometimes you may want to create a new disk group with high redundancy to hold tablespaces for a new gift card redemption application. Using the view `V$ASM_DISK`, you can view all disks discovered using the initialization parameter `ASM_DISKSTRING` along with the status of the disk—in other words, whether it is assigned to an existing disk group or it is unassigned. Here is how you do that:

```
SQL> select group_number, disk_number, name,
  2      failgroup, create_date, path from v$asm_disk;

GROUP_ DISK_
NUMBER NUMBER NAME       FAILGROUP  CREATE_DA PATH

------ ------ ---------- ---------- --------- ---------
     0      0                                 /dev/raw/
                                              raw6
     0      1                                 /dev/raw/
                                              raw5
     0      2                                 /dev/raw/
                                              raw4
     0      3                                 /dev/raw/
                                              raw3
```

```
     1      1 DATA1_0001 DATA1_0001 18-APR-04 /dev/raw/
                                              raw2
     1      0 DATA1_0000 DATA1_0000 18-APR-04 /dev/raw/
                                              raw1

6 rows selected.

SQL>
```

Out of the six disks available for ASM, only two of them are assigned to a single disk group, each in their own failure group. You can obtain the disk group name from the view V$ASM_DISKGROUP.

```
SQL> select group_number, name, type, total_mb, free_mb
  2     from v$asm_diskgroup;

GROUP_NUMBER NAME         TYPE     TOTAL_MB    FREE_MB
------------ ------------ ------ ---------- ----------
           1 DATA1        NORMAL      16378      14024

SQL>
```

Note that if you had a number of ASM disks and disk groups, you could have joined the two views on the GROUP_NUMBER column and filtered the query result by GROUP_NUMBER. Also, you see from V$ASM_DISKGROUP that the disk group DATA1 is a NORMAL REDUNDANCY group consisting of two disks.

Your first step is to create the disk group.

```
SQL> create diskgroup data2 high redundancy
  2  failgroup fg1 disk '/dev/raw/raw3' name d2a
  3  failgroup fg2 disk '/dev/raw/raw4' name d2b
  4  failgroup fg3 disk '/dev/raw/raw5' name d2c
  5  failgroup fg4 disk '/dev/raw/raw6' name d2d;

Diskgroup created.

SQL>
```

Looking at the dynamic performance views, you see the new disk group available in V$ASM_DISKGROUP and the failure groups in V$ASM_DISK.

```
SQL> select group_number, name, type, total_mb, free_mb
  2    from v$asm_diskgroup;
```

```
GROUP_NUMBER NAME          TYPE     TOTAL_MB    FREE_MB
------------ ------------ ------ ---------- ----------
           1 DATA1        NORMAL      16378      14024
           2 DATA2        HIGH        24572      24420

SQL> select group_number, disk_number, name,
  2      failgroup, create_date, path from v$asm_disk;

GROUP_ DISK_
NUMBER NUMBER NAME       FAILGROUP  CREATE_DA PATH
------ ------ ---------- ---------- --------- ---------
     2      3 D2D        FG4        11-MAY-04 /dev/raw/
                                               raw6
     2      2 D2C        FG3        11-MAY-04 /dev/raw/
                                               raw5
     2      1 D2B        FG2        11-MAY-04 /dev/raw/
                                               raw4
     2      0 D2A        FG1        11-MAY-04 /dev/raw/
                                               raw3
     1      1 DATA1_0001 DATA1_0001 18-APR-04 /dev/raw/
                                               raw2
     1      0 DATA1_0000 DATA1_0000 18-APR-04 /dev/raw/
                                               raw1

6 rows selected.

SQL>
```

However, if disk space is tight, you do not need four members; for a high-redundancy disk group, only three failure groups are necessary, so the disk group is dropped and re-created with only three members.

```
SQL> drop diskgroup data2;

Diskgroup dropped.
```

If the disk group had any database objects other than disk group metadata, you would have to specify `INCLUDING CONTENTS` in the `DROP DISKGROUP` command. This is an extra safeguard to make sure that disk groups with database objects are not accidentally dropped. Here is how you do that:

```
SQL> create diskgroup data2 high redundancy
  2    failgroup fg1 disk '/dev/raw/raw3' name d2a
```

```
  3    failgroup fg2 disk '/dev/raw/raw4' name d2b
  4    failgroup fg3 disk '/dev/raw/raw5' name d2c;

Diskgroup created.

SQL> select group_number, disk_number, name,
  2       failgroup, create_date, path from v$asm_disk;

GROUP_ DISK_
NUMBER NUMBER NAME       FAILGROUP  CREATE_DA PATH
------ ------ ---------- ---------- --------- ---------
     0      3                       11-MAY-04 /dev/raw/
                                              raw6
     2      2 D2C        FG3        11-MAY-04 /dev/raw/
                                              raw5
     2      1 D2B        FG2        11-MAY-04 /dev/raw/
                                              raw4
     2      0 D2A        FG1        11-MAY-04 /dev/raw/
                                              raw3
     1      1 DATA1_0001 DATA1_0001 18-APR-04 /dev/raw/
                                              raw2
     1      0 DATA1_0000 DATA1_0000 18-APR-04 /dev/raw/
                                              raw1

6 rows selected.

SQL>
```

Now that the configuration of the new disk group has been completed, you can create a tablespace in the new disk group from the database instance.

```
SQL> create tablespace users3 datafile '+DATA2';
Tablespace created.
```

Since ASM files are OMF, no other datafile characteristics need to be specified when creating the tablespace.

Altering Disk Groups

You can add and drop disks from a disk group; also, you can alter most characteristics of a disk group without re-creating the disk group or impacting user transactions on objects in the disk group.

When a disk is added to a disk group, a rebalance operation is performed in the background after the new disk is formatted for use in the disk group. As mentioned earlier in this chapter, the initialization parameter ASM_POWER_LIMIT controls the speed of the rebalance.

Continuing with the example in the previous section, suppose you decide to improve the I/O characteristics of the disk group DATA1 by adding the last available raw disk to the disk group as follows:

```
SQL> alter diskgroup data1
  2     add failgroup d1fg3 disk '/dev/raw/raw6' name d1c;

Diskgroup altered.
```

The command returns immediately, and the format and rebalance continues in the background. You then check the status of the rebalance operation by checking V$ASM_OPERATION.

```
SQL> select group_number, operation, state, power, actual,
  2     sofar, est_work, est_rate, est_minutes
  3  from v$asm_operation;

GROUP_                                                 EST_
NUMBER OPERA STAT POWER ACTUA SOFAR EST_WORK EST_RATE MIN
------ ----- ---- ----- ----- ----- -------- -------- ----
     1 REBAL RUN      1     1     3      964       60   16
```

This output shows that with a POWER setting of 1, the ASM operation is expected to take approximately 16 minutes more to complete. Since the estimate is a bit higher than you expected, you decide to allocate more resources to the rebalance operation and change the power limit for this particular rebalance operation.

```
SQL> alter diskgroup data1 rebalance power 8;

Diskgroup altered.
```

Checking the status of the rebalance operation confirms that the estimated time for completion in the column EST_MINUTES has been reduced to 4 minutes instead of 16.

```
SQL> select group_number, operation, state, power, actual,
  2     sofar, est_work, est_rate, est_minutes
  3  from v$asm_operation;

GROUP_                                                 EST_
NUMBER OPERA STAT POWER ACTUA SOFAR EST_WORK EST_RATE MIN
------ ----- ---- ----- ----- ----- -------- -------- ----
     1 REBAL RUN      8     8    16      605      118    4
```

About four minutes later, you check the status once more.

```
SQL> /

no rows selected
```

Finally, you can confirm the new disk configuration from the V$ASM_DISK and V$ASM_DISKGROUP views.

```
SQL> select group_number, disk_number, name,
  2   failgroup, create_date, path from v$asm_disk;

GROUP_ DISK_
NUMBER NUMBER NAME       FAILGROUP  CREATE_DA PATH
------ ------ ---------- ---------- --------- ---------
     1      2 D1C        D1FG3      11-MAY-04 /dev/raw/
                                               raw6
     2      2 D2C        FG3        11-MAY-04 /dev/raw/
                                               raw5
     2      1 D2B        FG2        11-MAY-04 /dev/raw/
                                               raw4
     2      0 D2A        FG1        11-MAY-04 /dev/raw/
                                               raw3
     1      1 DATA1_0001 DATA1_0001 18-APR-04 /dev/raw/
                                               raw2
     1      0 DATA1_0000 DATA1_0000 18-APR-04 /dev/raw/
                                               raw1

6 rows selected.

SQL> select group_number, name, type, total_mb, free_mb
  2     from v$asm_diskgroup;

GROUP_NUMBER NAME         TYPE     TOTAL_MB    FREE_MB
------------ ------------ ------ ---------- ----------
           1 DATA1        NORMAL      22521      20116
           2 DATA2        HIGH        18429      18279

SQL>
```

Note that the disk group is still normal redundancy, even though it has three failure groups. However, the I/O performance of SELECT statements against objects in the disk group is improved because of additional copies of extents available in the disk group.

Real World Scenario

Mixing Disk Types within Disk Groups

For our shop floor scheduling and trouble ticket system, we wanted to improve the response time for technicians who checked the status of a repair job, as the application issuing the queries against the database were taking up to 10 seconds during the first shift. To help alleviate the problem, we noticed that we had two spare disk drives in the server running the Oracle 10*g* instance and put the disks to good use by using them in another failure group for the existing disk group.

After only a few minutes of testing, the performance of the queries got worse instead of better in many cases. Upon further investigation, we discovered why the extra disk drives in the server were not used for the database: They were older, slower disks, and as a rule of thumb a disk group should not mix disk drives of different performance levels. Depending on which disk the database object's extents are mapped to, the I/O response time will vary dramatically and may actually be slower than using only the faster disks.

One situation exists where this configuration is temporarily an acceptable configuration: when converting a disk group from slower disks to faster disks. As the faster disks are added, the disk group rebalances, and once the rebalance operation is complete, the slower disks can be dropped from the disk group.

Other disk group `ALTER` commands are as follows:

ALTER DISKGROUP ... DROP DISK This removes a disk from a failure group within a disk group and performs an automatic rebalance.

ALTER DISKGROUP ... DROP ... ADD This drops a disk from a failure group and adds another disk in the same command.

ALTER DISKGROUP ... MOUNT This makes a disk group available to all instances.

ALTER DISKGROUP ... DISMOUNT This makes a disk group unavailable to all instances.

ALTER DISKGROUP ... CHECK ALL This verifies the internal consistency of the disk group.

Using the EM Database Control with ASM Disk Groups

You can also use the EM Database Control to administer disk groups. For a database that uses ASM disk groups, the link Disk Groups under the Administration tab brings you to a login screen for the ASM instance, as shown in Figure 5.32. Remember that authentication for an ASM instance uses operating system authentication only.

After authentication with the ASM instance, you can perform the same operations that you performed earlier in this chapter at the command line: mounting and dismounting disk groups, adding disk groups, adding or deleting disk group members, and so forth. Figure 5.33 shows the ASM administration screen, and Figure 5.34 shows the statistics and options for the disk group `DATA1`.

FIGURE 5.32 ASM instance authentication

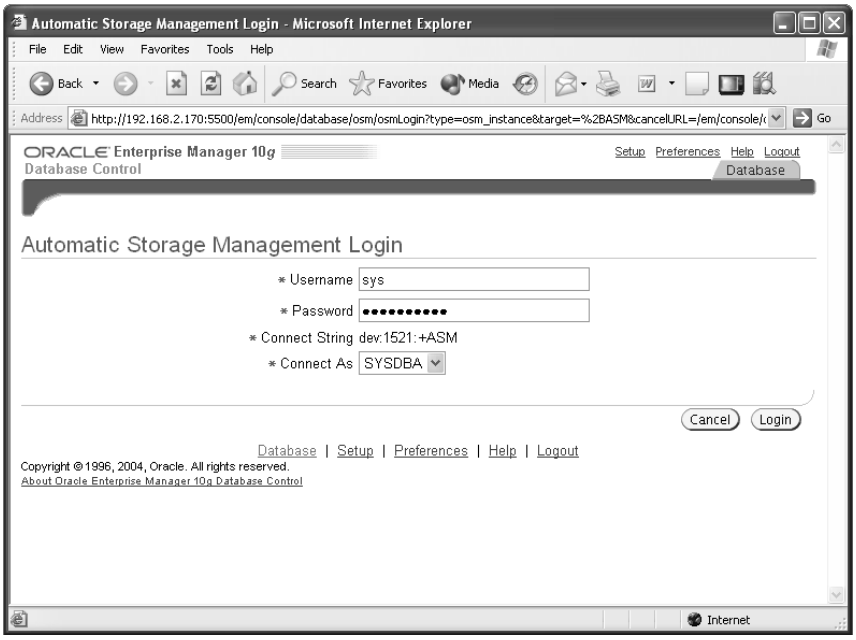


FIGURE 5.33 ASM administration screen

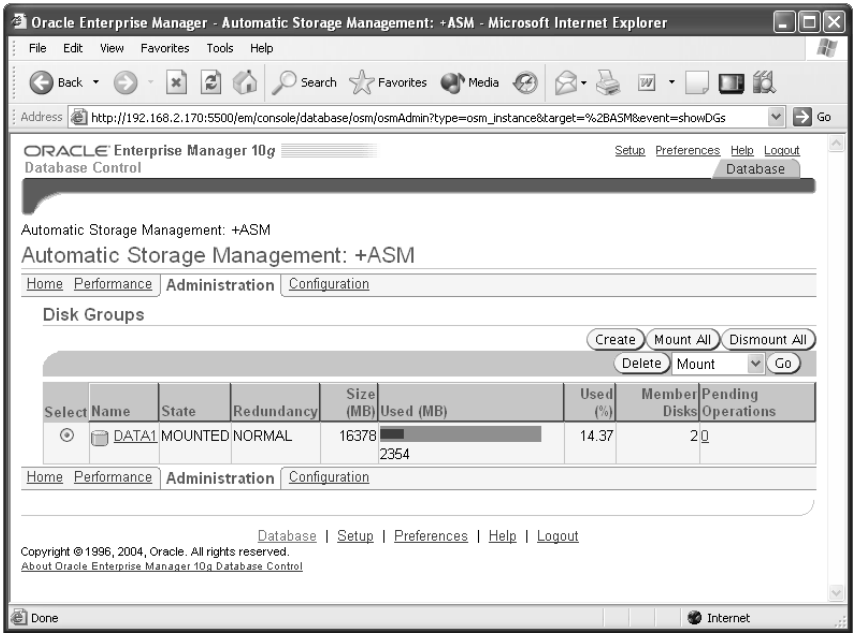
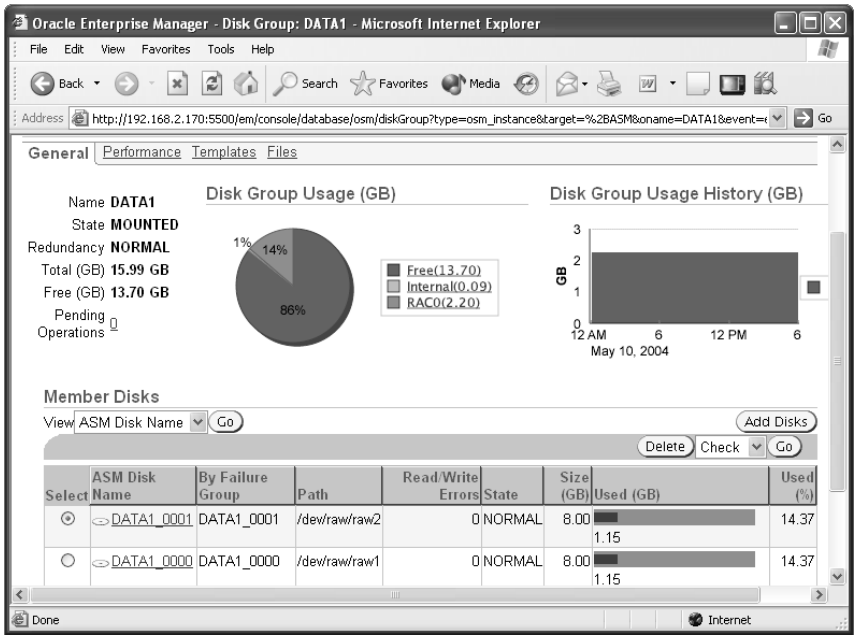


FIGURE 5.34 Disk group maintenance screen



Other the EM Database Control ASM-related screens show things such as I/O response time for the disk group, the templates defined for the disk group, and the initialization parameters in effect for this ASM instance.

Database Migration to ASM

Because ASM files cannot be accessed via the operating system, you must use the Recovery Manager (RMAN) to move database objects from a non-ASM disk location to an ASM disk group. Follow these steps to move these objects:

1. Note the filenames of the control files and the online redo log files.
2. Shut down the database `NORMAL`, `IMMEDIATE`, or `TRANSACTIONAL`.
3. Back up the database.
4. Edit the SPFILE to use OMF for all file destinations.
5. Edit the SPFILE to remove the `CONTROL_FILES` parameter.
6. Run the following RMAN script, substituting your specific filenames as needed:

```
STARTUP NOMOUNT;
RESTORE CONTROLFILE FROM '<controlfile location>';
ALTER DATABASE MOUNT;
BACKUP AS COPY DATABASE FORMAT
   '+<disk group destination>';
```

```
SWITCH DATABASE TO COPY;
SQL "ALTER DATABASE RENAME <logfile1>
         TO '+<disk group destination>' ";
# repeat for all log file members
ALTER DATABASE OPEN RESETLOGS;
```

7. Delete or archive the old database files.

Even though all files in this example are now ASM files, you can still create a non-ASM tablespace if, for example, you want to transport a tablespace to a database that does not use ASM.

Summary

In this chapter we presented an in-depth tour of the automatic features that can help you manage tablespaces along with the segments in the tablespaces in a proactive, instead of a reactive, manner.

Tablespaces can be monitored proactively when they reach one of two thresholds, and an alert can be generated to notify you that a tablespace has crossed the warning or critical threshold level. We showed how the PL/SQL package `DBMS_SERVER_ALERT` gives you a way to programmatically change these thresholds.

The Segment Advisor and segment shrink work together to not only find segments that have unused space but also to compact the space in a segment and free up the space for other database objects. Sorted hash clusters provides you not only with another way to use disk space efficiently but also to optimize the performance of applications that use data in a first-in, first-out (FIFO) fashion.

Going beyond tablespaces and segments to all Oracle file types, we showed you how Automatic Storage Management (ASM) can reduce or eliminate the headaches involved in managing the disk space for all Oracle file types, including online and archived logs, RMAN backupsets, flashback logs, and even initialization parameter files (SPFILEs).

We reviewed the concepts related to a special type of instance called an ASM instance along with the initialization parameters specific to an ASM instance. In addition, we presented the dynamic performance views that allow you to view the components of an ASM disk group as well as to monitor the online rebalancing operations that occur when disks are added or removed from a disk group. Starting and stopping an ASM instance is similar to a traditional database instance, with the added dependencies of database instances that use the disk groups managed by an ASM instance and therefore will not be available to users if the ASM instance is not available to service disk group requests.

ASM filenames have a number of different formats and are used differently depending on whether existing ASM files or new ASM files are being referenced. ASM templates are used in conjunction with ASM filenames to ease the administration of ASM files.

Near the end of the chapter, we reviewed ASM disk group architecture, showing how failure groups can provide redundancy and performance benefits while at the same time eliminating the need for a third-party logical volume manager. Dynamic disk group rebalancing automatically tunes I/O performance when a disk is added or deleted from a disk group or a disk in a disk group fails. While we focused on the SQL commands necessary to manage disk groups, we also presented the EM Database Control interface for performing these same operations.

Exam Essentials

Be able to monitor space usage in a tablespace. Respond to space warning and critical alerts by adding disk space or removing objects. Adjust the space thresholds using either DBMS_SERVER_ALERT or the EM Database Control interface.

Understand how the Segment Advisor and segment shrink work together to optimize space usage and performance. Use the Segment Advisor to analyze one segment or an entire tablespace, and then use segment shrink functionality to compress one or more segments and optionally move the HWM.

Describe how sorted hash clusters are created and used. Identify the types of applications that can benefit from hash clusters whose elements are maintained in a sorted list for each value of the cluster key.

Identify the purpose of the Undo Advisor and Redo Logfile Size Advisor within the Oracle advisory framework. Be able to optimize the UNDO_RETENTION parameter as well as the size of the undo tablespace by using Undo Advisor. Use Redo Logfile Size Advisor to maximize performance by optimizing the time between log file switches.

Enumerate the benefits and characteristics of Automatic Storage Management. Understand how ASM can relieve you of manually optimizing I/O across all files in the tablespace by using ASM disk groups. Show how ASM operations can be performed online with minimal impact to ongoing database transactions.

Be able to create an ASM instance and configure its initialization parameters. Understand the new initialization parameters INSTANCE_TYPE, ASM_POWER_LIMIT, ASM_DISKSTRING, and ASM_DISKGROUPS. Configure DB_UNIQUE_NAME and LARGE_POOL_SIZE for an ASM instance. Start up and shut down an ASM instance noting the dependencies with database instances that are using the ASM instance's disk groups.

Understand how ASM filenames are constructed and used when creating Oracle objects. Differentiate how different ASM file formats are used depending on whether the file is an existing ASM file, whether a new ASM file is being created, or multiple ASM files are being created. Understand the different system templates for creating ASM files and how the characteristics are applied to the ASM files.

Be able to create, drop, and alter ASM disk groups. Define multiple failure groups for new disk groups and how the number of failure groups is different for two-way and three-way mirroring. Show how disk rebalancing can be controlled or rolled back.

Identify the steps involved in converting non-ASM files to ASM files using RMAN. Migrate a database to ASM disk groups by shutting down the database, editing the SPFILE, running an RMAN script for each file to be converted, and opening the database with RESETLOGS.

Review Questions

1. Which data dictionary view provides the recommended action, as a SQL statement, from the Segment Advisor?
   - **A.** DBA_ADVISOR_FINDINGS
   - **B.** DBA_ADVISOR_RECOMMENDATIONS
   - **C.** DBA_ADVISOR_ACTIONS
   - **D.** DBA_ADVISOR_RATIONALE

2. Which of the following is not true about sorted hash clusters?
   - **A.** The new access path is used regardless of the type of predicate in the WHERE clause.
   - **B.** You are allowed to create indexes on sorted hash clusters.
   - **C.** The cost-based optimizer must be used to take advantage of the new access path.
   - **D.** Additional sorts are not necessary if you access the cluster by one of the lists of hash key columns.
   - **E.** More than one table can be stored in a sorted hash cluster.

3. Consider the following scenario: The user SCOTT runs a query at 8:25 a.m. that receives an "ORA-01555: Snapshot too old" error after running for 15 minutes. An alert is sent to the DBA that the undo tablespace is incorrectly sized. At 10:15 a.m. the DBA checks the initialization parameter UNDO_RETENTION, and its value is 3600; the parameter is sized correctly. The DBA doubles the size of the undo tablespace by adding a second datafile. At 1:15 p.m. the user SCOTT runs the same query and once again receives an "ORA-01555: Snapshot too old" error. What happens next? (Choose the best answer.)
   - **A.** The DBA receives another alert indicating that the undo tablespace is still undersized.
   - **B.** The user SCOTT calls the DBA to report that the query is still failing.
   - **C.** The second datafile autoextends so that future queries will have enough undo to complete when there is concurrent DML activity.
   - **D.** Resumable Space Allocation suspends the query until the DBA adds another datafile to the undo tablespace and then the query runs to completion.

4. The background process _____ checks for tablespace threshold violation or clearance every _____ minutes.
   - **A.** MMON, 10
   - **B.** SMON, 10
   - **C.** TMON, 30
   - **D.** PMON, 15
   - **E.** MMON, 30

5. Which of the following initialization parameters influences the recommended redo logfile size provided by the Redo Logfile Size Advisor?

   A. LOG_CHECKPOINT_INTERVAL

   B. OPTIMAL_LOGFILE_SIZE

   C. FAST_START_IO_TARGET

   D. FAST_START_MTTR_TARGET

   E. None of the above

6. Which of the following is not a benefit of segment shrink?

   A. Full table scans will take less time.

   B. Better index access because of a smaller B*Tree.

   C. Space is freed up for other database objects.

   D. All chained rows are fixed.

   E. Space below the HWM is released and the HWM moved down.

7. Which of the following ASM file templates are not striped as Fine?

   A. FLASHBACK

   B. ARCHIVELOG

   C. CONTROLFILE

   D. ONLINELOG

8. You want to migrate your database to ASM, so you've done a clean shutdown, made a closed backup of the entire database, noted the location of your control files and online redo log files, and changed your SPFILE to use OMF. The last step is running an RMAN script to do the conversion. Using the following steps, which is the correct order or the RMAN commands?

```
1   STARTUP NOMOUNT
2   ALTER DATABASE OPEN RESETLOGS
3   SQL "ALTER DATABASE RENAME 'logfile1 path' TO '+dgrp4 ' "   # plus all
    other log files
4   SWITCH DATABASE TO COPY
5   BACKUP AS COPY DATABASE FORMAT '+dgrp4 '
6   ALTER DATABASE MOUNT
7   RESTORE CONTROLFILE FROM 'controlfile_location'
```

   A. 2, 5, 3, 1, 7, 6, 4

   B. 1, 7, 6, 5, 4, 3, 2

   C. 5, 1, 2, 7, 4, 6, 3

   D. 7, 3, 1, 5, 6, 2, 4

9. The EM Database Control Segment Resource Estimation feature uses all the following characteristics of the proposed table except for which one?

   A. Column datatypes

   B. PCTUSED

   C. PCTFREE

   D. Column sizes

   E. Estimated number of rows

10. To reference existing ASM files, you need to use a fully qualified ASM filename. Your development database has a disk group named DG2A, the database name is DEV19, and the ASM file you want to reference is a datafile for the USERS02 tablespace. Which of the following is a valid ASM filename for this ASM file?

    A. dev19/+DG2A/datafile/users02.701.2

    B. +DG2A/dev19/datafile/users02.701.2

    C. +DG2A/dev19/users02/datafile.701.2

    D. +DG2A.701.2

    E. +DG2A/datafile/dev19.users.02.701.2

11. Which of the following is not a benefit of sorted hash clusters? (Choose the best answer.)

    A. Rows within a given cluster key value are sorted by the sort key(s).

    B. The ORDER BY clause is not required to retrieve rows in ascending or descending order of the sort key(s).

    C. Cluster key values are hashed.

    D. Rows selected by a cluster key value using an equality operator are returned in ascending or descending order.

12. On the development database rac0 there are six raw devices /dev/raw/raw1 through /dev/raw/raw6. /dev/raw/raw1 and /dev/raw/raw2 are 8GB each, and the rest are 6GB each. An existing disk group +DATA1, of NORMAL REDUNDANCY, uses /dev/raw/raw1 and /dev/raw/raw2. Which series of the following commands will drop one of the failgroups for +DATA1, create a new disk group +DATA2 using two of the remaining four raw devices, and then cancel the drop operation from +DATA1?

    A.
    ```
    ALTER DISKGROUP DATA1 DROP DISK DATA1_0001;
    CREATE DISKGROUP DATA2 NORMAL REDUNDANCY
      FAILGROUP DATA1A DISK '/dev/raw/raw3'
      FAILGROUP DATA1B DISK '/dev/raw/raw4';
    ALTER DISKGROUP DATA1 UNDROP DISKS;
    ```

B.
```
ALTER DISKGROUP DATA1 DROP DISK DATA1_0001;
CREATE DISKGROUP DATA2 HIGH REDUNDANCY
  FAILGROUP DATA1A DISK '/dev/raw/raw3'
  FAILGROUP DATA1B DISK '/dev/raw/raw4';
ALTER DISKGROUP DATA1 UNDROP DISKS;
```

C.
```
ALTER DISKGROUP DATA1 DROP DISK DATA1_0001;
CREATE DISKGROUP DATA2 NORMAL REDUNDANCY
  FAILGROUP DATA1A DISK '/dev/raw/raw3'
  FAILGROUP DATA1B DISK '/dev/raw/raw4';
ALTER DISKGROUP DATA1 UNDROP DATA1_0001;
```

D.
```
ALTER DISKGROUP DATA1 DROP DISK DATA1_0001
  ADD DISKGROUP DATA2 NORMAL REDUNDANCY
  FAILGROUP DATA1A DISK '/dev/raw/raw3'
  FAILGROUP DATA1B DISK '/dev/raw/raw4';
ALTER DISKGROUP DATA1 UNDROP DISKS;
```

13. In the following scenario, the DBA wants to reclaim a lot of wasted space in the HR.EMPLOYEES table by using the segment shrink functionality. Which of the following is the correct order of the steps?

```
1 ALTER TABLE HR.EMPLOYEES SHRINK SPACE;
2 ALTER TABLE HR.EMPLOYEES DISABLE ROW MOVEMENT;
3 ALTER TABLE HR.EMPLOYEES ENABLE ROW MOVEMENT;
4 ALTER TABLE HR.EMPLOYEES SHRINK SPACE COMPACT;
5 ALTER TABLE HR.EMPLOYEES SHRINK SPACE CASCADE;
```

A. 3, 4, 1, 5, 2

B. 4, 1, 3, 2, 5

C. 5, 2, 1, 3, 4

D. 4, 1, 2, 3, 5

14. Which of the following calls to DBMS_SERVER_ALERT.SET_THRESHOLD will set the thresholds for the UNDOTBS1 tablespace to 60 percent and 90 percent? (Choose the best answer.)

A.
```
dbms_server_alert.set_threshold(
  dbms_server_alert.tablespace_pct_full,
  dbms_server_alert.operator_ge, 60,
  dbms_server_alert.operator_ge, 90,
  1, 1, null,
  dbms_server_alert.object_type_tablespace,
  null);
```

B.
```
dbms_server_alert.set_threshold(
  dbms_server_alert.tablespace_pct_full,
  dbms_server_alert.operator_le, 60,
  dbms_server_alert.operator_le, 90,
  1, 1, null,
  dbms_server_alert.object_type_datafile,
  'UNDOTBS1');
```

C.
```
dbms_server_alert.set_threshold(
  dbms_server_alert.tablespace_full,
  dbms_server_alert.operator_ge, 60,
  dbms_server_alert.operator_ge, 90,
  1, 1, null,
  dbms_server_alert.object_type_tablespace,
  'UNDOTBS1');
```

D.
```
dbms_server_alert.set_threshold(
  dbms_server_alert.tablespace_pct_full,
  dbms_server_alert.operator_ge, 60,
  dbms_server_alert.operator_ge, 90,
  1, 1, null,
  dbms_server_alert.object_type_tablespace,
  'UNDOTBS1');
```

15. Which of the following statements is not true about segment shrink operations? (Choose the best answer.)

A. Tables with ROWID-based materialized views are maintained.

B. Segment shrink is only allowed on segments whose space is automatically managed.

C. Heap-organized and index-organized tables can be shrunk.

D. `ROW MOVEMENT` must be enabled for heap-organized segments.

E. Chained rows may be repaired during a segment shrink operation.

F. Triggers are not fired during a segment shrink operation.

16. Which of the following is not a feature of the Segment Advisor within the EM Database Control?

A. Growth trend analysis

B. Segment resource estimation

C. Finding candidates for segment shrink

D. Finding table segments with chained rows

17. Choose the set of the following initialization parameters that is valid and recommended for an ASM instance.

    A.
    ```
    INSTANCE_TYPE=RDBMS
    ASM_POWER_LIMIT=2
    LARGE_POOL_SIZE=8MB
    DB_UNIQUE_NAME=+ASM
    ASM_DISKGROUPS=DATA1,DATA2
    ```

    B.
    ```
    INSTANCE_TYPE=ASM
    ASM_POWER_LIMIT=2
    LARGE_POOL_SIZE=8MB
    DB_UNIQUE_NAME=+ASM
    ASM_DISKGROUPS=DATA1,DATA2
    ```

    C.
    ```
    INSTANCE_TYPE=ASM
    ASM_POWER_LIMIT=15
    LARGE_POOL_SIZE=8MB
    DB_UNIQUE_NAME=+ASM
    ASM_DISKGROUPS=DATA1,DATA2
    ```

    D.
    ```
    INSTANCE_TYPE=ASM
    ASM_POWER_LIMIT=2
    LARGE_POOL_SIZE=4MB
    DB_UNIQUE_NAME=+ASM
    ASM_DISKGROUPS=DATA1,DATA2
    ```

18. Which of the following scenarios concerning ASM instance shutdown is correct?

    A. When an ASM instance is shut down with `NORMAL`, `IMMEDIATE` or `TRANSACTIONAL`, the same shutdown command is passed to the dependent instances and the ASM instance waits for all dependent instances to shut down before it shuts down.

    B. When an ASM instance shuts down with `NORMAL`, an alert is sent to all dependent instances, notifying the DBA to shut down the dependent instances manually before the ASM instance shuts down.

    C. When an ASM instance shuts down with the `TRANSACTIONAL` option, all dependent instances shut down with either `NORMAL`, `IMMEDIATE` or `TRANSACTIONAL`, depending on the dependent database's default.

    D. When an ASM instance is shut down with `NORMAL`, `IMMEDIATE` or `TRANSACTIONAL`, the same shutdown command is passed to the dependent instances and the ASM instance does not wait for all dependent instances to shut down before it shuts down.

    E. When an ASM instance shuts down with the `IMMEDIATE` option, the ASM instance shuts down immediately and all dependent instances shut down with `ABORT`.

19. Which of the following conditions will trigger an additional sort on a sorted hash cluster? (Choose two.)

A. The `ORDER BY` clause specifies nonsort columns that are not indexed.

B. An `ORDER BY` clause is used in the query although the sort may still fit in memory.

C. The cost-based optimizer is in effect.

D. The `ORDER BY` clause is omitted, and the `WHERE` clause does not reference the cluster key.

E. The `ORDER BY` clause specifies trailing sort columns.

20. Which of the following is not true about segment shrink operations in tablespaces with automatic segment space management?

A. Clustered tables cannot be shrunk.

B. LOB segments can be shrunk.

C. IOT mapping tables and overflow segments cannot be shrunk.

D. Tables with function-based indexes cannot be shrunk.

E. `ROW MOVEMENT` must be enabled for heap-based segments.

Answers to Review Questions

1. C. The data dictionary view DBA_ADVISOR_ACTIONS contains the SQL statement(s) that the Segment Advisor supplies to implement its recommendation for segment maintenance. DBA_ADVISOR_FINDINGS contains the results of the analysis, but no SQL. DBA_ADVISOR_RECOMMENDATIONS presents one or more findings and the benefits for performing the recommendation. DBA_ADVISOR_RATIONALE provides a more detailed set of reasons why the recommendation should be implemented, along with the impact of not performing the recommendation.

2. A. The new access path in a sorted hash cluster is used only if an equality predicate is used.

3. B. Even if the size of the undo tablespace is adjusted after an undo space problem, only one alert is sent for each 24-hour period. Therefore, the only way that the problem will be resolved promptly is for SCOTT to call the DBA, as the DBA will not receive another alert until the next day when another query fails.

4. A. The new background process MMON checks for threshold violations every 10 minutes. An alert is triggered when the threshold is reached or is cleared.

5. D. FAST_START_MTTR_TARGET specifies the desired time, in seconds, for instance recovery after a crash or an instance failure. Therefore, the Redo Logfile Size Advisor uses this value to determine the optimal logfile size. OPTIMAL_LOGFILE_SIZE is not an initialization parameter but a column in the view V$INSTANCE_RECOVERY. The initialization parameters FAST_START_IO_TARGET specifies recovery at the I/O level, and LOG_CHECKPOINT_INTERVAL specifies the frequency of checkpoints in terms of redo logfile blocks used.

6. D. While some chained rows may be fixed with segment shrink functionality, it is not guaranteed that all chained rows will be fixed since not all blocks may be read in a segment shrink operation.

7. B. Files such as ARCHIVELOG files use coarse-grained striping. Fine striping stripes the files every 128KB while coarse striping stripes the files every 1MB. All file types with the exception of FLASHBACK, CONTROLFILE, and ONLINELOG are striped coarse.

8. B. After the RMAN script is run, and the database is up and running successfully, you may delete the old database files.

9. B. Only PCTFREE is used in the calculation, as it is the amount of space to leave free in the block for updates to existing rows. PCTUSED is not needed unless the segment space management is not AUTO. In addition, extent sizes calculated by this feature helps assess the impact on the tablespace where this segment will be stored.

10. B. A fully qualified existing ASM filename has the format +*group*/*dbname*/*filetype*/*tag*.*file*.*incarnation*. In this case, *filetype* is datafile, and *tag* is the tablespace name to which it belongs, or users02.

11. C. While cluster key values in a sorted hash cluster are hashed, this is also true of regular hash clusters and therefore is not a benefit unique to sorted hash clusters.

12. A. Note that the `UNDROP` operation will cancel a drop operation in progress but cannot reverse a drop operation that has already completed. For `HIGH REDUNDANCY`, at least three failure groups must be specified. While you can combine a drop and add operation into one command, the command can reference only one disk group.

13. A. While the segment shrink operation could combine steps A and D, the impact to the users may be lessened by performing two smaller operations instead of one large one.

14. D. The call to `DBMS_SERVER_ALERT.SET_THRESHOLD` must specify the metric `TABLESPACE_PCT_FULL`, the two thresholds, an object type of tablespace, and the tablespace name itself. Specifying `NULL` for the tablespace name will set the threshold for all tablespaces, not just the `UNDOTBS1` tablespace.

15. A. Because the ROWIDs are changed with a segment shrink operation, tables with ROWID-based materialized views cannot be shrunk unless the materialized views are dropped and re-created after the segment shrink operation.

16. D. The Segment Advisor is not used to find tables with chained rows, but instead is used for finding segments that are good candidates for segment shrink or may be growing too fast.

17. B. The `INSTANCE_TYPE` for an ASM instance is `ASM`; otherwise, it is `RDBMS` whether it uses ASM or not. The `ASM_POWER_LIMIT` command controls the speed of a disk group rebalance, but its maximum value is 11. For an ASM instance, the minimum recommended value for `LARGE_POOL_SIZE` is 8MB.

18. A. When an ASM instance shuts down with `NORMAL`, `IMMEDIATE` or `TRANSACTIONAL`, the same shutdown option is passed to all dependent instances and the ASM instance waits for the dependent instances to shut down before shutting itself down. If an ASM instance shuts down with `ABORT`, it immediately shuts down, the dependent instances lose their connection to the ASM instance and as a result shut down with `ABORT` either before or after the ASM instance shuts down completely.

19. A, E. If a query on a sorted hash cluster retrieves rows and an `ORDER BY` clause specifies either nonsort columns or a suffix of the sort columns, additional sorting is required, assuming that indexes are not defined on the columns in the `ORDER BY` clause.

20. B. For segments in tablespaces with automatic segment space management, LOB segments cannot be shrunk. In addition, tables with LONG columns, on-commit materialized views, and ROWID-based materialized view cannot be shrunk. In all cases, shrink operations cannot be performed on segments managed by freelists.

Chapter 6

Performance and Application Tuning

ORACLE DATABASE 10*g* NEW FEATURES FOR ADMINISTRATORS EXAM OBJECTIVES OFFERED IN THIS CHAPTER:

- ✓ **Application Tuning**
  - Use the new optimizer statistics
  - Use the SQL Tuning Advisor
  - Use the SQL Access Advisor
  - Use the performance pages of Database Control

Exam objectives are subject to change at any time without prior notice and at Oracle's sole discretion. Please visit Oracle's training and certification website (`http://www.oracle.com/education/certification/`) for the most current exam objectives listing.

Oracle Database 10*g* (Oracle 10*g*) provides a number of new features and tools to make tuning a database more automated and less error prone. The retirement of the rule-based optimizer model along with the automated statistics-gathering features can significantly improve the overall performance of queries. In addition, DML activities can be automatically monitored for all tables in the database to help the Automatic Database Diagnostic Monitor (ADDM) identify which objects need new statistics generated.

The SQL Tuning Advisor uses an enhanced mode to take a heavily used and resource-intensive SQL statement and perform a number of analyses to generate an optimal execution plan that can be far superior to the execution plan generated by the traditional cost-based optimizer algorithm. The SQL Tuning Advisor will also use the information from the ADDM to compensate for stale or missing statistics until the statistics can be recomputed.

The SQL Access Advisor, run by itself or from a recommendation by the SQL Tuning Advisor, is used typically in a data warehouse environment to recommend changes to an indexing or materialized view strategy, taking into account storage and maintenance trade-offs.

In this chapter, we'll present the new automatic statistics-gathering features of Oracle 10*g* and the corresponding data dictionary views. We will talk about the desupport of the rule-based optimizer and what is replacing it in Oracle 10*g*. Next, we will give you a tour of the SQL Tuning Advisor and how it can automate many of the labor-intensive tuning tasks required in previous versions of Oracle. For a DSS environment, we will review how the SQL Access Advisor can recommend changes to a database's indexing and materialized view strategy to maximize throughput and optimize storage requirements. Finally, we will take you on a tour of some key performance pages in the Enterprise Manager (EM) Database Control and show how you can drill down and identify potential problem areas in a GUI environment.

Managing Optimizer Statistics

The optimizer statistics-gathering function in Oracle 10*g* has been enhanced to become more automated. If the database is created using the Database Creation Assistant (DBCA), a batch job is automatically created and started at database creation to collect statistics on database objects with missing or stale statistics.

To account for CPU-intensive or CPU-only operations, the optimizer now takes into account both CPU time and I/O load when creating an execution plan; in addition, the optimizer can use dynamic sampling to generate additional statistics at runtime to further fine-tune the execution plan. To further enhance the performance of CPU-bound queries on fixed tables and data dictionary tables, the `DBMS_STATS` package has been enhanced to gather statistics on these tables.

Monitoring tables for DML activity has been simplified by using a single initialization parameter to control the collection of statistics instead of collecting statistics on individual tables.

Given the comprehensive support for statistics collection, the rule-based optimizer has been desupported. In the following sections, we'll review the new initialization parameter values available to control the behavior of the cost-based optimizer.

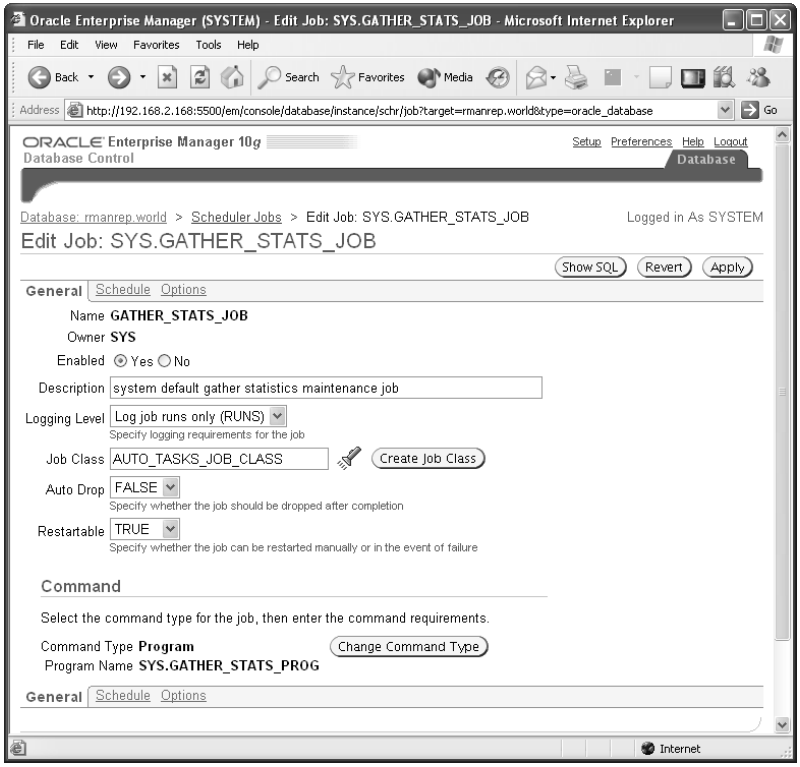
Gathering Automatic Statistics

When a new database is created, the job `GATHER_STATS_JOB` is automatically created and scheduled. This job gathers statistics on a regular basis for database objects whose statistics are either missing or stale. It calls the procedure `DBMS_STATS.GATHER_DATABASE_STATS_JOB_PROC`, which operates similarly to the procedure `DBMS_STATS.GATHER_DATABASE_STATS` with the `GATHER AUTO` option available in previous releases of Oracle.

The `GATHER_DATABASE_STATS_JOB_PROC` procedure provides additional benefits beyond automating the collection process: it processes objects that most need updated statistics first.

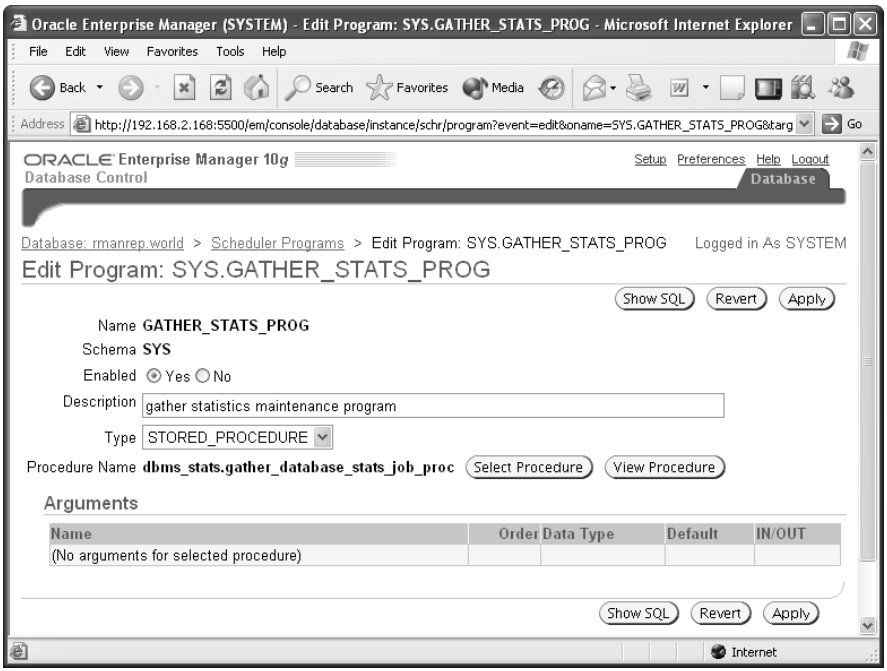
In Figure 6.1, the EM Database Control Scheduler Jobs page (reachable from the EM Database Control Administration tab via the Jobs link under Scheduler) shows the `GATHER_STATS_JOB` and the program it runs: `SYS.GATHER_STATS_PROG`.

FIGURE 6.1 EM Database Control job editing



This program in turn calls the procedure DBMS_STATS.GATHER_DATABASE_STATS_JOB_PROC as you can see on the Edit Program screen in Figure 6.2.

FIGURE 6.2 EM Database Control program editing



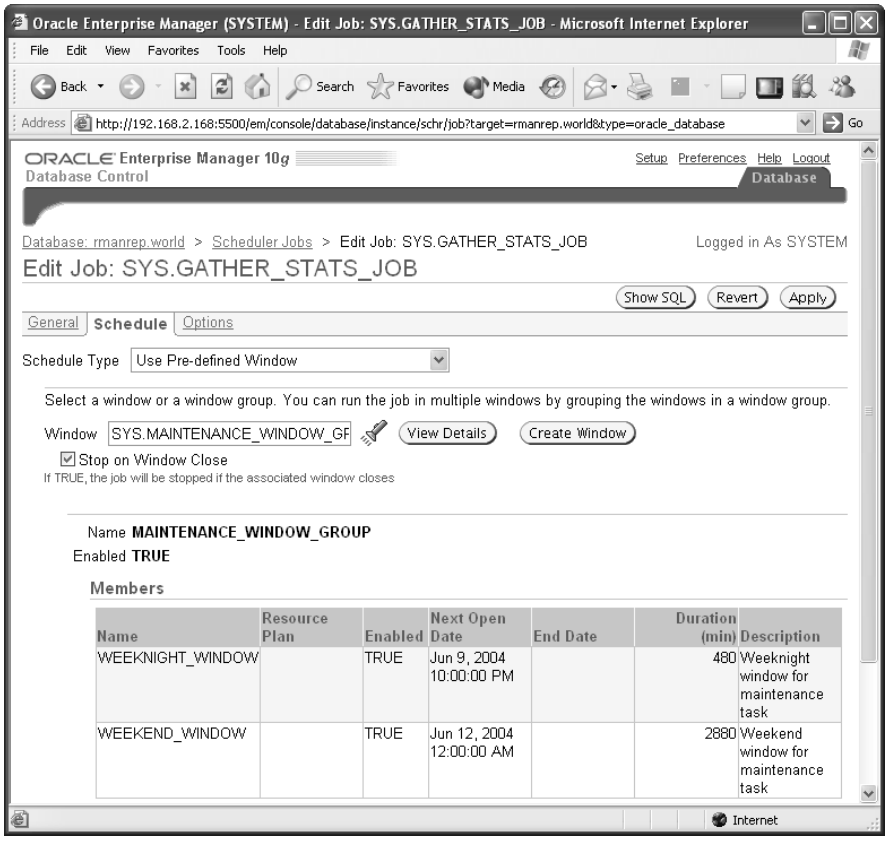
On the job editing schedule page, shown in Figure 6.3, you can see the two maintenance windows for running this job.

Within the specified maintenance windows, the GATHER_STATS_JOB procedure may not have time to update all missing and stale object statistics. As a result, the prioritization process performed by GATHER_DATABASE_STATS_JOB_PROC ensures that at a minimum the objects needing statistics the most are analyzed.

Leveraging Enhanced Query Optimization

Oracle's enhanced cost model now takes into account CPU-intensive or CPU-only operations, in contrast to versions of Oracle before Oracle 9*i* that only considered I/O costs. In Oracle 10*g*, the default cost model considers both CPU and I/O. Also, the table PLAN_TABLE has a new column, TIME, that estimates the elapsed time, in seconds, for the query as estimated by the new cost model.

FIGURE 6.3 EM Database Control job window editing



The new initialization parameter `OPTIMIZER_DYNAMIC_SAMPLING` controls how the enhanced query optimizer can deal more effectively with objects at runtime that have no statistics, have stale statistics, or are very volatile. Setting `OPTIMIZER_DYNAMIC_SAMPLING` to a number other than zero determines how much *dynamic sampling* will occur when the execution plan is generated. Dynamic sampling is a method of statistics collection, controlled by the initialization parameter `OPTIMZER_DYNAMIC_SAMPLING`, that produces compile-time statistics for query objects that have stale or missing statistics. The range of this parameter is from 0 to 10, with a default value of 2. For queries against very volatile objects, it is wise to not explicitly compute statistics and let dynamic sampling drive the generation of the execution plan.

Another initialization parameter that is changed as part of the enhanced query optimizer is `PGA_AGGREGATE_TARGET`. Automatic PGA memory management is enabled by default unless

PGA_AGGREGATE_TARGET is set to 0 or the parameter WORKAREA_SIZE_POLICY is set to MANUAL. By default, PGA_AGGREGATE_TARGET is 20 percent of the SGA size.

Gathering Data Dictionary Statistics

As of Oracle 10*g*, it is beneficial to collect statistics on data dictionary tables, both fixed and real tables. A *fixed table* is a table that exists in memory only that typically contains information about instance or memory structures and is presented in the form of a table. Since fixed tables reside in memory only, they have no I/O cost associated with them; now that the cost-based optimizer takes into account CPU cost, a more robust execution plan can be generated when taking into account statistics on fixed tables. In contrast, a real table is stored in a datafile, persists between instance restarts and incurs I/O overhead unless it is specifically cached in memory. Gathering statistics on real data dictionary tables provides the same benefit as statistics gathered on user or application tables: better execution plans.

In this section we'll show you how to gather statistics on both real and fixed tables, as well as review the other changes to the DBMS_STATS package.

Getting Statistics on Real Data Dictionary Tables

To collect statistics on data dictionary tables, use the procedure DBMS_STATS.GATHER_SCHEMA_STATS or DBMS_STATS.GATHER_DATABASE_STATS with the parameter GATHER_SYS set to TRUE.

```
SQL> exec dbms_stats.gather_database_stats( -
  2       estimate_percent => 5, -
  3       gather_sys => true);
PL/SQL procedure successfully completed.
```

Alternatively, a new procedure called DBMS_STATS.GATHER_DICTIONARY_STATS is convenient shorthand for gathering statistics on only the SYS, SYSTEM, and other RDBMS component tables.

```
SQL> exec dbms_stats.gather_dictionary_stats;
PL/SQL procedure successfully completed.
```

Either the SYSDBA privilege or the new system privilege ANALYZE ANY DICTIONARY is required to analyze data dictionary or fixed tables.

Getting Statistics on Fixed Data Dictionary Tables

If you use DBMS_STATS.GATHER_DATABASE_STATS, you can set the parameter GATHER_FIXED, which defaults to FALSE, to TRUE to gather statistics for fixed tables in addition to any other statistics collected.

If the need arises to collect statistics on an individual fixed table, you can use the DBMS_STATS package as with any traditional table.

```
SQL> exec dbms_stats.gather_table_stats( -
  2      ownname => 'SYS', -
  3      tabname => 'x$le');
PL/SQL procedure successfully completed.
```

Only fixed table statistics can be gathered with the procedure GATHER_FIXED_OBJECT_STATS.

```
SQL> exec dbms_stats.gather_fixed_object_stats;
PL/SQL procedure successfully completed.
```

Gathering statistics on fixed tables is typically required only once during a typical system workload; in other words, unless a new application has been installed, a monthly data warehouse load has been performed, or the database software has been patched or upgraded, it is not necessary to regather fixed table statistics.

Exploring Other Changes to *DBMS_STATS*

In addition to the new procedures in DBMS_STATS, new values for the parameters GRANULARITY and DEGREE are available in all the GATHER_*_STATS procedures.

The new values for GRANULARITY are AUTO (the default value) and GLOBAL AND PARTITION. Using AUTO will determine the granularity value based on the partitioning and subpartitioning type: If the subpartition type is LIST, the global, partition, and subpartition statistics are generated; otherwise, only global and partition statistics are generated. Using GLOBAL AND PARTITION gathers only global and partition statistics even if subpartitions exist.

DEGREE can now have a value of AUTO_DEGREE. Depending on the number of CPUs and the size of the object, Oracle sets DEGREE to either 1 or DEFAULT_DEGREE. The default value of DEGREE is NULL, which directs the DBMS_STATS procedures to use the default value specified for DEGREE when the table or index was created or altered.

The default values for these parameters should be sufficient in most cases.

Monitoring DML Tables

In previous versions of Oracle, you would use the command ALTER TABLE … MONITORING to capture the amount of DML activity against one or more tables and subsequently use DBMS_STATS to gather statistics on these tables under the assumption that the statistics have become stale.

Starting with Oracle 10*g*, you can no longer monitor individual tables and must use the initialization parameter STATISTICS_LEVEL. The values for STATISTICS_LEVEL are as follows:

- BASIC
- TYPICAL
- ALL

A value of BASIC disables monitoring, and as a result the Automatic Workload Repository (AWR) snapshots are disabled in addition to the ADDM. Using BASIC may be advisable only in a DSS environment where the queries rarely vary day to day, the system has been thoroughly tuned already, the size of the database changes infrequently, the database is static, and the fastest possible execution speed of all queries is the top priority.

Using a value of TYPICAL will collect most statistics required for database self-management and delivers the best overall performance; specifying ALL collects additional statistics such as timed operating system statistics and plan execution statistics, but incurs a significant amount of overhead above and beyond the TYPICAL level that may have a noticeable impact on user transactions.

Understanding Rule-Based Optimizer Desupport

While the rule-based optimizer (RBO) still exists in Oracle 10*g*, it is no longer supported. The RBO has no changes in Oracle 10*g*, and no bug fixes will be provided for the RBO. As a result, the values CHOOSE and RULE are no longer valid for the OPTIMIZER_MODE initialization parameter. In addition, the CHOOSE and RULE optimizer hints are no longer supported. The only valid values for OPTIMIZER_MODE are as follows:

FIRST_ROWS A value of FIRST_ROWS directs the optimizer to use costs and internal algorithms to deliver the first few rows quickly.

FIRST_ROWS_n FIRST_ROWS_*n*, where *n* can be 1, 10, 100, or 1000, uses a cost-based approach to deliver the first *n* rows as quickly as possible.

ALL_ROWS ALL_ROWS is the default value for OPTIMIZER_MODE. The optimizer picks an execution plan to provide the best throughput to return all results of the query, minimizing the total resources needed to run the query.

Understanding the SQL Tuning Advisor

Oracle 10*g*'s Automatic SQL Tuning feature of the query optimizer replaces manual tuning and, as a result, automates the entire tuning process. You access the Automatic SQL Tuning feature via the *SQL Tuning Advisor*. The SQL Tuning Advisor has two modes: *normal mode* and *tuning mode*.

Normal mode is much like the query optimizer in previous versions of Oracle. The SQL statement is compiled, and an execution plan is generated, usually generating a good plan for most SQL statements given the very narrow time constraints in normal mode, usually a fraction of a second.

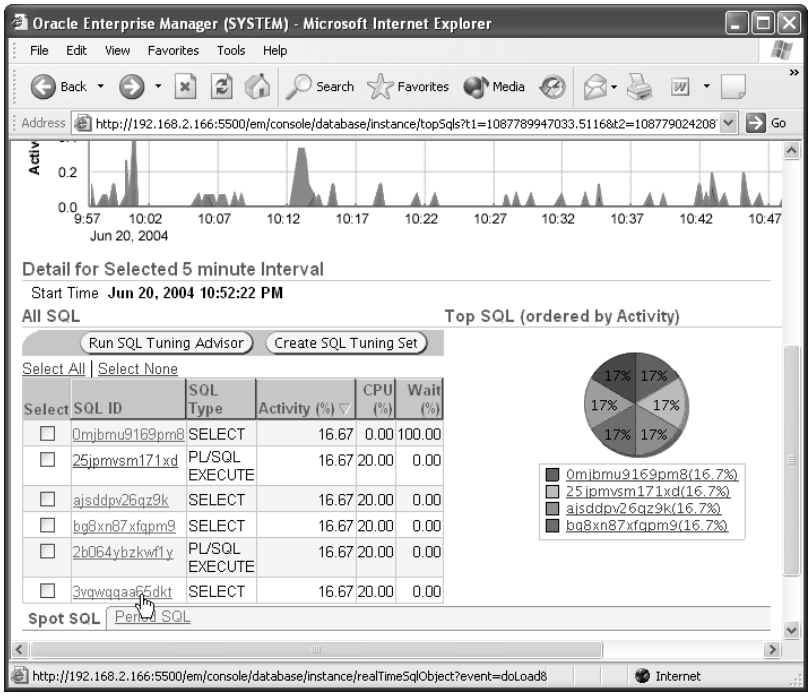
Tuning mode is used only for previously identified high-load SQL, since its analysis is measured in minutes rather than fractions of a second. The output from tuning mode goes beyond an execution plan to a series of recommended actions and rationales that should produce a better execution plan for future executions of the SQL statement. In tuning mode, the Oracle query optimizer is called the *Automatic Tuning Optimizer* (ATO).

In the following sections, we will provide details on how each tuning mode works: its components, how to use it, how to use one of its subcomponents directly, and how to access this functionality via the EM Database Control.

Introducing the SQL Tuning Advisor

Before you can tune a high-load SQL statement, you must be able to identify which SQL statements are causing the high load on the system. In previous versions of Oracle, this process alone was labor intensive or required third-party tools. In Oracle 10*g*, the ADDM automates the process of identifying the high-load SQL from the SQL workload. In Figure 6.4, ADDM has identified a number of high-load SQL statements from the selected five-minute interval.

FIGURE 6.4 EM Database Control High-load SQL



For more information on ADDM, see Chapter 3, "Automating Management."

The SQL Tuning Advisor receives one or more SQL statements as input, and considering a number of factors, including CPU, I/O, and temporary space usage, provides advice on how to improve the execution plan along with expected benefits. The SQL Tuning Advisor performs four specific types of analysis:

- Statistics analysis
- SQL profiling
- Access path analysis
- SQL structure analysis

Statistics Analysis

The ATO verifies if the objects in the query have up-to-date statistics. If not, it recommends gathering statistics; in the mean time, it provides information to take the place of statistics until new statistics are gathered, such as dynamic sampling techniques controlled by the initialization parameter `OPTIMIZER_DYNAMIC_SAMPLING`. The information gathered is stored in a SQL profile, discussed in the next section.

SQL Profiling

The SQL profiling step uses other methods to verify its analysis in the statistics analysis phase and creates customized optimizer settings for the SQL query being analyzed, such as `ALL_ROWS` or `FIRST_ROWS_`*n*. Verification methods include past executions of the SQL statement or even partially executing the SQL statement. It recommends creating a *SQL profile* to store this information for future use by the query optimizer when it is running in normal mode. A SQL profile is a collection of additional information about a SQL query that is collected during the automatic tuning of a SQL statement that can be used to improve the execution plan for future executions of the SQL statement. The creation and use of the profile is completely transparent to the user running the same SQL statement in the future; the user may, however, notice that the query runs faster than the last time!

Access Path Analysis

ATO's *access path analysis* may indicate that a new index can dramatically improve the query's performance; part of ATO's recommendations may include one or more new indexes on each table in the query. The SQL Access Advisor, discussed later in this chapter, performs a similar

Real World Scenario

Longevity of a SQL profile

Information in a SQL profile does not necessarily become obsolete after a day or two; it stays flexible even in the face of added or deleted indexes or growth of tables. We had just saved a SQL profile for an order-entry table earlier in the week, so we were concerned when the analysts were complaining about slower queries later in the week. It turned out that three different things happened that we were not aware of nor paid attention to: first, the domain codes for the order types were modified to include new overseas locations. This made the statistics for the table stale, and the statistics collection window was not large enough to capture new statistics for the order entry table yet; other, worse-performing tables were being analyzed ahead of the order table. In addition, the ADDM put one of the SQL statements near the top of the high-load SQL list, but those queries were always high on the list to begin with, and we did not notice it moving up in the list. We were also behind on standardizing the interface for performing queries against the order tables and the data warehouse tables, so any one particular SQL statement was most likely different from the rest.

The lesson to be learned here is fourfold. First, stay on the distribution list for changes to business rules that will most likely affect the performance of your database so you can be proactive instead of reactive. Second, pay attention to the alerts generated by the ADDM before the users start calling. Third, even though the statistics collection may be automated, you still have to have the maintenance window large enough to analyze your largest and most volatile tables on a frequent basis. Fourth, and probably something that has been true since the Oracle database first cached SQL statements, limit the ad-hoc SQL on a production system to avoid memory problems and improve the chances that the SQL a user is executing is already in the cache.

analysis. In fact, since the access path analysis does not look beyond one SQL statement, one of the recommendations may be to run the SQL Access Advisor to perform further analysis along with the rest of the SQL workload.

SQL Structure Analysis

ATO's SQL structure analysis tries to find potential coding errors in a SQL statement or SQL constructs that may produce bad plans. Its recommendations include alternate coding methods for the SQL statement. For example, the SQL structure analysis may recommend a `NOT IN` instead of a `NOT EXISTS`, or it may recommend a `UNION ALL` if it determines that a `UNION` (and therefore an additional sort) may not be necessary. In addition, mismatched datatypes

in the predicates, which can potentially eliminate the use of an index, are flagged by the analysis. Other potential design mistakes such as using a Cartesian product are also identified. However, the final determination as to whether these recommendations will be implemented is up to the end user: for example, in rare cases a Cartesian product is a valid construct in a SQL statement.

Using SQL Tuning Advisor

The SQL Tuning Advisor uses a number of different sources for the SQL statements to be analyzed.

- High-load SQL identified by the ADDM
- SQL statements that are still in the cursor cache
- SQL statements from the AWR
- A user-defined set of SQL statements

Note that the user-defined set of SQL statements may never have been executed: the SQL Tuning Advisor is a great way to analyze your SQL long before it goes into production.

If the SQL statements come from the cursor cache, AWR, or a custom workload, they can be filtered or sorted before going to the Tuning Advisor.

For a custom workload consisting of more than one SQL statement, you can use a *SQL Tuning Set (STS)*. An STS is a convenient way to maintain a set of SQL statements along with its execution information, such as the schema name under which the SQL was executed, the values of the bind variables, average elapsed time to execute, and how many times the statement has been executed. An STS may be stacked: a new STS can consist of other SQL statements and STSs.

In the following sections, we will show you how to use the SQL Tuning Advisor with both the EM Database Control and via the `DBMS_SQLTUNE` package. In addition, we'll present the new initialization parameter that controls the behavior of the SQL Tuning Advisor.

SQL Tuning and the EM Database Control

Identifying top SQL statements within the EM Database Control and tuning these SQL statements with the SQL Tuning Advisor is very straightforward using the EM Database Control's web-based interface. Clicking the Top SQL link under the Performance tab on the database home page, you can identify which SQL statements are using the most resources.

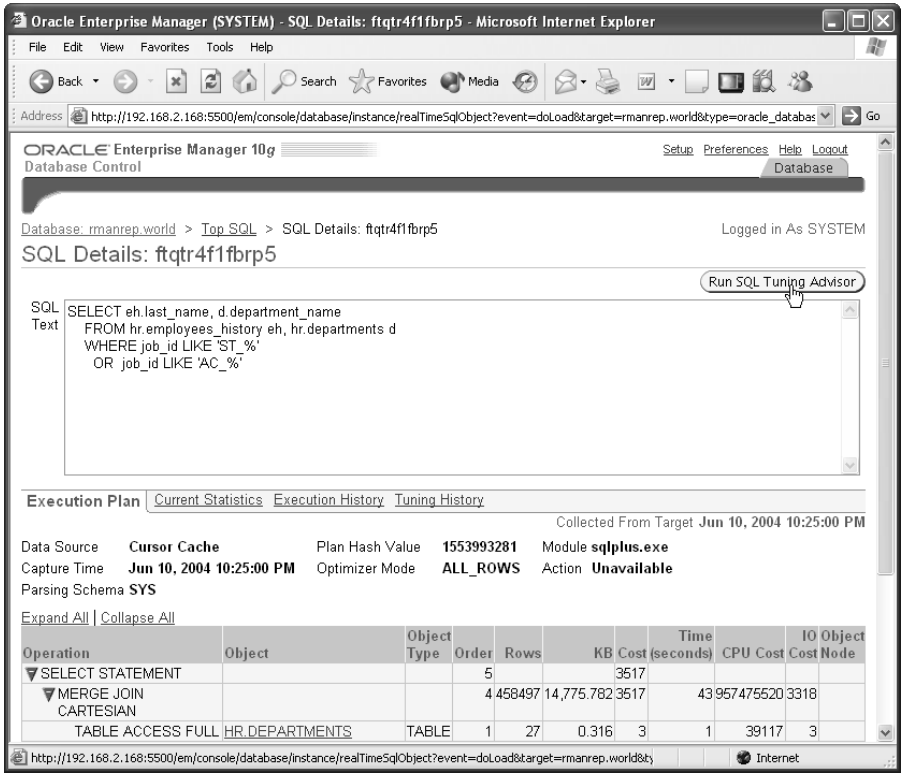
In the following example, one of the application developers has created an employee history table named `HR.EMPLOYEES_HISTORY` that contains employees who have either changed

departments or left the company. One of the top SQL statements that accesses this new table is as follows:

```
select eh.last_name, d.department_name
     from hr.employees_history eh, hr.departments d
     where job_id like 'ST_%' or job_id like 'AC_%';
```

The Top SQL page of the EM Database Control identifies this query as using a lot of resources compared to the rest of the SQL load. On the SQL Details page shown in Figure 6.5 you can see the SQL statement itself along with the execution plan used.

FIGURE 6.5 EM Database Control SQL Details page



You suspect that improvements could be made to this query, so you click the Run SQL Tuning Advisor link and schedule a job to perform the analysis on the Schedule Advisor page, shown in Figure 6.6.

Clicking the OK button submits the job. On the Recommendations page shown in Figure 6.7, you see that there are three findings: one of the tables does not have any statistics, there are no indexes on one of the tables, and the query itself has a Cartesian join, which is almost always a query design error.

To implement one of these recommendations, you can select the recommendation and click the Implement link. For example, if you select Index and click Implement, you can schedule a job to implement the creation of the index. Before you submit the job, you can view the SQL that will be used to implement the recommendation, as you can see in Figure 6.8.

FIGURE 6.6 EM Database Control Schedule Advisor page

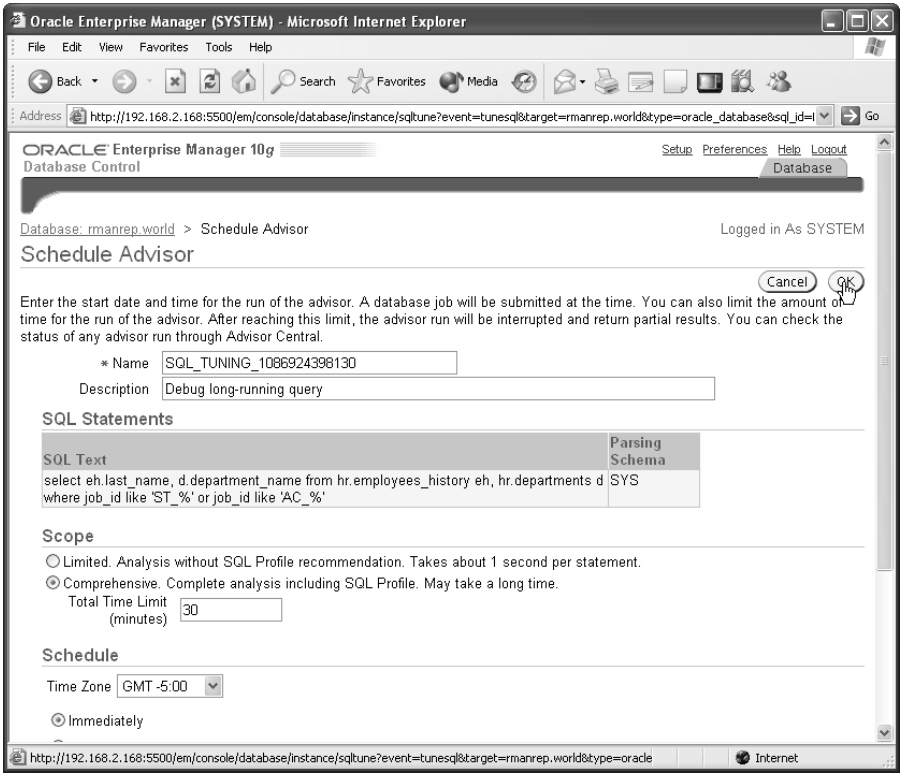


FIGURE 6.7 EM Database Control Recommendations page

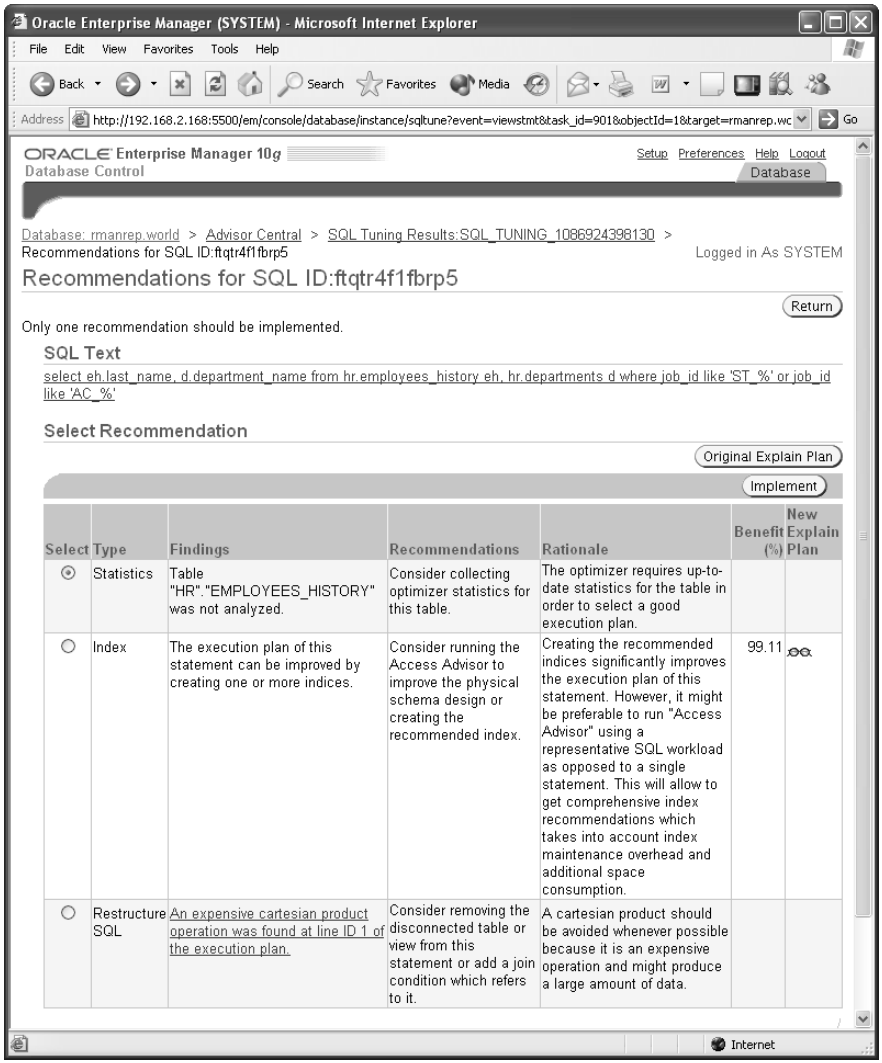
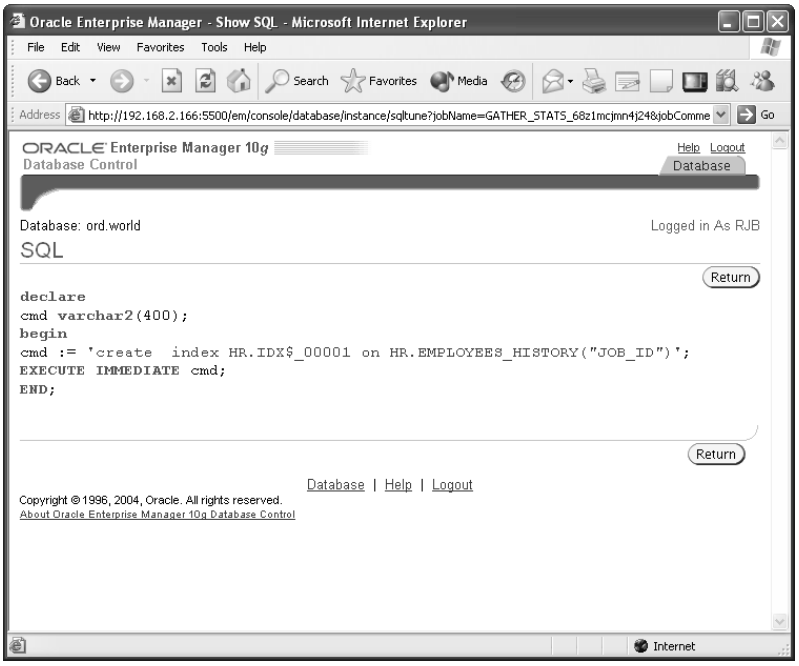


FIGURE 6.8 EM Database Control Indexing Recommendation SQL



SQL Tuning and the *DBMS_SQLTUNE* Package

While the EM Database Control interface makes it easy to access the SQL Tuning Advisor, sometimes either the command-line interface or a PL/SQL application must be used to perform tuning tasks. For example, a third-party application that provides an ad-hoc query tool and a PL/SQL debugging module may also integrate an interface into the SQL Tuning Advisor to provide a single interface to an application developer. The package `DBMS_SQLTUNE` provides access to the SQL Tuning Advisor.

The packages in `DBMS_SQLTUNE` fall into the following three general categories:

SQL tuning task management This involves creating or dropping a tuning task, running a tuning task, or displaying a SQL Tuning Advisor recommendation.

SQL profile management This involves accepting and saving a profile, dropping a profile, or changing a profile's attributes.

STS management This involves creating or dropping an STS, adding SQL statements to an STS, or displaying the SQL statements in an STS.

A typical session using the SQL Tuning Advisor would use `DBMS_SQLTUNE` procedures and functions as follows:

1. Create a tuning task with `CREATE_TUNING_TASK`.

2. Execute the tuning task using EXECUTE_TUNING_TASK.
3. Review the results of the tuning task by calling the function REPORT_TUNING_TASK.
4. Accept the SQL profile generated by the tuning task using ACCEPT_SQL_PROFILE.

At a minimum, the ADVISOR privilege is required to use DBMS_SQLTUNE to create and execute tuning tasks. This is the same privilege required to use the other advisors built upon Oracle's advisory framework, which includes the Segment Advisor, Undo Advisor, Redo Logfile Size Advisor, and so forth. The CREATE ANY SQL PROFILE privilege is required to create and save a SQL profile.

SQL Tuning Initialization Parameters

The new initialization parameter SQLTUNE_CATEGORY defines the category to use when applying a SQL profile to a SQL statement. The default value is DEFAULT. Similarly, when a SQL profile is saved, the default category assigned to the profile is DEFAULT.

Creating other categories may be useful in a development environment. To test a new SQL profile, you may assign the category TEST when saving the profile. When you connect to the database and change the value of SQLTUNE_CATEGORY to TEST at the session level using ALTER SESSION SET SQLTUNE_CATEGORY=TEST, only those profiles saved with the TEST category will apply to the session and you can test the new profile; conversely, other user sessions will continue to use the SQL profiles assigned to the DEFAULT category, unaffected by your work with the new profiles.

The combination of the category name and the SQL text uniquely identifies a SQL profile. As a result, identical SQL statements can exist in multiple profiles as long as each profile is in a different category.

When the testing is complete, you can change the category for the profile to DEFAULT, and it will automatically apply to all sessions that use the DEFAULT category. For example, executing the following PL/SQL procedure changes the category of the SQL profile SYS_SQLPROF_3887495559238 from TEST to DEFAULT:

```
SQL> exec dbms_sqltune.alter_sql_profile( -
  2      name => 'SYS_SQLPROF_3887495559238', -
  3      attribute_name => 'CATEGORY' -
  4      value => 'DEFAULT');
PL/SQL procedure successfully completed.
```

Here is a complete list of the attributes for a SQL profile that can be changed with the ATTRIBUTE_NAME parameter:

- STATUS: Can be either ENABLED or DISABLED to enable or disable the profile
- NAME: Can change the name of the profile; this must be a valid Oracle identifier and unique within the database
- DESCRIPTION: Can be any string up to 500 characters
- CATEGORY: Can be set to any category name; this must be a valid Oracle identifier and must be unique when combined with the SQL text

Understanding the SQL Access Advisor

The SQL Access Advisor, another component of the Oracle advisory framework and the DBMS_ADVISOR package, helps you determine which indexes, materialized views, and materialized view logs will help the performance of a single query, an entire workload, or a derived workload based on a specified schema. The SQL Access Advisor provides the most benefits in a data warehouse or decision support environment, where the activity is primarily SELECT statements.

In the following sections, we will provide an overview of the SQL Access Advisor and the types of recommendations it can provide; in addition, we will present some examples of the SQL Access Advisor using the EM Database Control.

Introducing the SQL Access Advisor

The SQL Access Advisor provides a number of benefits. It uses rules from the optimizer itself, making it highly likely that any recommended changes to the workload will improve the execution plan. It's also an intuitive, GUI- and wizard-based application that automatically generates scripts to implement its recommendations.

Input to the SQL Access Advisor can come from one or all of the following sources:

- Current SQL statements from V$SQL (the SQL cache)
- A user-specified list of SQL statements
- The name of a schema; in a data warehouse environment, this is typically a dimensional model in a single schema
- STSs previously saved in the workload repository

Given the workload, the SQL Access Advisor performs an analysis that includes all the following tasks:

- Considers whether only indexes, only materialized views, or a combination of both would provide the most benefit
- Balances storage and maintenance costs against the performance gains when recommending new indexes or materialized views
- Generates DROP recommendations to drop an unused index or materialized view if a full workload is specified
- Optimizes materialized views to leverage query rewrite and fast refresh where possible
- Recommends materialized view logs to facilitate fast refresh
- Recommends combining multiple indexes into a single index where appropriate

You can specify that a workload is either a *full workload* or a *partial workload*. A full workload is typically the entire set of SQL statements run as part of an application or throughout a business day. A partial workload may be one SQL statement or a group of problematic SQL statements. When running the SQL Access Advisor, it is important to specify whether the

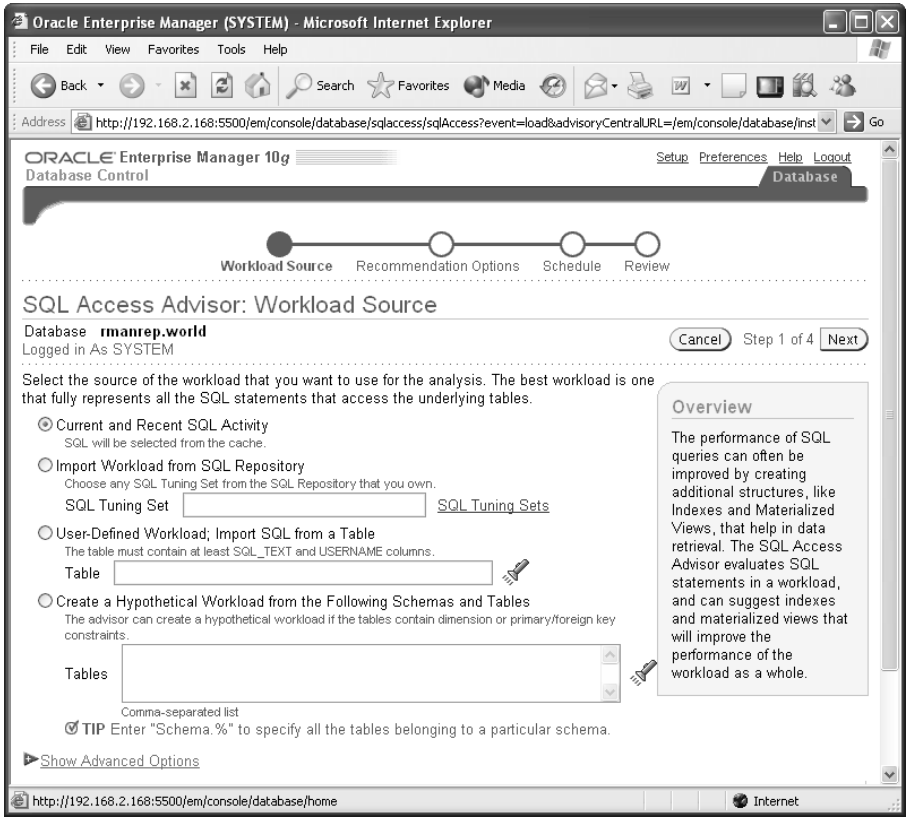
workload is full or partial. If the workload is partial, the SQL Access Advisor will not recommend dropping indexes, changing the index type, or dropping a materialized view, as dropping an index may dramatically affect the performance of a query that was not included in the partial workload.

When the SQL Access Advisor is analyzing a partial workload, it is operating in *limited mode*. In contrast, when analyzing a full workload, the SQL Access Advisor is operating in *comprehensive mode*.

Using the SQL Access Advisor

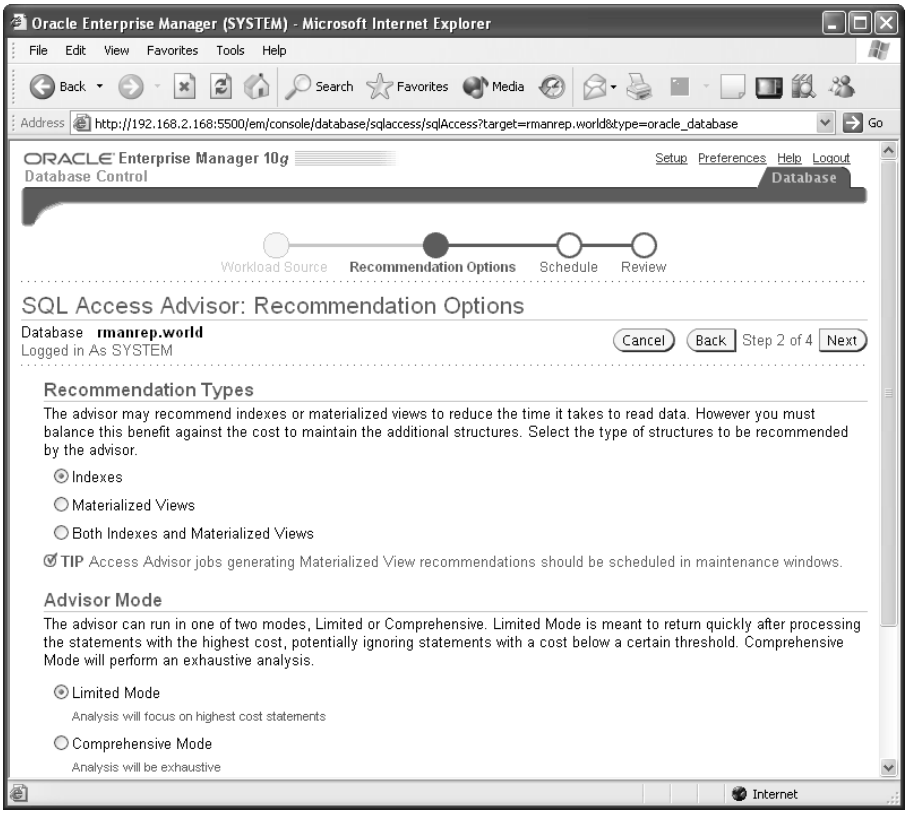
To run the SQL Access Advisor wizard via the EM Database Control, click the Performance tab from the database home page and then the Advisor Central link at the bottom of page. From the Advisor Central page, click the SQL Access Advisor link. The SQL Access Advisor wizard launches, bringing you to the SQL Access Advisor Workload Source page shown in Figure 6.9.

FIGURE 6.9 SQL Access Advisor's Workload Source page



To use the SQL Access Advisor, consider an example. You will use recent SQL activity from the SQL cache to perform your analysis and then click Next. On the SQL Access Advisor Recommendations Options page shown in Figure 6.10, you will want to perform a quick analysis of the recent SQL statements, since you do not want to wait until your nightly maintenance window to perform the analysis; a comprehensive analysis during peak processing times may impact the overall throughput of the database. As a result, you are going to see if new indexes or statistics collection can benefit the highest-cost SQL statements run recently.

FIGURE 6.10 SQL Access Advisor Recommendation Options page



Since you want to see the results immediately, you specify that the analysis job should be started immediately on the SQL Access Advisor Schedule page, shown in Figure 6.11. On the page you can also provide a name and a description for the task to make it easy to identify the task output later.

In the last step of the SQL Access Advisor wizard, the Review page shown in Figure 6.12, you have one more opportunity to review the parameters of the job before you submit it.

A few moments later, from the Advisor Central page shown in Figure 6.13, you can see that the job you submitted has completed.

Clicking the link containing the name of the job you just submitted brings you to the Advisor Central's Recommendation Summary page; clicking one of the recommendation links brings you to one of the individual recommendation pages, as shown in Figure 6.14.

FIGURE 6.11 SQL Access Advisor Schedule page

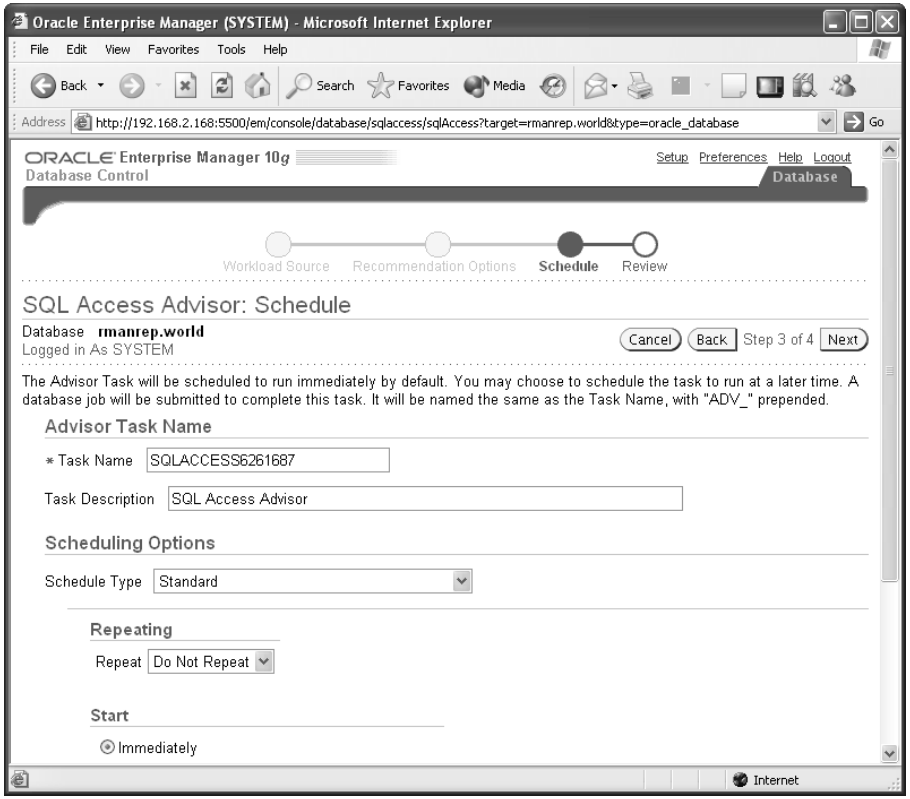


FIGURE 6.12 SQL Access Advisor Review page

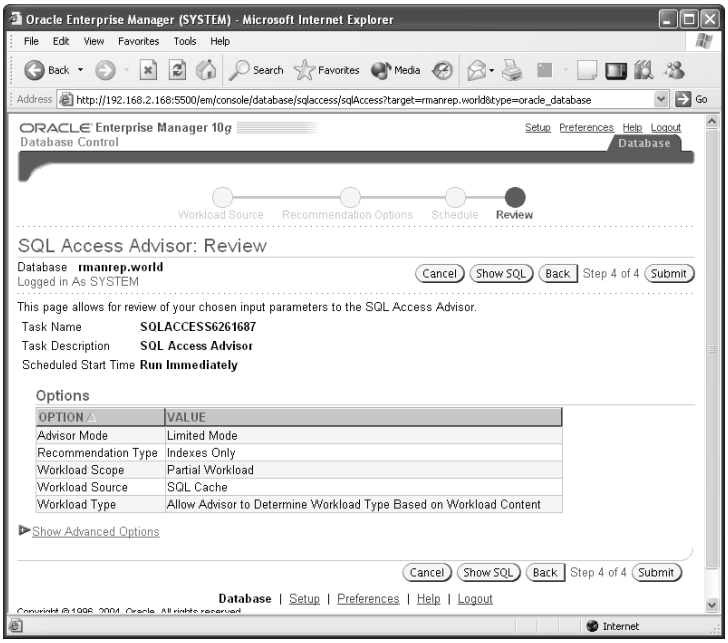


FIGURE 6.13 Advisor Central's completed jobs

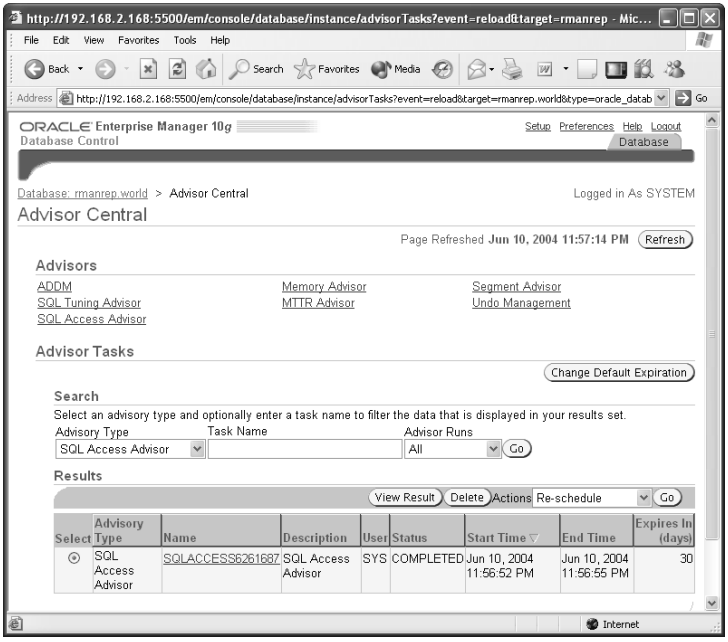
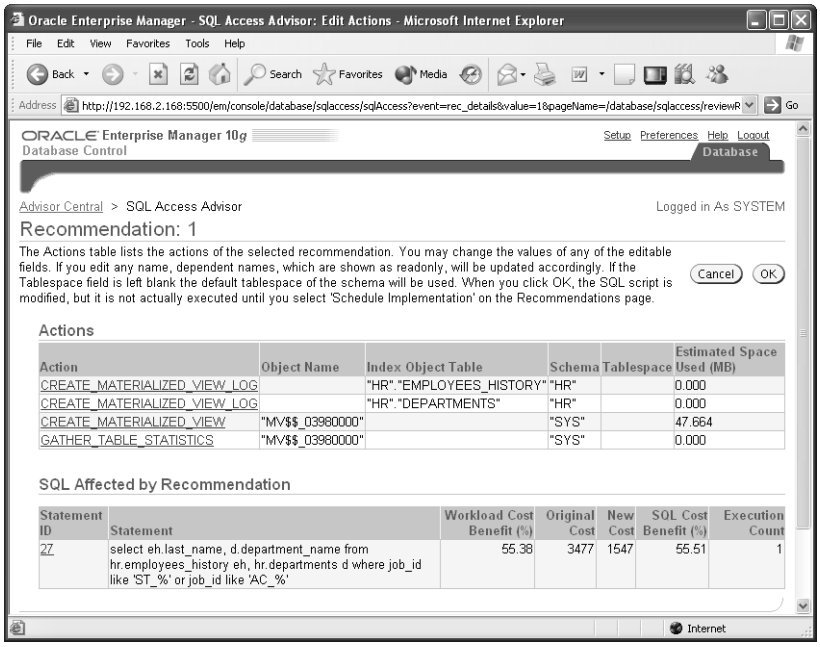


FIGURE 6.14 A SQL Access Advisor recommended action



Not surprisingly, one of the recommendations provided by the SQL Access Advisor is the same as one of the recommendations from the SQL Tuning Advisor: collect statistics on the `HR.EMPLOYEES_HISTORY` table. As you can also see from the recommendation, implementing all the recommendations will reduce the execution cost by more than half but will require an additional 47.664MB of disk space to store the recommended materialized view.

Accessing the Database Control Performance Pages

Under the SQL Tuning Advisor and the SQL Access Advisor, you focused specifically on the SQL statements that have a high impact on the database throughput. From a much broader perspective, the EM Database Control also gives you an overall look at both the host system and the instance, potentially advising you of conditions outside the instance that may impact performance. The three major tuning areas exposed by the EM Database Control performance pages are as follows:

- CPU usage
- Top SQL statements that affect the instance
- Top sessions that affect the instance

Notice the database page shown in Figure 6.15. You can see that about half the CPU capacity is being used, with the Oracle instance being responsible for just more than 10 percent of the load on the server.

Clicking the Performance tab gives you a more detailed look at both the host performance and database session wait classes, as you can see on the Performance tab shown in Figure 6.16.

The wait events are divided into classes, such as User I/O, Network Usage, and CPU Used. In Figure 6.16, the Configuration wait class seems to have spiked the most along with most other wait classes starting at around 12:40 a.m. Clicking the Configuration link or on the corresponding portion of the graph allows you to drill down further into the sessions and SQL wait statistics. On the Active Sessions Waiting: Configuration page, shown in Figure 6.17, you can drill down either by session or by top SQL.

While waits are inevitable in any instance, you should be looking out for any SQL or sessions with a disproportionate percentage of waits compared to other SQL or sessions.

FIGURE 6.15 Database performance statistics

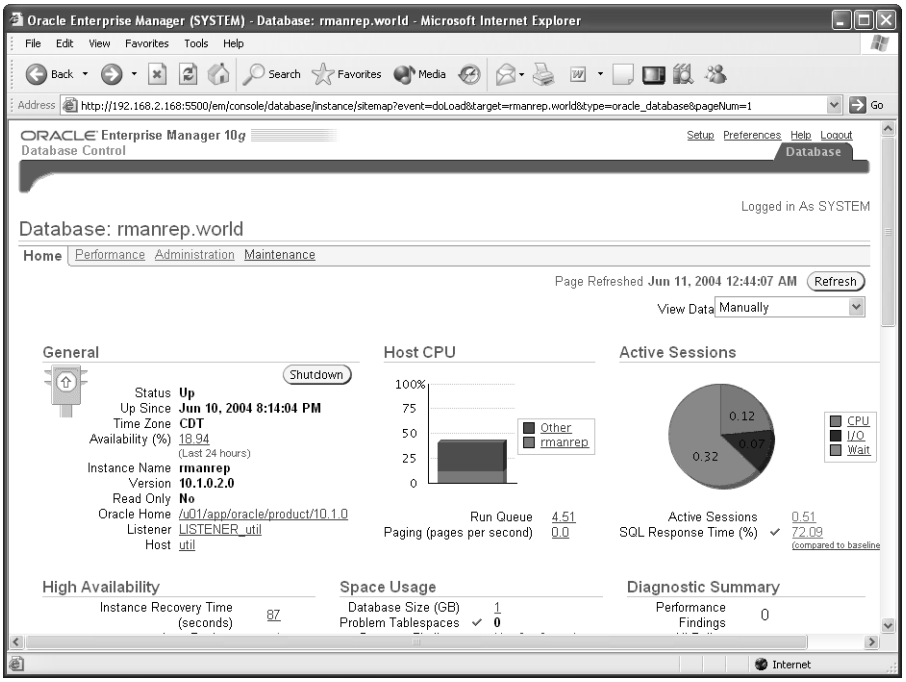


FIGURE 6.16 Database Performance tab

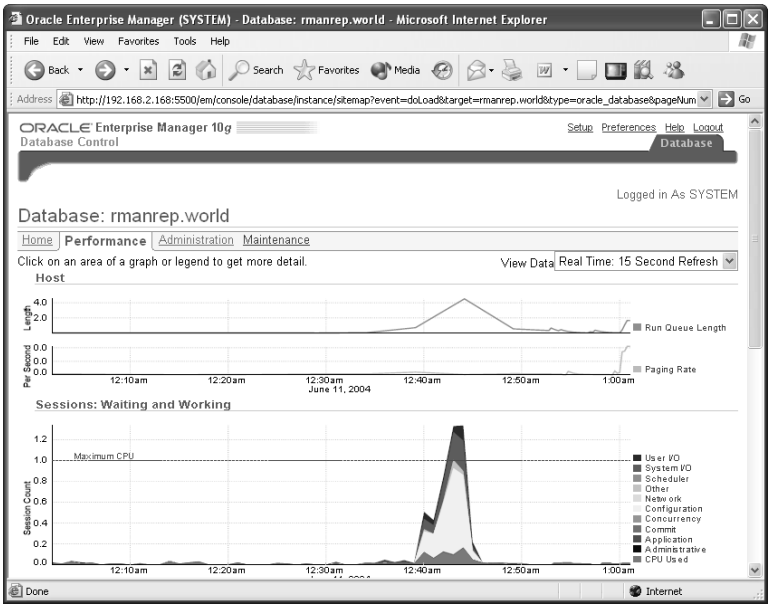
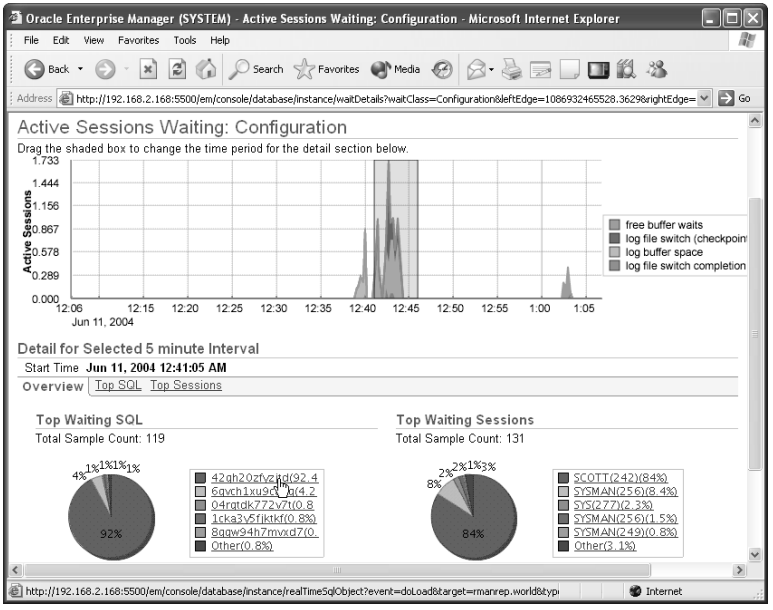


FIGURE 6.17 Active Sessions Waiting: Configuration page



Summary

In this chapter, we presented a number of new automated methods for statistics collection in Oracle 10*g*. Not only do these collection methods save time for the busy DBA, they also make execution plans more efficient; even when statistics have not been explicitly collected for a table, dynamic sampling will collect statistics on the fly during SQL statement compile time.

Now that the Oracle optimizer's cost model considers both CPU and I/O costs as the default, it is important to collect statistics on both data dictionary tables and fixed tables. In addition, the deprecation of Oracle's rule-based optimizer brings with it a number of changes to the optimizer-related initialization parameters.

The SQL Tuning Advisor, one of many wizards in Oracle 10*g*, is an in-depth analysis tool for high-load SQL statements. The SQL Tuning Advisor will perform a number of tasks in tuning mode once high-load SQL statements have been identified by the ADDM: It provides advice on how to optimize the execution plan, estimates on the benefits for the advice, and even the SQL scripts required to implement the advice. In addition, it creates a SQL profile so that subsequent executions of the high-load SQL will be more efficient.

The SQL Access Advisor performs a more specific analysis of one SQL statement, a workload, or a schema, recommending what indexes, materialized views, and materialized view logs can be added or dropped to improve performance of queries, especially in a data warehouse environment. The SQL Access Advisor presents not only the execution benefits of its recommendations but also any additional costs such as storage and maintenance costs of new indexes or materialized views.

Near the end of the chapter, we reviewed the performance pages within the EM Database Control, showing how easy it is to identify performance problems in the database and drilling down to the session or SQL statement contributing to the performance problem.

Exam Essentials

Be able to enumerate the new features of the cost-based optimizer model. Identify the initialization parameters used to control dynamic sampling and the behavior of the cost-based model: `OPTIMIZER_DYNAMIC_SAMPLING`, `STATISTICS_LEVEL`, `ALL_ROWS`, and `FIRST_ROWS_`*n*.

List the new PL/SQL packages and scheduler jobs. Be able to use the `DBMS_STATS` package to gather statistics on data dictionary and fixed tables.

Understand the purpose of the SQL Tuning Advisor and how it works. Explain the two different modes for Automatic SQL Tuning using the SQL Tuning Advisor—normal mode and tuning mode—and the circumstances where each mode is appropriate. Describe the four types of analysis performed by the SQL Tuning Advisor in tuning mode: statistics analysis, SQL profiling, access path analysis, and SQL structure analysis.

Enumerate the procedures within `DBMS_SQLTUNE`. Identify the purpose of each procedure within `DBMS_SQLTUNE` and how they are used as an alternative to the EM Database Control interface for accessing SQL Tuning Advisor.

Identify the purpose of the SQL Access Advisor. Differentiate the types of environments in which the SQL Access Advisor is most beneficial and list the types of analyses and recommendations it performs. Describe the differences in the types of recommendations produced by the SQL Access Advisor in full mode and partial mode. Be able to use the EM Database Control wizard to produce a set of recommendations from the SQL Access Advisor wizard.

Be able to effectively use the performance pages of the EM Database Control. Identify the purposes of each graph within the performance pages and how they relate to both Oracle processes and the host machine. Be able to drill down within the Active Sessions graph to identify the sessions and SQL statements responsible for each wait class.

Review Questions

1. Which value of the initialization parameter STATISTICS_LEVEL provides the best overall performance?
   - **A.** ALL
   - **B.** NONE
   - **C.** TYPICAL
   - **D.** BASIC
2. In which of the following steps would the Automatic Tuning Advisor (ATO) recommend changes to a query containing predicates with mismatched datatypes or functions?
   - **A.** SQL structure analysis.
   - **B.** Statistics analysis.
   - **C.** Access path analysis.
   - **D.** SQL profiling.
   - **E.** None of the above; this recommendation would come out of the SQL Access Advisor.
3. The initialization parameter SQLTUNE_CATEGORY provides what functionality for the SQL Tuning Advisor?
   - **A.** SQLTUNE_CATEGORY specifies the source for SQL statements used by the SQL Advisor.
   - **B.** SQLTUNE_CATEGORY specifies the default category name for the SQL profile that is used by default when a session first connects.
   - **C.** SQLTUNE_CATEGORY specifies whether CPU or I/O should have precedence when tuning a SQL statement.
   - **D.** There is no such initialization parameter.
4. The predefined job _____ gathers statistics for objects in the database using the procedure _____.
   - **A.** GATHER_STATS_JOB, DBMS_STATS.GATHER_DATABASE_STATS_JOB_PROC
   - **B.** GATHER_STATS, DBMS_STATS.GATHER_DATABASE_STATS_JOB_PROC
   - **C.** GATHER_STATS_JOB, DBMS_STATS.GATHER_DATABASE_STATS
   - **D.** GATHER_STATS_JOB, DBMS_STATS.GATHER_AUTO

5. Database users can launch the SQL Tuning Advisor from the EM Database Control provided they have which of the following system privileges?

   A. `DBA`

   B. `SYSDBA`

   C. `SQL_ADVISOR`

   D. `ADVISOR`

   E. `ADMINISTER SQL TUNING SET`

6. Choose the correct statement regarding the SQL Access Advisor.

   A. The SQL Access Advisor takes an actual workload as input and recommends changes to SQL statements from the workload.

   B. The SQL Access Advisor takes a hypothetical workload from a schema and generates missing statistics.

   C. The SQL Access Advisor generates materialized views on the fly for high-load SQL statements identified by ADDM.

   D. The SQL Access Advisor takes an actual workload as input and recommends a new index on a table.

   E. The SQL Access Advisor takes an individual SQL statement, generates the most efficient execution plan possible, and saves it in a SQL profile.

7. The performance pages of the EM Database Control provide tuning information about all except which of the following areas?

   A. Top sessions

   B. High DML activity

   C. Top SQL statements

   D. CPU and wait classes

8. Which of the following steps is not performed by the enhanced query optimizer in tuning mode?

   A. Check objects in the query for stale or missing statistics.

   B. Identify SQL statements that tend to have bad execution plans and recommend alternatives.

   C. Determine if a new index can improve access to each table in the query.

   D. An initial execution plan is generated only for high-load SQL statements.

   E. Collect information from previous executions of the SQL statement and build a SQL profile.

9. Automatic SQL Tuning can be accessed through a command-line interface in addition to the EM Database Control. Identify the PL/SQL package used to access Automatic SQL Tuning.

A. DBMS_MONITOR

B. DBMS_SQLTUNE

C. DBMS_SQL_ADVISOR

D. DBMS_ADVISOR

E. DBMS_SQL

10. The SQL Access Advisor can provide all except which of the following as output from its analysis?

A. Considers storage and maintenance costs if new objects are recommended

B. Generates drop recommendations even for a partial workload

C. Recommends combining multiple indexes into one index

D. Recommends materialized view logs where possible for fast refresh

11. Which of the following procedures will gather statistics on dictionary objects? (Choose all that apply.)

A. DBMS_STATS.GATHER_FIXED_OBJECTS_STATS

B. DBMS_STATS.GATHER_SCHEMA_STATS with the GATHER_SYS argument set to TRUE

C. DBMS_STATS.GATHER_DATABASE_STATS with the GATHER_SYS argument set to TRUE

D. DBMS_STATS.GATHER_DICTIONARY_STATS

12. The SQL Tuning Advisor uses one or more SQL statements as input. Which of the following is not a source of SQL statements for the SQL Tuning Advisor?

A. SQL statements that were in the cursor cache during the previous seven days

B. High-load SQL statements identified by ADDM

C. A user's custom workload

D. SQL statements captured by the AWR

13. Which of the following columns is new to the table PLAN_TABLE?

A. CPU

B. TIME

C. IO

D. SPACE

14. Statistics cannot be gathered for which of the following types of tables?

A. Fixed tables

B. Real tables in the Data Dictionary

C. Real tables in non-SYSTEM user schemas

D. None of the above, statistics can be gathered on all tables, in any schema, regardless of whether they are fixed or real.

15. If the initialization parameter STATISTICS_LEVEL is set to BASIC, what is the monitoring level for DML operations on tables?

A. Table DML changes are not monitored

B. The monitoring level is the same as using the command ALTER TABLE . . . MONITORING

C. The monitoring level is the same as using the command ALTER TABLE . . . NOMONITORING

D. BASIC is not a valid value for this parameter, only NONE, TYPICAL and ALL are allowed values

16. Which of the following values are no longer supported for the OPTIMIZER_MODE initialization parameter?

A. CHOOSE and RULE

B. COST and RULE

C. FIRST_ROWS and ALL_ROWS

D. FIRST_ROWS and FIRST_ROWS_*n*

17. Which of the following SQL statements is not a good candidate for the SQL Tuning Advisor?

A. Transactions that have SQL statements with multiple large sorts

B. SQL statements with heavy I/O requirements

C. A user's ad-hoc query against the data warehouse

D. A statement that consumes a relatively high amount of CPU time every day of the week

18. Which of the following statements about a SQL profile is not true?

A. A SQL profile is stored persistently in the data dictionary

B. A SQL profile can be accepted or rejected

C. A SQL profile is used in conjunction with existing statistics to generate a good execution plan

D. A SQL profile is used in tuning mode to produce a good execution plan

19. During the SQL Structure Analysis phase of the SQL Tuning Advisor, which of the following is not recommended by the ATO? Choose two.

A. Substituting a `UNION ALL` for a `UNION`

B. A recommendation to create an index

C. Using `NOT IN` instead of `EXISTS`

D. Data type mismatches between predicates and indexed columns

E. A recommendation to create a materialized view

20. Which of the following values is not valid for the `ATTRIBUTE_NAME` parameter of the procedure `DBMS_SQLTUNE.ALTER_SQL_PROFILE`?

A. `STATUS`

B. `CATEGORY`

C. `VALUE`

D. `DESCRIPTION`

E. `NAME`

Answers to Review Questions

1. C. A value of TYPICAL for STATISTICS_LEVEL collects all major statistics required for database self-management. Specifying ALL collects all statistics for TYPICAL in addition to timed operating system statistics and plan execution statistics; however, ALL adds a significant amount of overhead and may impact overall database throughput. When you specify BASIC, most statistics collections are turned off, limiting the functionality of the AWR and ADDM. The value NONE is not valid for STATISTICS_LEVEL.

2. A. Using a function or mismatched datatypes in a predicate can prevent the use of an index. SQL structure analysis will also recommend things such as using UNION ALL instead of UNION or point out Cartesian joins or other possible design mistakes.

3. B. When a SQL profile is created, you assign a category to it. When a session connects to the database, all SQL profiles with a category name that matches the value of SQLTUNE_CATEGORY automatically apply to the session. SQLTUNE_CATEGORY is a dynamic parameter that is modifiable both at the session level and for the instance.

4. A. The new procedure DBMS_STATS.GATHER_DATABASE_STATS_JOB_PROC runs in the predefined job GATHER_STATS_JOB to collect statistics on the objects that need updated statistics the most before the maintenance window closes. There is no such predefined job GATHER_STATS, and while DBMS_STATS.GATHER_DATABASE_STATS operates similarly to DBMS_STATS.GATHER_DATABASE_STATS_JOB_PROC with the GATHER AUTO option, it is not called from GATHER_STATS_JOB.

5. D. The ADVISOR system privilege is required to create a tuning task. DBA is a role and contains more privileges than necessary to use the SQL Tuning Advisor. The system privilege SYSDBA is also not required. SQL_ADVISOR is not a system privilege, and the ADMINISTER SQL TUNING SET privilege is only required to create and maintain SQL tuning sets.

6. D. The SQL Access Advisor either takes an actual workload or derives a workload from a schema and recommends indexes, materialized views, and materialized view logs to speed the execution path for queries in the workload.

7. B. While high DML activity can contribute to sessions using high CPU and I/O, it is not specifically measured and reported by the EM Database Control.

8. D. While an initial execution plan is generated for both normal mode and tuning mode, it is not limited to high-load SQL statements.

9. B. DBMS_SQLTUNE contains a number of packages used to create, drop, and execute tuning tasks, in addition to managing SQL profiles and SQL tuning sets.

10. B. The SQL Access Advisor will not generate drop recommendations for partial workloads.

11. A, B, C, D. Several of the procedures in DBMS_STATS will gather statistics on all or some of the objects in the data dictionary, which can include statistics on fixed tables.

12. A. The SQL Tuning Advisor cannot access SQL statements that are no longer in the cursor cache, only those that are currently in the cursor cache, unless they were captured by AWR or identified by ADDM.

13. B. The table PLAN_TABLE has only one new column, TIME.

14. D. Statistics can be gathered on any table in any schema, fixed or real. In addition to gathering statistics on fixed tables using the GATHER_FIXED argument of GATHER_DATABASE_STATS, statistics on individual fixed tables can be gathered by using the existing procedures within DBMS_STATS with a fixed table name as an argument.

15. A. When STATISTICS_LEVEL is set to BASIC, table monitoring for DML changes is disabled. MONITORING and NOMONITORING are still part of the ALTER TABLE syntax, but they are ignored because monitoring is no longer allowed only at the object level. NONE is not a valid value for the STATISTICS_LEVEL parameter.

16. A. CHOOSE and RULE are no longer supported; the only valid values for OPTIMZER_MODE are ALL_ROWS, FIRST_ROWS, and FIRST_ROWS_*n*, where n is 1, 10, 100, or 1000.

17. C. The SQL Tuning Advisor is not useful for an occasional ad-hoc query from a user; it is most suited for frequently executed queries that have high CPU, I/O or temporary space requirements.

18. D. A SQL profile is used in normal mode to produce a good execution plan; the profile is created in tuning mode.

19. B, E. Recommendations to create an index comes from the ATO's Access Path Analysis or the SQL Access Advisor; recommendations for new materialized views comes from the SQL Access Advisor

20. C. VALUE is not a valid value for ATTRIBUTE_NAME, however, it is another one of the parameter names for DBMS_SQLTUNE.ALTER_SQL_PROFILE.

Chapter 7

Backup, Recovery, and High Availability

ORACLE DATABASE 10*g* NEW FEATURES FOR ADMINISTRATORS EXAM OBJECTIVES OFFERED IN THIS CHAPTER:

- ✓ **Backup and Recovery Enhancements**
  - Simplify file management for all recovery-related files
  - Reduce restore time by applying incremental backups to data file image copies
  - Simplify recovery after opening the database with the RESETLOGS option
  - Speed backup times by creating faster incremental backups
  - Minimize load requirements by specifying limits in backup time windows
  - Save storage space through writing compressed backup sets
- ✓ **Flashback Any Error**
  - Configure and use Flashback Database
  - Recover dropped tables with the Flashback Drop feature
  - Retrieve row history information with the Flashback Versions Query feature
  - Audit or recover FROM transactions with the Flashback Transaction Query feature
  - Recover tables to a point in time with the Flashback Table feature

Exam objectives are subject to change at any time without prior notice and at Oracle's sole discretion. Please visit Oracle's training and certification website (`http://www.oracle.com/education/certification/`) for the most current exam objectives listing.

Oracle Database 10*g* (Oracle 10*g*) provides the flash recovery area where you can store not only the traditional components found in a backup strategy such as control files, archived log files, and Recovery Manager (RMAN) datafile copies but also a number of other file components such as flashback logs. The flash recovery area simplifies backup operations, and it increases the availability of the database because many backup and recovery operations using the flash recovery area can be performed when the database is open and available to users.

With each release of Oracle since Oracle 8, RMAN has gotten a number of dramatic enhancements, and Oracle 10*g* is no exception. The RMAN command syntax has been significantly standardized, making command-line syntax easier to use. RMAN provides another way to reduce the recovery time for a tablespace or the entire database: incrementally updated backups. You can apply any RMAN incremental backup to an image copy of a datafile to significantly reduce the amount of time needed to recover the datafile in case of a media failure.

RMAN also provides a number of other enhancements, making it easier to back up part of the database or the entire database. You can create image copies for the entire database with just one command instead of one command for each tablespace. Also, RMAN provides the functionality to provide a hot-swappable capability to the files in the flash recovery area, improving upon the manual techniques required in previous releases of Oracle. Finally, RMAN supports binary compression of backup sets to not only save disk space in the flash recovery area but also to potentially reduce the amount of time needed to perform the backup.

Leveraging the flash recovery area, Oracle 10*g* has a number of flashback features that can recover from nearly every logical error that you as a DBA or a user may encounter. Improving on Flashback Query from previous Oracle releases, Oracle 10*g* adds Flashback Versions Query to see all versions of rows between two times and adds Flashback Transaction Query to see all changes made by an individual transaction.

Other flashback features make recovery operations simpler and faster than in previous releases of Oracle. Flashback Database moves the database back to a previous point in time using a new type of log saved in the flash recovery area appropriately called *flashback logs*. At the table level, Flashback Table can recover a table to a previous point in time along with its dependent objects; in addition, a dropped table can easily be recovered by leveraging the new recycle bin capabilities available in each tablespace. At the row level, the Flashback Query features mentioned previously can also provide the SQL commands necessary to undo only selected portions of the table.

In this chapter, we will thoroughly review the capabilities of the flash recovery area and show how to monitor and maintain it to maximize recovery capabilities while minimizing the impact to its availability. In addition, we will cover the new features available in RMAN along with a number of miscellaneous enhancements available for backing up and recovering the database at the SQL command level. Finally, we will review the entire flashback architecture and show you how it can recover from virtually any type of logical error, from the database level all the way down to one row erroneously deleted in one table.

Leveraging the Flash Recovery Area

As the price of disk space drops, the difference in its price compared to tape is offset by the advantages of using disk as the primary backup medium: Even a slow disk can be accessed randomly a magnitude faster than a tape drive. This rapid access means that any database recovery operation will take only minutes instead of hours.

Using disk space as the primary medium for all database recovery operations is the key component of Oracle 10*g*'s flash recovery area. The *flash recovery area* is a single, unified storage area for all recovery-related files and recovery activities in an Oracle database.

The flash recovery area can be a single directory, an entire file system, or an Automatic Storage Management (ASM) disk group. To further optimize the use of disk space for recovery operations, a flash recovery area can be shared by more than one database.

In the following sections, we will cover all major aspects of a flash recovery area: what can and should be kept in the flash recovery area and how to set up a flash recovery using initialization parameters and SQL commands. Also, as with other aspects of Oracle 10*g*, we will show how you can manage most parts of the flash recovery area using the Enterprise Manager (EM) Database Control. We will also explain how to manage the flash recovery area efficiently, including how to back up the flash recovery area itself. Finally, we will review the data dictionary views related to the flash recovery area and present a few best practices for the flash recovery area in conjunction with Oracle Managed Files (OMF).

Flash Recovery Area Occupants

All the files needed to recover a database from a media failure or a logical error are contained in the flash recovery area. The files that can reside in the flash recovery area are as follows:

Control files A copy of the control file is created in the flash recovery area when the database is created. This copy of the control file can be used as one of the mirrored copies of the control file to ensure that at least one copy of the control file is available after a media failure.

Archived log files When the flash recovery area is configured, the initialization parameter `LOG_ARCHIVE_DEST_10` is automatically set to the flash recovery area location. The corresponding ARC*n* processes create archived log files in the flash recovery area and any other defined `LOG_ARCHIVE_DEST_`*n* locations.

Flashback logs If Flashback Database is enabled, then its flashback logs are stored in the flash recovery area.

You can find more information about configuring and using flashback logs with Flashback Database later in this chapter in the section entitled "Flashback Database"

Control file and SPFILE autobackups The flash recovery area holds control file and SPFILE autobackups generated by RMAN, if RMAN is configured for control file autobackup. When RMAN backs up datafile #1, the control file is automatically included in the RMAN backup.

Data file copies For RMAN BACKUP AS COPY image files, the default destination is the flash recovery area.

You can find more information on RMAN image copy enhancements later in this chapter in the section entitled "Recovery with Incrementally Updated Backups."

RMAN backup sets By default, RMAN uses the flash recovery area for both backup sets and image copies. In addition, RMAN puts restored archive log files from tape into the flash recovery area in preparation for a recovery operation.

Flash Recovery Area and SQL Commands

You must define two initialization parameters to set up the flash recovery area: DB_RECOVERY_FILE_DEST_SIZE and DB_RECOVERY_FILE_DEST. Since these are both dynamic parameters, the instance need not be shut down and restarted for the flash recovery area to be usable.

DB_RECOVERY_FILE_DEST_SIZE, which must be defined before DB_RECOVERY_FILE_DEST, defines the size of the flash recovery area. To maximize the benefits of the flash recovery area, it should be large enough to hold a copy of all datafiles, all incremental backups, online redo logs, archived redo logs not yet backed up to tape, control files, and control file autobackups. At a bare minimum, you should have enough space to hold the archived log files not yet copied to tape.

Here is an example of configuring DB_RECOVERY_FILE_DEST_SIZE:

```
SQL> alter system
  2   set db_recovery_file_dest_size = 8g scope=both;
```

The size of the flash recovery area will be 8GB, and since we used the SCOPE=BOTH parameter in the ALTER SYSTEM command, the initialization parameter will take effect immediately and will stay in effect even after a database restart.

All instances in a Real Application Clusters (RAC) database must have the same values for DB_RECOVERY_FILE_DEST_SIZE and DB_RECOVERY_FILE_DEST.

The parameter DB_RECOVERY_FILE_DEST specifies the physical location where all flash recovery files are stored. The ASM disk group or file system must have at least as much space as the amount specified with DB_RECOVERY_FILE_DEST_SIZE, and it can have significantly more; DB_RECOVERY_FILE_DEST_SIZE, however, can be increased on the fly if more space is needed and the file system where the flash recovery area resides has the space available.

In the following example, we use the directory fra in the ASM disk group +DATA2 for the flash recovery area, like so:

```
SQL> alter system
  2   set db_recovery_file_dest = '+DATA2/fra' scope=both;
```

Clearing the value of DB_RECOVERY_FILE_DEST disables the flash recovery area; the parameter DB_RECOVERY_FILE_DEST_SIZE cannot be cleared until the DB_RECOVERY_FILE_DEST parameter has been cleared first.

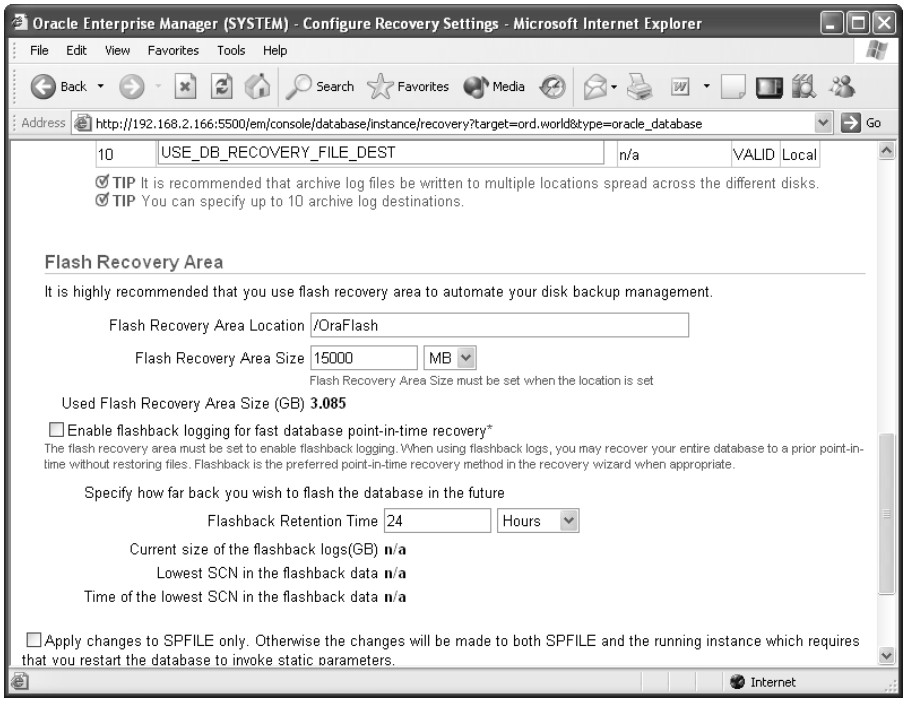
Flash Recovery Area and the EM Database Control

You can create and maintain the flash recovery area using the EM Database Control. After selecting the Maintenance tab, click the Configure Recovery Settings link, and you will see the Configure Recovery Settings page shown in Figure 7.1.

In the Flash Recovery Area section of the page, you see that the flash recovery area has been configured for this database in the file system /OraFlash, with a maximum size of 15000MB (15GB). Just more than 3GB of space is currently used in the flash recovery area. Flashback logging has not yet been enabled for this database.

We will present Flashback Database and how it uses flashback logs later in this chapter in the section entitled "Flashback Database."

FIGURE 7.1 Configure Recovery Settings page



Flash Recovery Area Management

Because the space in the flash recovery area is limited by the initialization parameter DB_RECOVERY_FILE_DEST_SIZE, the Oracle database keeps track of which files are no longer needed on disk so that they can be deleted when there is not enough free space for new files. Each time a file is deleted from the flash recovery area, a message is written to the alert log.

A message is written to the alert log in other circumstances. If no files can be deleted, and the recovery area used space is at 85 percent, a warning message is issued. When the space used is at 97 percent, a critical warning is issued. These warnings are recorded in the alert log file, are viewable in the data dictionary view DBA_OUTSTANDING_ALERTS, and are available to you on the main page of the EM Database Control

When you receive these alerts, you have a number of options. If your retention policy can be adjusted to keep fewer copies of datafiles or reduce the number of days in the recovery window, this can help alleviate the space problems in the flash recovery area. Assuming that your retention policy is sound, you should instead add more disk space or back up some of the files in the flash recovery area to another device such as a tape device, as you will see in the next section.

Flash Recovery Directory Structure

The flash recovery area directory structure is used by RMAN in a very organized fashion with separate directories for each file type, such as archived logs, backupsets, image copies, control file autobackups, and so forth. In addition, each subdirectory is further divided by a datestamp, making it easy to locate backupsets or image copies based on their creation date.

In this example, you can see how the flash recovery area is cleanly subdivided by instance name (ORD), date, and backup type:

```
SQL> show parameter db_recovery_file_dest

NAME                          TYPE        VALUE
----------------------------- ----------- ------------------
db_recovery_file_dest         string      /OraFlash
db_recovery_file_dest_size    big integer 15000M

SQL> ! find /OraFlash -print
/OraFlash
/OraFlash/ORD
/OraFlash/ORD/archivelog
/OraFlash/ORD/archivelog/2004_03_22
/OraFlash/ORD/archivelog/2004_03_29
/OraFlash/ORD/archivelog/2004_03_29/
               o1_mf_1_374_06j6k8rv_.arc
...
/OraFlash/ORD/archivelog/2004_03_29/
               o1_mf_1_388_06kzq6kh_.arc
```

```
/OraFlash/ORD/archivelog/2004_03_30
/OraFlash/ORD/archivelog/2004_03_30/
               o1_mf_1_389_06l387rz_.arc
/OraFlash/ORD/archivelog/2004_03_30/
               o1_mf_1_390_06l39gg0_.arc
...
/OraFlash/ORD/archivelog/2004_05_03/
               o1_mf_1_803_09g5chc7_.arc
/OraFlash/ORD/archivelog/2004_05_04
/OraFlash/ORD/archivelog/2004_05_04/
               o1_mf_1_804_09g95l91_.arc
/OraFlash/ORD/archivelog/2004_05_04/
               o1_mf_1_805_09gdd6fz_.arc
...
/OraFlash/ORD/archivelog/2004_05_04/
               o1_mf_1_806_09gdfqmz_.arc
/OraFlash/ORD/archivelog/2004_05_04/
               o1_mf_1_807_09gdh5j6_.arc
/OraFlash/ORD/archivelog/2004_05_20/
               o1_mf_1_1192_0btrwov1_.arc
/OraFlash/ORD/archivelog/2004_07_28/
               o1_mf_1_1605_0jjczwjb_.arc
/OraFlash/ORD/archivelog/2004_07_28/
               o1_mf_1_1608_0jjpybv1_.arc
/OraFlash/ORD/backupset
/OraFlash/ORD/backupset/2004_03_29
/OraFlash/ORD/backupset/2004_03_29/
               o1_mf_nnnd1_TAG20040329T085843_06jgf8m3_.bkp
/OraFlash/ORD/backupset/2004_03_29/
               o1_mf_nnnd1_TAG20040329T164957_06kb0r82_.bkp
/OraFlash/ORD/backupset/2004_03_28
...
/OraFlash/ORD/backupset/2004_03_28/
               o1_mf_ncnnf_TAG20040328T133408_06gb5m45_.bkp
/OraFlash/ORD/backupset/2004_03_28/
               o1_mf_nnnd0_TAG20040328T133534_06gb8872_.bkp
/OraFlash/ORD/backupset/2004_04_15
/OraFlash/ORD/autobackup
/OraFlash/ORD/autobackup/2004_03_29/
              o1_mf_s_522078814_06jzoyoz_.bkp
...
```

```
/OraFlash/ORD/autobackup/2004_03_28/
               o1_mf_s_521989816_06g8ryqb_.bkp
/OraFlash/ORD/autobackup/2004_03_28/
               o1_mf_s_522020993_06h771yb_.bkp
/OraFlash/ORD/datafile

SQL>
```

Backing Up the Flash Recovery Area

A new RMAN command makes it easy to back up recovery files in the flash recovery area once a tape drive destination is configured, as in the following example:

```
RMAN> configure channel device type sbt parms '. . .';

RMAN> backup device type sbt recovery files;
```

The BACKUP RECOVERY FILES command in this example backs up all recovery files on disk that have not previously been backed up to tape, including full and incremental backup sets, control file autobackups, archived redo logs, and datafile copies.

The EM Database Control provides identical functionality when scheduling a backup and specifying a customized backup strategy in the Schedule Backup: Strategy page shown in Figure 7.2.

Flash Recovery Area Data Dictionary Views

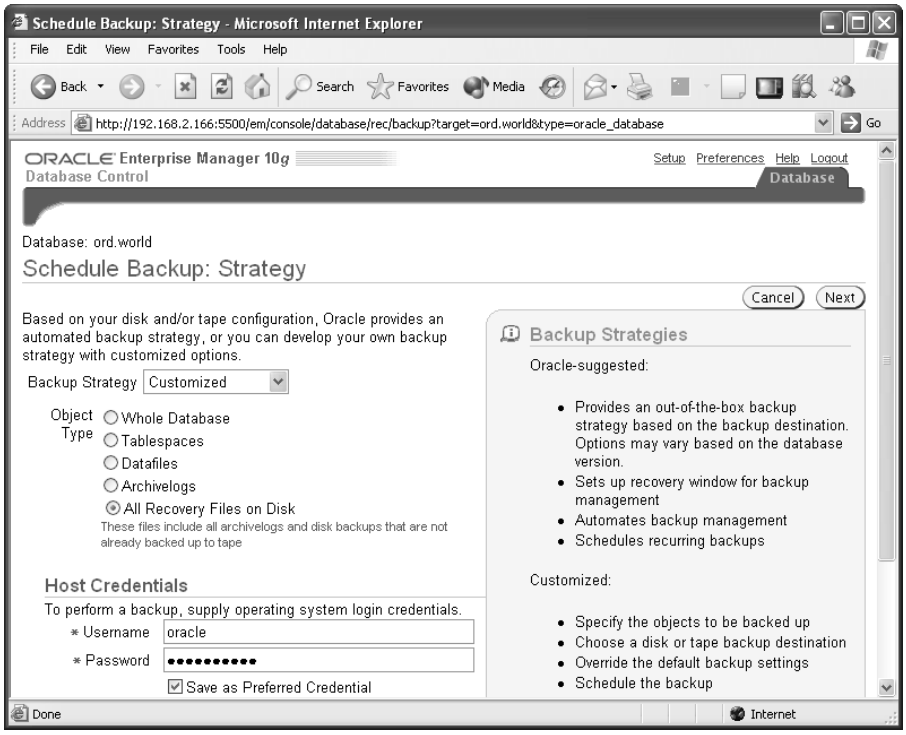
To support the flash recovery area, you can use one new dynamic performance view and two new columns in several existing dynamic performance views.

The new dynamic performance view V$RECOVERY_FILE_DEST provides information about the flash recovery area, such as the location of the flash recovery area, how much disk space is allocated to the flash recovery area, how much space is currently allocated in the flash recovery area, how many files are in the flash recovery area, and how much space can be freed in the flash recovery area if there is space pressure on the flash recovery area.

The query that follows displays the contents of the V$RECOVERY_FILE_DEST view:

```
SQL> select name, space_limit max_size,
  2      space_used used, space_reclaimable obsolete,
  3      number_of_files num_files
  4  from v$recovery_file_dest;

NAME            MAX_SIZE       USED   OBSOLETE  NUM_FILES
------------- ---------- ---------- ---------- ----------
/OraFlash     1.5729E+10 3392246272  181256192        272

1 row selected.
```

FIGURE 7.2 Schedule Backup: Strategy page, with the Customized option



The size of the recovery area is still 15GB, unchanged from our previous query using the EM Database Control. Approximately 3.4GB of the flash recovery area is in use, and if space is running low, about 181MB of disk space can be freed. Currently 272 files are in the flash recovery area.

While using the EM Database Control is convenient and a time-saver in many cases, sometimes you need to query the dynamic performance views directly. The two columns in the preceding query—`SPACE_RECLAIMABLE` (`OBSOLETE`) and `NUMBER_OF_FILES` (`NUM_FILES`)—are not exposed via the EM Database Control interface.

In addition to the new dynamic performance view `V$RECOVERY_FILE_DEST`, two new columns appear in existing dynamic performance views: `IS_RECOVERY_DEST_FILE` and `BYTES`.

The column `IS_RECOVERY_DEST_FILE` appears in the following dynamic performance views:

- `V$CONTROLFILE`
- `V$LOGFILE`
- `V$ARCHIVED_LOG`
- `V$DATAFILE_COPY`
- `V$BACKUP_PIECE`

The value of the column is YES if the file was created in the flash recovery area; otherwise the value is NO. The following SQL command output shows the name and status for archived redo log files created in the last three hours:

```
SQL> select name, completion_time, is_recovery_dest_file
  2    from v$archived_log
  3  where completion_time > sysdate-0.125;

NAME                      COMPLETIO IS_
------------------------- --------- ---
/OraFlash/ORD/archivelog/ 04-JUL-04 YES
2004_07_04/o1_mf_1_1891_0
gkg9x52_.arc

/OraFlash/ORD/archivelog/ 04-JUL-04 YES
2004_07_04/o1_mf_1_1892_0
gkgqq60_.arc

/OraFlash/ORD/archivelog/ 04-JUL-04 YES
2004_07_04/o1_mf_1_1893_0
gkj2bcw_.arc

/OraFlash/ORD/archivelog/ 04-JUL-04 YES
2004_07_04/o1_mf_1_1894_0
gkmlpcp_.arc

/OraFlash/ORD/archivelog/ 04-JUL-04 YES
2004_07_04/o1_mf_1_1895_0
gkqzfoz_.arc

5 rows selected.
```

In this database, all the archived redo logs are created in the flash recovery area.

The other new column is the BYTES column in the view V$BACKUP_PIECE. This column indicates the size, in bytes, of the file in the flash recovery area. Here is an example:

```
SQL> select recid, handle, bytes from v$backup_piece
  2     where recid = 25;

     RECID HANDLE                                    BYTES
---------- ---------------------------------- ----------
        25 /u10/oradata/ord/0tfh79h4_1_1        179591168

1 row selected.
```

Flash Recovery Area Best Practices

While Oracle Managed Files (OMF) has been available since Oracle 9*i*, it was recommended only for testing and development databases or production databases with logical volume managers that supported large, dynamically extensible files with RAID support.

Now that Oracle 10*g* supports OMF with ASM and the flash recovery area, OMF is a viable and useful option for many more database environments. Setting the initialization parameters `DB_CREATE_FILE_DEST` and `DB_CREATE_ONLINE_LOG_DEST_n` to a location in an ASM disk group lets Oracle manage the file naming for all database files while ASM manages the performance and redundancy capabilities required in a production database environment.

Setting the initialization parameters `DB_RECOVERY_FILE_DEST_SIZE` and `DB_RECOVERY_FILE_DEST` puts all recovery-related files in one place, simplifying administration. OMF is automatically used for file naming when a flash recovery area is defined.

Performing Incremental and Incrementally Updated Backups

Two new features of RMAN further reduce the time it takes to both back up and restore your database. Incrementally updated backups apply RMAN incremental backups to an existing image copy, potentially reducing recovery time in the event of media failure. Conversely, RMAN's fast incremental backup capability uses a tracking file to identify only the blocks that need to be backed up in an incremental backup scenario, potentially reducing the amount of time it takes to create the incremental backup in the first place.

Recovery with Incrementally Updated Backups

An RMAN *incrementally updated backup* recovers a copy of a datafile by applying an RMAN incremental backup to an existing RMAN image copy. The updated image copy is identical to an image copy made at the same system change number (SCN) as the incremental backup that was applied to the image copy. For example, assume that you make an image copy of datafile #1 (part of the `SYSTEM` tablespace) on Sunday at SCN 1052340 and then perform one or more incremental backups through Wednesday at SCN 2283487. Next, you perform an incrementally updated backup after the last incremental backup: The image copy of datafile #1 is identical to an image copy of datafile #1 made at SCN 2283487. Incrementally updated backups save time in recovery situations because fewer archived log files need to be applied in a media failure scenario.

In the following example, you have at least one image copy of the `SYSTEM` tablespace's datafiles, and you perform an incremental RMAN backup:

```
[oracle@oltp oracle]$ rman target /

Recovery Manager: Release 10.1.0.2.0 - Production
```

```
Copyright (c) 1995, 2004, Oracle.  All rights reserved.

connected to target database: ORD (DBID=1387044942)

RMAN> backup incremental level 1 tablespace system;

Starting backup at 05-JUL-04
using target database controlfile
          instead of recovery catalog
allocated channel: ORA_DISK_1
channel ORA_DISK_1: sid=254 devtype=DISK
channel ORA_DISK_1: starting compressed incremental
     level 1 datafile backupset
channel ORA_DISK_1: specifying datafile(s) in backupset
input datafile fno=00001
          name=/u05/oradata/ord/system01.dbf
channel ORA_DISK_1: starting piece 1 at 05-JUL-04
channel ORA_DISK_1: finished piece 1 at 05-JUL-04
piece
  handle=/OraFlash/ORD/backupset/2004_07_05/
     o1_mf_nnnd1_TAG20040705T084706_0glpyyjy_.bkp
          comment=NONE
channel ORA_DISK_1: backup set complete,
          elapsed time: 00:01:36
Finished backup at 05-JUL-04

Starting Control File and SPFILE Autobackup at 05-JUL-04
piece handle=/OraFlash/ORD/autobackup/2004_07_05/
     o1_mf_s_530700523_0glq1zo2_.bkp comment=NONE
Finished Control File and SPFILE Autobackup at 05-JUL-04

RMAN>
```

Since you have not performed an image copy in a while, you decide to update the existing image copy of the database with the recent incremental backups, including the one you just made.

```
RMAN> recover copy of datafile 1;

Starting recover at 05-JUL-04
using channel ORA_DISK_1
channel ORA_DISK_1: starting incremental
          datafile backupset restore
```

```
channel ORA_DISK_1: specifying datafile copies to recover
recovering datafilecopy fno=00001
   name=/OraFlash/ORD/datafile/o1_mf_system_0ggyw94d_.dbf
channel ORA_DISK_1: restored backup piece 1
piece handle=/OraFlash/ORD/backupset/2004_07_05/
     o1_mf_nnnd1_TAG20040705T084706_0glpyyjy_.bkp
          tag=TAG20040705T084706
channel ORA_DISK_1: restore complete
Finished recover at 05-JUL-04

Starting Control File and SPFILE Autobackup at 05-JUL-04
piece handle=/OraFlash/ORD/autobackup/2004_07_05/
     o1_mf_s_530702222_0glrq0n9_.bkp comment=NONE
Finished Control File and SPFILE Autobackup at 05-JUL-04

RMAN>
```

The image copy of datafile #1, `/OraFlash/ORD/datafile/o1_mf_system_0ggyw94d_.dbf`, is now updated with all incremental backups and can reduce the amount of time it takes to perform a recovery of the `SYSTEM` tablespace since any archived redo log files created before the incremental recovery do not need to be applied. If multiple image copies of the `SYSTEM` tablespace's datafiles exist, only the latest version of the image copy is updated with the incremental backup.

It is easy to set up automated incrementally updated backups using the Oracle-suggested strategy in the EM Database Control. On the Schedule Backup: Strategy page, shown in Figure 7.3, you select the Oracle-suggested backup strategy and specify Disk as the only backup medium.

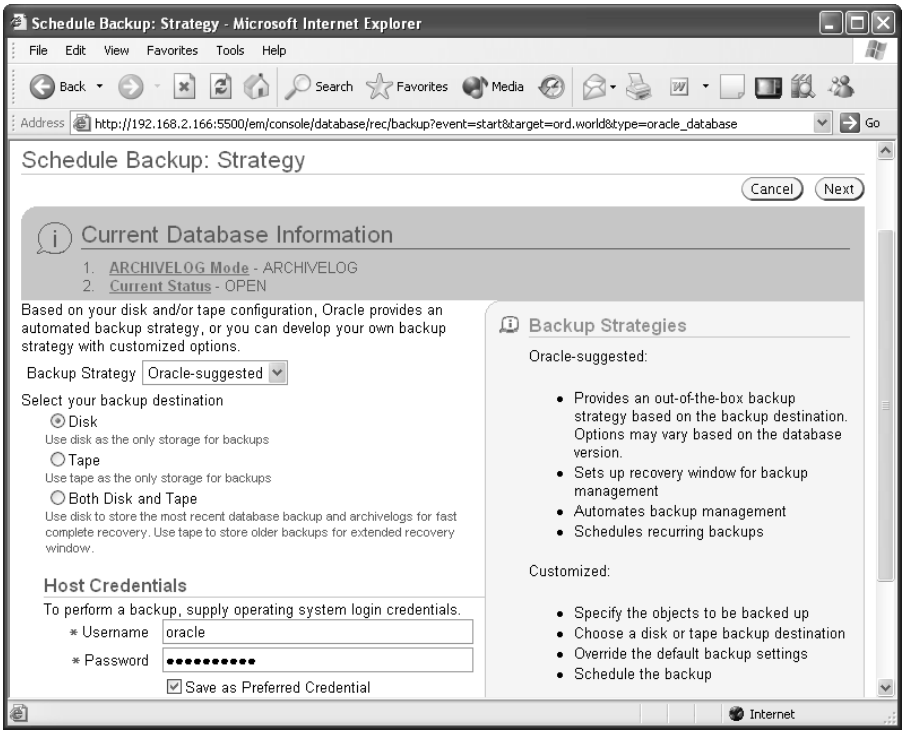
Oracle's suggested strategy starts with a full database copy as the first backup, with incremental backups and incrementally updated backups daily.

Fast Incremental Backups

Fast incremental backups optimize an RMAN incremental backup by quickly identifying those data blocks that have changed since the previous backup. Fast incremental backups require the use of a *change-tracking file* to track the physical location of all database changes. During an incremental backup, RMAN uses the change tracking file to quickly identify only the blocks that have changed, avoiding the time-consuming task of reading the entire datafile to determine which blocks have changed. The slight overhead of maintaining the tracking file is easily offset by the time savings whenever an incremental backup occurs, especially in databases that are not heavily updated, although most online transaction processing system (OLTP) databases can benefit from fast incremental backups.

Disk space is another consideration when using fast incremental backups: The size of the change-tracking file is proportional to the size of the database and the number of nodes in a RAC environment. A new background process, *CTWR (Change Tracking Writer)*, is also required when using fast incremental backups.

FIGURE 7.3 Schedule Backup: Strategy page, with the Oracle-Suggested option selected



Enabling block change tracking is straightforward using OMF and an ALTER DATABASE command, as in this example:

```
SQL> alter database enable block change tracking;
Database altered.
```

Because we used OMF, the block change-tracking file was automatically named and placed in the directory specified by the DB_CREATE_FILE_DEST initialization parameter.

```
SQL> show parameter db_create_file_dest

NAME                         TYPE        VALUE
---------------------------- ----------- ----------------
db_create_file_dest          string      /u04/oradata

SQL> ! ls -l /u04/oradata/ORD/changetracking
total 11348
-rw-r-----    1 oracle   oinstall 11600384 Jul  5 10:05
```

```
        o1_mf_0glvc2gb_.chg

SQL>
```

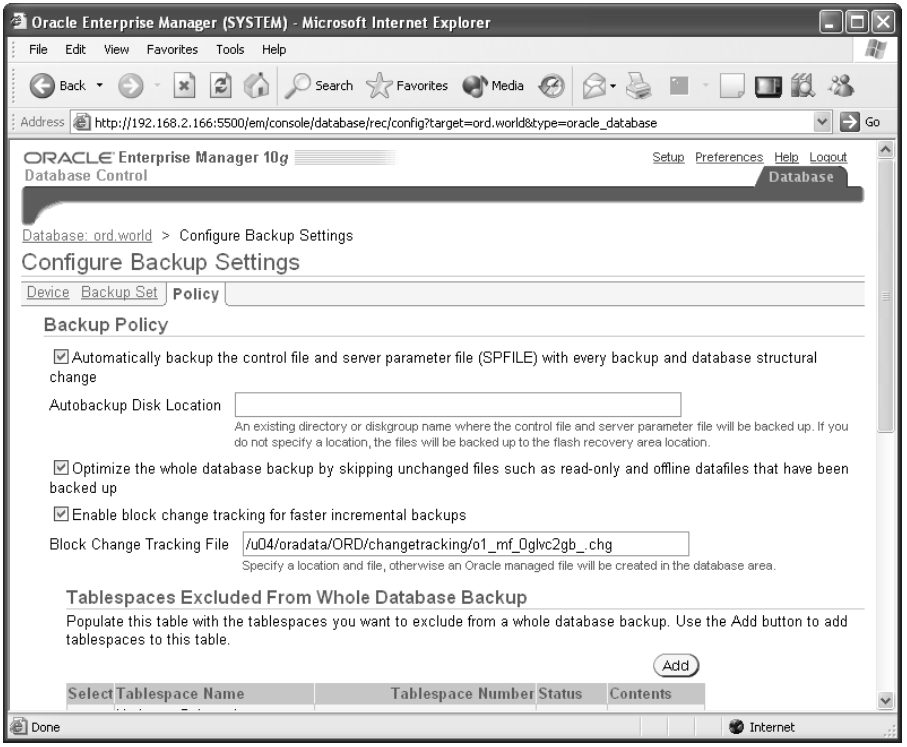
If you are not using OMF, then you will have to add the `USING FILE` clause to the `ALTER DATABASE` command when enabling block change tracking, as in this example:

```
SQL> alter database
  2    enable block change tracking using file
  3    '/u04/oradata/ord/changetracking/chg01.dbf';
Database altered.
```

Oracle recommends placing the block change-tracking file on the same disk as the database files; this is automatic if you are using OMF.

`ALTER DATABASE DISABLE BLOCK CHANGE TRACKING` turns off support for fast incremental backups. Enabling and disabling via the EM Database Control is also straightforward, as you can see in Figure 7.4, the Configure Backup Settings page.

FIGURE 7.4 Configure Backup Settings page: Performing fast incremental backups



On the EM Database Control page in Figure 7.4, you can see the block change-tracking file you created in the SQL `ALTER DATABASE` command.

The dynamic performance view `V$BLOCK_CHANGE_TRACKING` shows where the block change-tracking file is stored, whether it is enabled, and how large it is, as you can see in the following query:

```
SQL> select * from v$block_change_tracking;

STATUS     FILENAME                       BYTES
---------- ------------------------- ----------
ENABLED    /u04/oradata/ORD/changetra   11599872
           cking/o1_mf_0glvc2gb_.chg


1 row selected.
```

Using Miscellaneous Backup Features

A number of other enhancements have been made to both RMAN and traditional backup commands to make the syntax more consistent as well as to make certain operations less error prone and easier to perform.

RMAN enhancements include an easier way to create backups of multiple tablespaces as well as the entire database; in addition, RMAN now supports binary compression of backup sets to reduce the disk space required for backups, as well as providing a compression scheme that is optimized for Oracle datafiles.

For backups outside RMAN, the new `ALTER DATABASE...BEGIN/END BACKUP` command provides shorthand for placing individual tablespaces into `BACKUP` mode while skipping read-only or missing datafiles for any tablespace in the database.

RMAN Command Changes

Other enhancements to RMAN include the ability to drop a database, including the backup files; automatic channel failover; enhanced RMAN scripts; and controlling the resources used by RMAN during backup and recovery operations by using the new duration and throttling options.

Dropping a Database in RMAN

Although you can drop a database from the SQL*Plus command line and the Database Configuration Assistant (DBCA), dropping the database from RMAN has the additional benefit of dropping all backup copies and archived log files for the database if you include the `INCLUDING BACKUPS` clause, as shown here:

```
RMAN> drop database including backups;
```

If you drop the database from DBCA or SQL*Plus, or you omit the INCLUDING BACKUPS clause in RMAN, you can still remove the database files manually. To remove the database information from the repository catalog when you drop a database from DBCA or SQL*Plus, use the RMAN UNREGISTER DATABASE command. If you are only using the control file for your RMAN metadata, this command is not necessary.

Automatic Channel Failover

If you are using multiple channels during an RMAN backup to either tape or disk and one of the channels fails, the backup job continues on the remaining channels. Any errors including channel errors are reported in the dynamic performance view V$RMAN_OUTPUT after the backup job is complete.

Enhanced Scripting Capabilities

Scripting capabilities have been enhanced in RMAN. Text scripts can be converted to stored scripts, and vice versa; in addition, *global script* capabilities allow all databases that connect to the same catalog database to share scripts, reducing script maintenance efforts.

Duration, Throttling, and Partial Backup Options

To reduce the impact to ongoing transactions in the database while RMAN backups are running, new duration, throttling, and partial backup options are available in RMAN BACKUP commands. The options are as follows:

BACKUP...DURATION By specifying a maximum duration or time frame for a backup operation, you can minimize the impact of the backup operation in a 24/7 environment. The new DURATION option, which replaces RATE and READRATE in previous versions of RMAN, throttles the I/O requirements of the backup operation. To spread out the backup of the USERS tablespace over a maximum of two hours, use the following command:

```
RMAN> backup tablespace users duration 2:00;
```

By default, the backup will complete as fast as possible within the two-hour time frame; see MINIMIZE LOAD and MINIMIZE TIME.

BACKUP...DURATION...PARTIAL Adding PARTIAL to the BACKUP command prevents an error message from being issued by RMAN in case the backup does not finish the operation in the specified amount of time. Any complete backup sets are available for recovery operations, and any partial or incomplete backup operations will have to be restarted.

BACKUP...DURATION...MINIMIZE LOAD The MINIMIZE LOAD clause, used with disk backups only, automatically adjusts the throughput of the backup operation to complete the backup in the estimated completion time specified by DURATION.

BACKUP...DURATION...MINIMIZE TIME MINIMIZE TIME, the default when using DURATION, will complete the backup in the shortest possible time.

In the following example you will back up the USERS tablespace over a two hour period, minimizing the impact to the rest of the database:

```
RMAN> backup duration 2:00 minimize load
2> tablespace users;

Starting backup at 29-JUL-04
using channel ORA_DISK_1
channel ORA_DISK_1: starting compressed
     full datafile backupset
channel ORA_DISK_1: specifying datafile(s) in backupset
input datafile fno=00004 name=/u05/oradata/ord/users01.dbf
input datafile fno=00007 name=/u05/oradata/ord/users02.dbf
channel ORA_DISK_1: starting piece 1 at 29-JUL-04
channel ORA_DISK_1: finished piece 1 at 29-JUL-04
piece handle=/OraFlash/ORD/backupset/2004_07_29/
     o1_mf_nnndf_TAG20040729T223445_0jmjgpmj_.bkp
     comment=NONE
channel ORA_DISK_1: backup set complete,
     elapsed time: 01:59:55
channel ORA_DISK_1: throttle time: 1:59:37
Finished backup at 29-JUL-04

Starting Control File and SPFILE Autobackup at 29-JUL-04
piece handle=/OraFlash/ORD/autobackup/2004_07_29/
     o1_mf_s_532823802_0jmjld7d_.bkp comment=NONE
Finished Control File and SPFILE Autobackup at 29-JUL-04

RMAN>
```

As the backup proceeds, RMAN may speed up or slow down the operation based on its estimate of the number of blocks to back up and the current throughput of the backup operation to hit the duration target as closely as possible.

Online Backup Mode

For environments that are not yet using RMAN for backup and recovery operations, the BEGIN BACKUP and END BACKUP clauses have been added to the ALTER DATABASE command.

Entire Database Backup

To put every tablespace into online backup mode, you can use the following command:

```
SQL> alter database begin backup;
```

You no longer have a need to place each tablespace into backup mode individually unless you want to back up only one tablespace at a time for performance reasons. The only requirements for this mode are that the database must be in ARCHIVELOG mode and the database must be mounted and open.

Once the entire database is in online backup mode, the database cannot be shut down normally, tablespaces cannot be placed in read-only mode, and tablespaces cannot be taken offline.

File Status and *BEGIN BACKUP*

When the entire database is in online backup mode with BEGIN BACKUP, no error messages are generated if any datafiles are missing, offline or read-only. However, error messages are still issued if an individual tablespace is placed into online backup mode and any of its datafiles are missing, offline, or read-only.

In the following example, the USERS2 tablespace is READ ONLY when the database is placed into BEGIN BACKUP mode:

```
SQL> alter tablespace users2 begin backup;
Database altered.

alter tablespace users2 begin backup
*
ERROR at line 1:
ORA-01642: begin backup not needed for read only tablespace 'USERS2'
```

File Status and *END BACKUP*

As with BEGIN BACKUP, taking the entire database out of online backup mode with END BACKUP will not generate an error message if any datafiles are read-only, missing, or offline. However, a warning message is generated for any offline datafiles.

Backing Up Different Object Types with RMAN

Enhancements to RMAN commands make your job even easier either by reducing the number of commands needed to perform a backup or by expanding the number of options available for backing up each type of object, whether it is a tablespace, a datafile, an archived log file, or the entire database.

Creating Image Copies

In previous versions of RMAN, the COPY command made image copies of datafiles. This command is deprecated in Oracle 10*g*'s version of RMAN for the BACKUP AS COPY command, which can copy an entire database, multiple tablespaces, datafiles, archived log files, or datafile copies in a single command. For disk devices, the default backup type is COPY; for tape devices, the default backup type is still BACKUPSET.

In the following example, you use the BACKUP AS COPY command to make an image copy of both the SYSTEM and SYSAUX tablespaces to the flash recovery area:

```
RMAN> backup as copy tablespace system, sysaux;

Starting backup at 05-JUL-04
using channel ORA_DISK_1
channel ORA_DISK_1: starting datafile copy
input datafile fno=00001
     name=/u05/oradata/ord/system01.dbf
output filename=/OraFlash/ORD/datafile/
     o1_mf_system_0gm4w4fz_.dbf tag=TAG20040705T124433
     recid=31 stamp=530714993
channel ORA_DISK_1: datafile copy complete,
     elapsed time: 00:05:19
channel ORA_DISK_1: starting datafile copy
input datafile fno=00003
     name=/u05/oradata/ord/sysaux01.dbf
output filename=/OraFlash/ORD/datafile/
     o1_mf_sysaux_0gm563sn_.dbf tag=TAG20040705T124433
     recid=32 stamp=530715257
channel ORA_DISK_1: datafile copy complete,
     elapsed time: 00:04:26
Finished backup at 05-JUL-04

Starting Control File and SPFILE Autobackup at 05-JUL-04
piece handle=/OraFlash/ORD/autobackup/2004_07_05/
     o1_mf_s_530715260_0gm5gmfm_.bkp comment=NONE
Finished Control File and SPFILE Autobackup at 05-JUL-04

RMAN>
```

Notice that RMAN automatically determines which datafiles belong to each tablespace and performs the image copy for each. In addition, the image copies generated by RMAN can be used directly in a recovery operation without using RMAN to extract a datafile from a previous backup set.

Using the EM Database Control, it's easy to change from backup sets to image copies on the Configure Backup Settings page, as you can see in Figure 7.5.

Full Database Backup

You can back up the entire database with the following command:

```
RMAN> backup database;
```

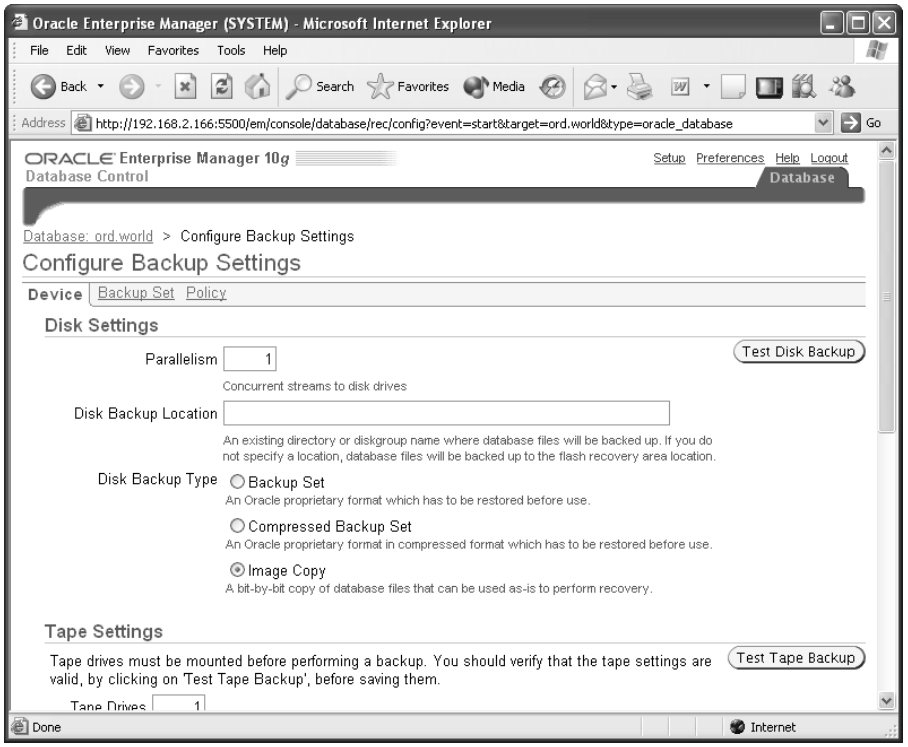
Depending on the default backup type, either backup sets will be created for all datafiles in the database or, as in the previous example, image copies.

You may want to back up a previous backup to tape, rather than create a direct backup to tape, so as not to impact a database that is up and running. In RMAN, you can use the following command to back up a previous copy of the entire database to the default tape device:

```
RMAN> backup copy of database;
```

Note the syntax differences between this and the BACKUP AS COPY DATABASE command: BACKUP AS COPY creates a direct image copy of the database, and BACKUP COPY OF creates a copy of the backup itself.

FIGURE 7.5 Configure Backup Settings page, with the Image Copy option selected



Individual Tablespace Backup

As you saw earlier in this chapter, RMAN makes it easy to make image copies of all datafiles within one or more tablespaces. As with most RMAN BACKUP commands, you can specify either AS COPY or AS BACKUPSET. If the default backup type is COPY, you can still take advantage of the convenient tablespace syntax, as in the following example:

```
RMAN> backup as backupset tablespace idx_8;

Starting backup at 05-JUL-04
using channel ORA_DISK_1
channel ORA_DISK_1: starting full datafile backupset
channel ORA_DISK_1: specifying datafile(s) in backupset
input datafile fno=00017 name=/u08/oradata/ord/idx08.dbf
channel ORA_DISK_1: starting piece 1 at 05-JUL-04
channel ORA_DISK_1: finished piece 1 at 05-JUL-04
piece handle=/OraFlash/ORD/backupset/2004_07_05/
     o1_mf_nnndf_TAG20040705T131930_0gm6xlz1_.bkp
     comment=NONE
channel ORA_DISK_1: backup set complete,
     elapsed time: 00:00:15
Finished backup at 05-JUL-04

Starting Control File and SPFILE Autobackup at 05-JUL-04
piece handle=/OraFlash/ORD/autobackup/2004_07_05/
     o1_mf_s_530716786_0gm6y46t_.bkp comment=NONE
Finished Control File and SPFILE Autobackup at 05-JUL-04

RMAN>
```

Backing up a tablespace backup is similar to backing up a full database backup to tape.

```
RMAN> backup copy of tablespace idx_8;
```

If the BACKUP command includes datafile #1, which is always part of the SYSTEM tablespace, then RMAN will add a copy of the control file and SPFILE in the backup set.

Datafile and Control File Backup

Backing up individual datafiles and control files operates similarly to backing up tablespaces. In the following example, you are explicitly backing up the control file to the flash recovery area:

```
RMAN> backup current controlfile;
```

The backup made by the previous command is identical to the backup made by the following command in SQL*Plus:

```
SQL> alter database backup controlfile to '/u04/oradata/ord/ctl.bk';
```

Compressed Backups

RMAN has been enhanced to provide *binary compression* for backup sets, reducing the amount of disk space required to make a backup. In many cases, the additional overhead required to compress the backup set is offset by the reduced I/O load when writing the backup set to disk. In addition, the binary compression algorithm used by RMAN is optimized for use with Oracle datafiles, making it a better alternative than using operating system file system or tape device compression schemes.

You can specify compression for a specific RMAN backup, or you can set it as the default for all RMAN backup sets. To specify compression in an RMAN command, add the `COMPRESSED` keyword. Here is an example of using the `COMPRESSED` keyword on a backup of the `USERS2` tablespace:

```
RMAN> backup as compressed backupset
2>       tablespace users2;

Starting backup at 29-JUL-04
using target database controlfile instead of
     recovery catalog
allocated channel: ORA_DISK_1
channel ORA_DISK_1: sid=242 devtype=DISK
channel ORA_DISK_1: starting compressed
     full datafile backupset
channel ORA_DISK_1: specifying datafile(s) in backupset
input datafile fno=00009 name=/u09/oradata/ord/big_users.dbf
channel ORA_DISK_1: starting piece 1 at 29-JUL-04
channel ORA_DISK_1: finished piece 1 at 29-JUL-04
piece handle=/OraFlash/ORD/backupset/2004_07_29/
     o1_mf_nnndf_TAG20040729T230940_0jmlj8rh_.bkp
     comment=NONE
channel ORA_DISK_1: backup set complete,
     elapsed time: 00:00:16
Finished backup at 29-JUL-04

Starting Control File and SPFILE Autobackup at 29-JUL-04
```

```
piece handle=/OraFlash/ORD/autobackup/2004_07_29/
     o1_mf_s_532825797_0jmljq92_.bkp comment=NONE
Finished Control File and SPFILE Autobackup at 29-JUL-04

RMAN> quit

Recovery Manager complete.
```

Note that the backup time for this backup is less than half than the uncompressed version of the backup, with the added bonus of a smaller backup set; In the example below, you compare the size of the backupset to the size of the tablespace you just backed up:

```
$ ls -l /OraFlash/ORD/backupset/2004_07_29
-rw-r-----    1 oracle   oinstall  1818624 Jul 29 23:09
                 o1_mf_nnndf_TAG20040729T230940_0jmlj8rh_.bkp

$ ls -l /u05/oradata/ord/users02.dbf
-rw-r-----    1 oracle   oinstall  5251072 Jul 29 23:05
                 /u05/oradata/ord/users02.dbf
$
```

The compression of the USERS2 tablespace is well over 60 percent.

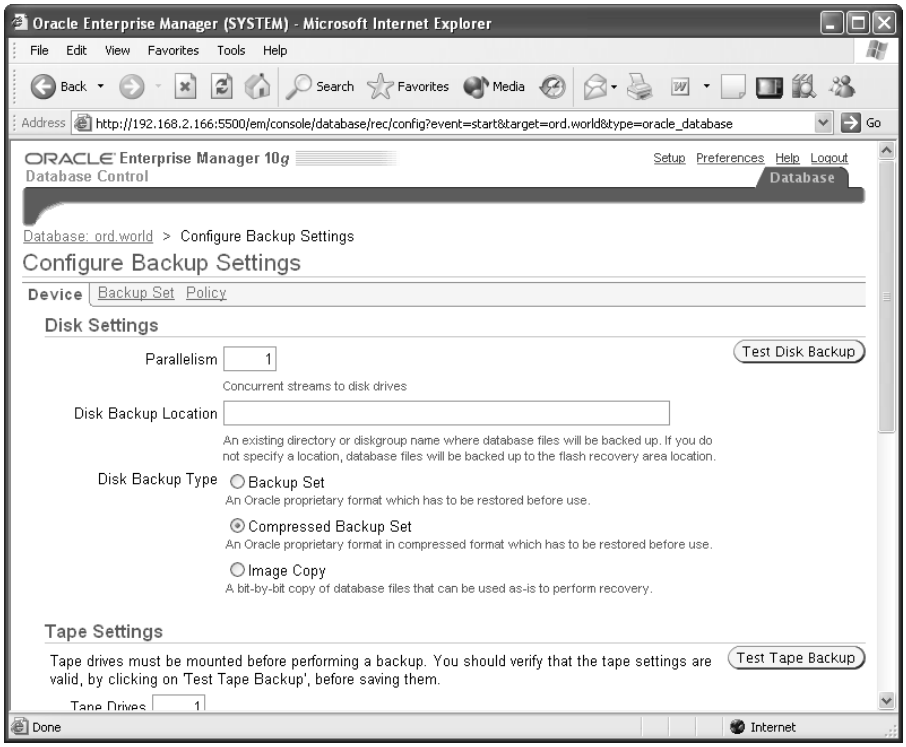
RMAN image copies cannot be compressed.

It's also easy to make compression the default for disk or tape using the CONFIGURE command.

```
RMAN> configure device type disk
2>      backup type to compressed backupset;

old RMAN configuration parameters:
CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO
     BACKUPSET PARALLELISM 1;
new RMAN configuration parameters:
CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO
     COMPRESSED BACKUPSET PARALLELISM 1;
new RMAN configuration parameters are successfully stored
released channel: ORA_DISK_1

RMAN>
```

Using the EM Database Control, it's easy to specify compression for all disk backups, as you can see in Figure 7.6, the Configure Backup Settings screen.

FIGURE 7.6 Configure Backup Settings page, with Compression Backup Set option selected



Introducing Miscellaneous Recovery Features

In the following sections, we will cover a couple of miscellaneous enhancements to both RMAN and SQL that make backups even more versatile in a recovery situation. RMAN now supports a fast way to recover an entire database by using the backup datafiles in the flash recovery area as the primary datafiles, dramatically reducing the amount of time it takes to bring the database back online compared to other recovery methods. The new `RESETLOGS` recovery option allows you to retain the use of archived log files created before the `RESETLOGS` command was issued.

Fast Recovery Using *SWITCH DATABASE*

The new RMAN command SWITCH DATABASE is the fastest way to recover a database using backup copies of the database: No files are copied, and no files need to be renamed. It takes one command.

```
RMAN> switch database to copy;
```

The downside to this method is that your datafiles are now in the flash recovery area. This may cause problems when you create backups: Now your datafiles and backups are in the same location. At your earliest opportunity, you should migrate the datafiles out of the flash recovery area and create new backups.

You can still use the RMAN command RESTORE DATABASE, but the recovery time is increased since the restore process copies the previously backed up datafiles from the flash recovery area to the current location specified by the control file and applies the appropriate archived log files.

Recovery Using *RESETLOGS*

In previous versions of Oracle, issuing the ALTER DATABASE OPEN RESETLOGS command required you to immediately perform a full database backup. In addition, any backups created before the RESETLOGS operation were not usable for subsequent recovery operations.

As of Oracle 10*g*, the RMAN backups created before the RESETLOGS operation are still usable. Incremental backups created after the RESETLOGS operation can be applied to full backups of a previous database incarnation.

To ensure that log files created after the RESETLOGS operation do not have naming conflicts with log files created before the RESETLOGS operation, the default format for the initialization parameter LOG_ARCHIVE_FORMAT has been changed, as shown here:

```
SQL> show parameter log_archive_format

NAME                         TYPE        VALUE
---------------------------- ----------- -----------------
log_archive_format           string      %t_%s_%r.dbf
```

The parameter %r represents the RESETLOGS identifier and changes every time a RESETLOGS operation occurs, ensuring that no filename collisions exist in the flash recovery area or an archived log file destination.

Flashing Back Any Logical Error

Oracle 10*g* supports a number of features that both users and DBAs alike can use to *flashback*, or recover, from many different types of logical errors that can occur in a database, including

a row erroneously deleted from a table, a table that was accidentally dropped, and database-wide logical corruption because the nightly batch job ran twice.

Flashback Query, available in Oracle *9i*, has been enhanced to include two new types of queries: Flashback Versions Query and Flashback Transaction Query. Flashback Versions Query allows a user or the DBA to see all versions of a table's row between two times, and with Flashback Transaction Query you can see all transactions that changed a row between two times.

Flashback Database provides an easy way to move the entire database back to a point of time in the past if widespread corruption is found in the database and if restoring individual tables or specific rows in tables would be too time-consuming.

Flashback Table brings a table and all its dependent objects back to a point in time if only a small number of tables have been corrupted; Flashback Drop restores a table to its previous state if it has been erroneously or inadvertently dropped.

While all these features are referred to as *flashback features*, they are implemented in a number of ways. Flashback Query relies on undo information in the undo tablespace, and Flashback Versions and Transaction Query rely on online and archived redo log files. Flashback Drop uses a new construct available in each tablespace called the *recycle bin*. Finally, Flashback Database uses a new type of log file that is saved in the flash recovery area called, appropriately enough, *flashback logs*.

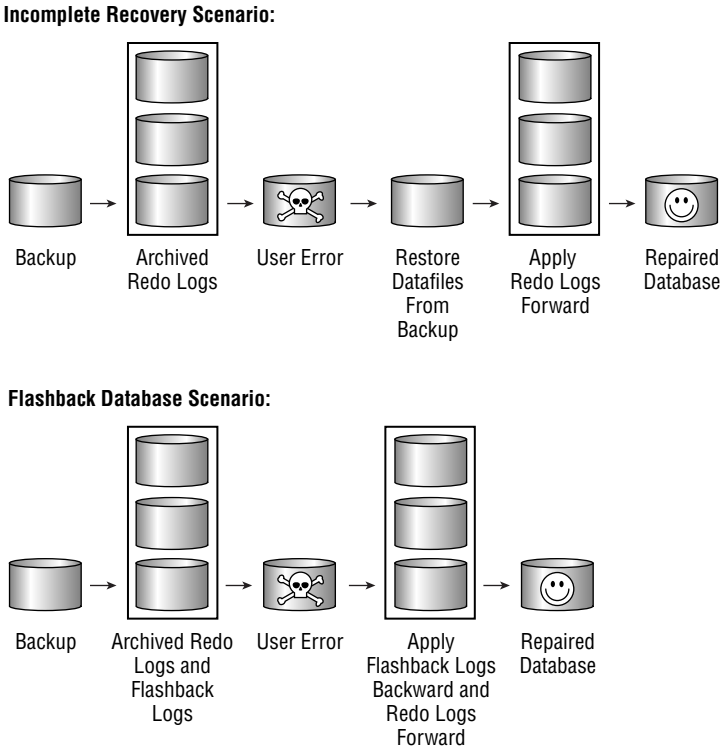
Flashback Database

Flashback Database allows you to quickly revert the entire database to its state as of a previous point in time. Rather than restoring an older copy of each datafile and performing incomplete recovery, the starting point is the present and recent changes are backed out of the database. For databases that get larger and larger, traditional point-in-time recovery techniques become prohibitive in terms of the amount of time it takes to restore datafiles; using Flashback Database can take significantly less time since only the most recent changes need to be backed out. Figure 7.7 shows how Flashback Database saves time: after a user error, the time-consuming file restoration step has been eliminated.

Whenever Flashback Database is enabled, the new background process `RVWR` is started in order to write data from the *flashback buffer* in the System Global Area (SGA) to flashback logs in the flash recovery area. For large production databases, the value of the `LOG_BUFFER` parameter should be at least 8MB to ensure that 16MB is allocated to the flashback buffer; 16MB is the maximum size of the flashback buffer (one granule).

In the following sections, we will show you the SQL commands or the EM Database Control web pages used to configure flashback database and flashback logs in the flash recovery area. We will present the new data dictionary views that can help you identify how much space in the flash recovery area will be needed to satisfy your retention target; in addition, you will see how to use both SQL commands and the EM Database Control to perform the actual flashback command. Finally, we will show you how to exclude tablespaces from generating flashback logs, as well as a few caveats for using flashback database.

FIGURE 7.7 Flashback Database Eliminates Restore Time



Configuring Flashback Database Using SQL

Flashback data is stored in the flash recovery area. The number of flashback logs to keep in the flash recovery area is measured in minutes using the initialization parameter DB_FLASHBACK_RETENTION_TARGET. You enable Flashback Database with an ALTER DATABASE command. Here are the SQL commands to set the parameter and enable Flashback Database:

```
SQL> shutdown immediate;
Database closed.
Database dismounted.
ORACLE instance shut down.

SQL> startup mount exclusive
ORACLE instance started.
```

```
Total System Global Area  197132288 bytes
Fixed Size                   778076 bytes
Variable Size             162537636 bytes
Database Buffers           33554432 bytes
Redo Buffers                 262144 bytes
Database mounted.

SQL> alter system set
  2     db_flashback_retention_target=60
  3     scope=both;

System altered.

SQL> alter database flashback on;

Database altered.

SQL> alter database open;

Database altered.

SQL>
```

In this example, you shut down the database and restart the database in `MOUNT EXCLUSIVE` mode; you must be in `MOUNT EXCLUSIVE` and `ARCHIVELOG` mode to disable Flashback Database. The initialization parameter `DB_FLASHBACK_RETENTION_TARGET` is set to 60 minutes. Finally, the database is opened. Any changes to the database are recorded in both the redo log files and the flashback logs.

To ensure that Flashback Database is enabled, you can check the dynamic performance view `V$DATABASE`, as in the following example:

```
SQL> select flashback_on from v$database;

FLA
---
YES

1 row selected.
```

Disabling Flashback Database with `ALTER DATABASE FLASHBACK OFF` automatically deletes all flashback logs in the flash recovery area.

Flash Back Using SQL or RMAN Commands

In the previous example, you configured Flashback Database to keep enough flashback logs in the flash recovery area to support a database flashback up to 60 minutes into the past. In the following example, you discover that several order-entry database tables in the database were accidentally overwritten with rows from the previous night's batch run; the users indicate that the batch job ran about 15 minutes ago. You decide to use Flashback Database to flash the database back 30 minutes to a state before the critical order entry tables were corrupted. You run the following SQL command:

```
SQL> flashback database to timestamp(sysdate-(1/48));
flashback database to timestamp(sysdate-(1/48))
*
ERROR at line 1:
ORA-38757: Database must be mounted EXCLUSIVE and not
     open to FLASHBACK.

SQL> shutdown immediate;
Database closed.
Database dismounted.
ORACLE instance shut down.
SQL> startup mount exclusive;
ORACLE instance started.

Total System Global Area  197132288 bytes
Fixed Size                   778076 bytes
Variable Size             162537636 bytes
Database Buffers           33554432 bytes
Redo Buffers                 262144 bytes
Database mounted.
SQL> flashback database to timestamp(sysdate-(1/48));

Flashback complete.

SQL> alter database open;
alter database open
*
ERROR at line 1:
ORA-01589: must use RESETLOGS or NORESETLOGS option
     for database open

SQL> alter database open resetlogs;
```

```
Database altered.

SQL>
```

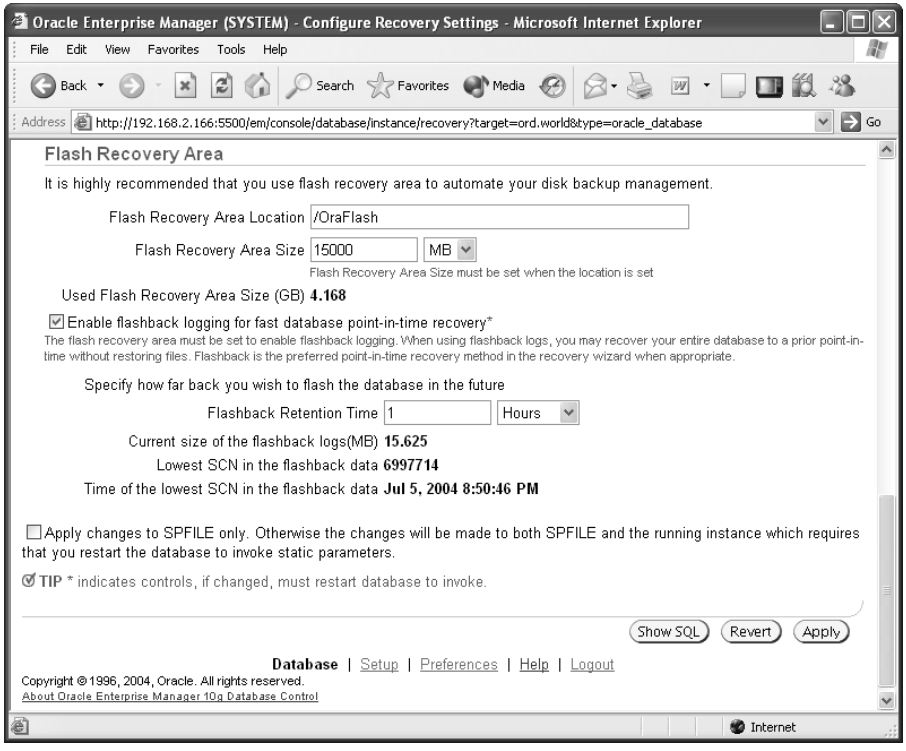
Note from this example that the database must be in MOUNT EXCLUSIVE mode to execute the flashback operation; in addition, once the flashback operation is complete, the database must be opened with RESETLOGS as if a traditional incomplete recovery had been performed; Flashback Database is essentially another form of incomplete recovery.

In addition to using a TIMESTAMP value for the FLASHBACK DATABASE command, you can use an SCN in the SQL version; using RMAN, you can flash back to a time stamp, SCN, or log sequence number (SEQUENCE) and thread number (THREAD).

Configuring and Using Flashback Database with the EM Database Control

Using the EM Database Control, you can enable Flashback Database on the Configure Recovery Settings page accessible from the Maintenance tab, as shown in Figure 7.8.

FIGURE 7.8 Configure Recovery Settings page: Enabling Flashback Database



Flashing back the database using the EM Database Control is almost as easy as configuring Flashback Database using the EM Database Control. Using the wizards on the Perform Recovery pages, you step through the same commands as if you typed the SQL or RMAN commands: you shut down the database, specify a whole database point-in-time recovery, and generate an RMAN script to flashback the database and re-open the database with RESETLOGS.

Monitoring Flashback Database

Two new dynamic performance views help you monitor the retention target you set with the DB_FLASHBACK_RETENTION_TARGET initialization parameter: V$FLASHBACK_DATABASE_LOG and V$FLASHBACK_DATABASE_STAT.

V$FLASHBACK_DATABASE_LOG

V$FLASHBACK_DATABASE_LOG helps you monitor the estimated and actual size of the flashback logs in the flash recovery, as you can see in the following query:

```
SQL> select retention_target, flashback_size,
  2     estimated_flashback_size
  3  from v$flashback_database_log;

RETENTION_TARGET FLASHBACK_SIZE ESTIMATED_FLASHBACK_SIZE
---------------- -------------- ------------------------
              60       28442624                 23486464

1 row selected.
```

The FLASHBACK_SIZE column indicates that you have more than 16MB of flashback logs; the ESTIMATED_FLASHBACK_SIZE column provides an estimate of how much space will be needed in the flash recovery area for flashback logs. In this example, if your flash recovery area is running low on space and does not have at least another 16MB of free space for flashback logs, you should consider either adding more space to the flash recovery area or reducing the value of RETENTION_TARGET.

V$FLASHBACK_DATABASE_STAT

The dynamic performance view V$FLASHBACK_DATABASE_STAT monitors the overhead of logging flashback data in the flashback logs. It contains at most 24 rows, with one row for each of the last 24 hours. In the following example, you query the newest row in the table, representing the flashback generation for the last hour:

```
SQL> select to_char(end_time,'yyyy-mm-dd hh:miAM')
  2     end_timestamp,
  3     flashback_data, db_data, redo_data
  4     from v$flashback_database_stat where rownum=1;
```

```
END_TIMESTAMP      FLASHBACK_DATA    DB_DATA  REDO_DATA
------------------ -------------- ---------- ----------
2004-07-05 10:50PM       23625728   77225984   13787136

1 row selected.
```

The FLASHBACK_DATA column represents the number of bytes of flashback data written during the last one-hour period, the DB_DATA column is the number of bytes of data blocks read and written, and the REDO_DATA column is the number of bytes of redo data written.

Excluding Tablespaces from Flashback Database

By default, flashback data is generated from all tablespaces. Sometimes you may not want to generate flashback data: for example, you may have a training tablespace with high DML activity whose contents are frequently initialized from a database export file. In this case, you can disable flashback generation at the tablespace level with an ALTER TABLESPACE command, as in the following example:

```
SQL> alter tablespace example flashback off;
```

If you need to flashback the database at any point in time, the EXAMPLE tablespace must be taken offline and recovered using other methods, if necessary. The column FLASHBACK_ON in the dynamic performance view V$TABLESPACE indicates whether flashback is enabled for each tablespace.

Flashback Database Considerations

You cannot use Flashback Database in a number of situations and must use other incomplete recovery methods.

You cannot use Flashback Database to recover dropped datafiles that were dropped after your target recovery time. In addition, you cannot flashback a datafile that was shrunk after the target recovery time.

If the control file was restored or re-created after the target recovery time, or the database was opened with RESETLOGS after the target recovery time, an incomplete recovery method such as applying archived redo log files to backup datafiles must be used instead.

Flashback Drop

Another one of Oracle 10*g*'s flashback features, *Flashback Drop*, lets you restore a dropped table without using point-in-time recovery, as required in previous versions of Oracle. While point-in-time recovery could effectively restore a table and its contents to a point in time before it was dropped, it was potentially time-consuming and had the side effect of losing work from other transactions that occurred within the same tablespace after the table was dropped.

In the following sections, we will talk about the new logical structure available in each tablespace; the recycle bin; and how you can query the recycle bin, retrieve dropped objects from the recycle bin, and purge the recycle bin.

Recycle Bin Concepts

The *recycle bin* is a logical structure within each tablespace that holds dropped tables and objects related to the tables, such as indexes. The space associated with the dropped table is not immediately available but shows up in the data dictionary view DBA_FREE_SPACE. When space pressure occurs in the tablespace, objects in the recycle bin are deleted in a first-in first-out (FIFO) fashion, maximizing the amount of time that the most recently dropped object remains in the recycle bin.

The recycle bin is implemented as a data dictionary table.

The dropped object still belongs to the owner and still counts against the quota for the owner in the tablespace; in fact, the table itself is still directly accessible from the recycle bin, as you will see in subsequent examples.

Retrieving Dropped Tables from the Recycle Bin

Retrieving a dropped table from the recycle bin is performed from the SQL command line by using the FLASHBACK TABLE...TO BEFORE DROP command. In the following example, the user GARY retrieves the table ORDER_ITEMS from the recycle bin after discovering that the table was inadvertently dropped:

```
SQL> select order_id, line_item_id, product_id
  2  from order_items
  3  where rownum < 5;
from order_items
     *
ERROR at line 2:
ORA-00942: table or view does not exist


SQL> flashback table order_items to before drop;

Flashback complete.

SQL> select order_id, line_item_id, product_id
  2  from order_items
  3  where rownum < 5;
```

```
  ORDER_ID LINE_ITEM_ID PRODUCT_ID
---------- ------------ ----------
      2355            1       2289
      2356            1       2264
      2357            1       2211
      2358            1       1781

SQL>
```

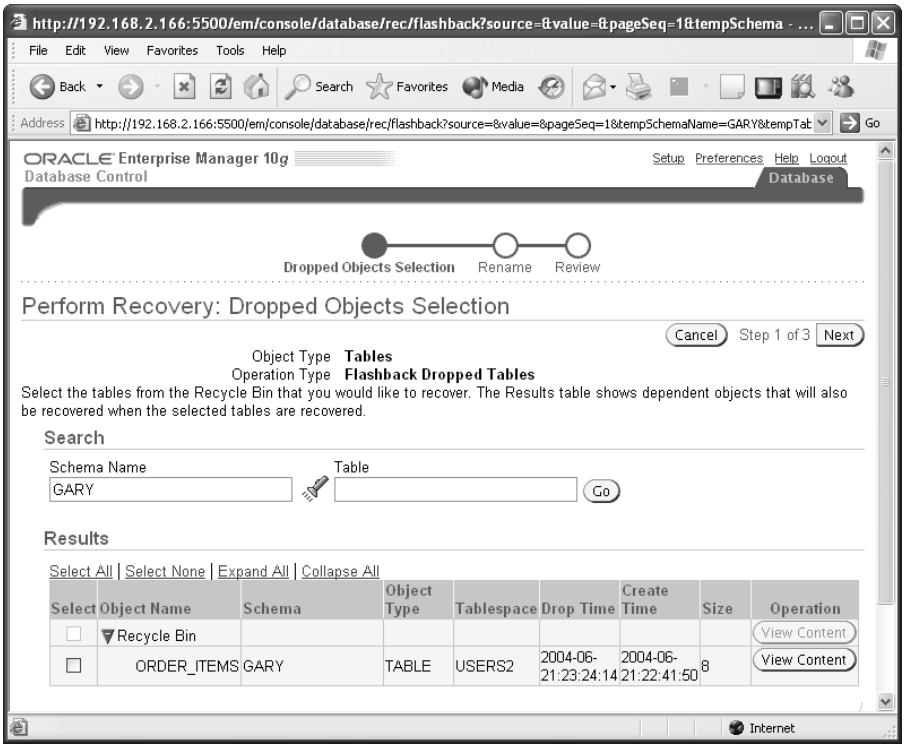
If the table ORDER_ITEMS was re-created after it was dropped, GARY would add the RENAME TO clause in the FLASHBACK TABLE command to give the restored table a new name, as in the following example:

```
SQL> drop table order_items;

Table dropped.

SQL> flashback table order_items to before drop
  2      rename to order_items_old_version;

Flashback complete.

SQL> select order_id, line_item_id, product_id
  2  from order_items_old_version
  3  where rownum < 5;

  ORDER_ID LINE_ITEM_ID PRODUCT_ID
---------- ------------ ----------
      2355            1       2289
      2356            1       2264
      2357            1       2211
      2358            1       1781

SQL>
```

If the table to be retrieved from the recycle bin was dropped more than once, and you want to retrieve an incarnation of the table before the most recent one, you can use the name of the table in the recycle bin; you will see how to find out the recycle bin name in the next section.

Using the EM Database Control, you can retrieve a dropped table from the recycle bin on the Perform Recovery: Dropped Objects Selection page, as you can see in Figure 7.9.

FIGURE 7.9 Perform Recovery: Dropped Objects Selection page



The user GARY has one table, ORDER_ITEMS, in the recycle bin that was dropped on June 21, 2004. Subsequent pages in this wizard allow you to rename the restored tables if a naming conflict exists with an existing object.

Querying the Recycle Bin

The contents of the recycle bin are available from a user's schema by querying the view USER_RECYCLEBIN or just RECYCLEBIN. As with most other data dictionary views, DBA_RECYCLEBIN shows objects that have been dropped by all users, along with an OWNER column. The important columns in DBA_RECYCLEBIN are as follows:

OWNER The schema owner of the object.

ORIGINAL_NAME The name of the object before it was dropped.

OBJECT_NAME The system-generated name of the object after it was dropped.

TYPE The object type (for example, TABLE or INDEX).

TS_NAME The tablespace to which the dropped object belongs.

CREATETIME Time stamp at which the original object was created.

DROPTIME Time stamp at which the object was dropped.

DROPSCN SCN at which the object was dropped.

CAN_UNDROP The object is available for retrieval from the recycle bin; in other words, it has not been purged explicitly or because of space pressure in the tablespace.

RELATED The object identifier of the dropped object.

SPACE The amount of space, in blocks, that the dropped object occupies.

Within SQL*Plus, you can use `SHOW RECYCLEBIN`. The user GARY queries his dropped objects in the recycle bin using the `SHOW RECYCLEBIN` command, as in the following example:

```
SQL> show recyclebin
ORIGINAL NAME  RECYCLEBIN NAME    OBJECT TYPE  DROP TIME
-------------- ------------------ ------------ ----------
ORDER_ITEMS    BIN$3Wxk60gIDFbgMK TABLE        2004-06-21
               jApgIiFQ==$0                    :23:24:14
SQL>
```

If GARY needs to access the contents of the purged `ORDER_ITEMS` table before it is undropped, he can refer to it in a SQL statement using the recycle bin name, as in the following example:

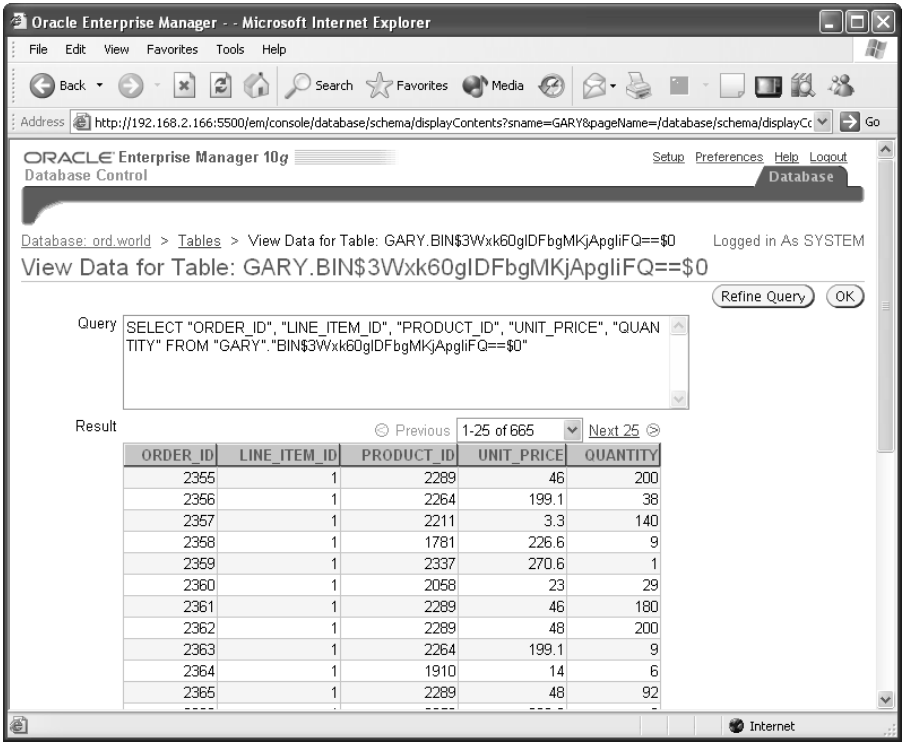
```
SQL> select order_id, line_item_id, product_id
  2  from "BIN$3Wxk60gIDFbgMKjApgIiFQ==$0"
  3  where rownum < 5;

  ORDER_ID LINE_ITEM_ID PRODUCT_ID
---------- ------------ ----------
      2355            1       2289
      2356            1       2264
      2357            1       2211
      2358            1       1781

SQL>
```

As we mentioned earlier, when a table is dropped its dependent objects, such as indexes, triggers, and constraints, are also placed into the recycle bin. The dependent objects have cryptic names in the recycle bin just as the table does; when the table is recovered, the dependent objects are recovered as well, but they keep their cryptic names. Therefore, it is advisable to query the recycle bin and `DBA_CONSTRAINTS` before flashing back a dropped table and renaming the dependent objects manually after flashing back.

Only `SELECT` statements are allowed against tables that reside in the recycle bin.

Using the EM Database Control, GARY can access the dropped table's contents on the View Data for Table page, as you can see in Figure 7.10. This page is accessible from the Perform Recovery page in Figure 7.9.

FIGURE 7.10 View Data for Table page



Recycle Bin Space Reclamation

As long as a tablespace has no space pressure, dropped objects are available indefinitely for recovery. Dropped objects are removed automatically under certain circumstances or can be removed manually by a user or by the DBA.

Automatic Space Reclamation

Automatic space reclamation occurs when the tablespace has space pressure: Either there is no free space outside of the space occupied by the objects in the recycle bin or a user's dropped objects in the recycle bin are exhausting the user's quota in a particular tablespace. Free space is allocated for new objects occurs in the following order:

1. Free space in the tablespace that is not occupied by dropped objects

2. Free space that corresponds to dropped objects (remember that once an object is dropped, its space is recorded in DBA_FREE_SPACE as being available)
3. Free space allocated by autoextending a tablespace, if one or more datafiles in the tablespace are autoextensible

Manual Space Reclamation

You can free the space occupied by dropped objects manually using several variations of the PURGE command. You can purge individual tables or indexes, you can purge users' dropped tables from a tablespace, or you can purge the entire recycle bin.

The PURGE TABLE and PURGE INDEX commands permanently remove tables and indexes from the recycle bin. Purging a table will automatically purge the dependent objects in the recycle bin as well.

If you use PURGE TABLESPACE, all objects in a specified tablespace are permanently removed from the recycle bin as are any dependent objects residing in other tablespaces. In the following example, you can remove all of GARY's objects from the recycle bin for the USERS2 tablespace:

```
SQL> purge tablespace users2 user gary;
Tablespace purged.
```

Any other objects in the recycle bin on USERS2 not owned by GARY remain in the recycle bin.

PURGE RECYCLEBIN, functionally equivalent to PURGE USER_RECYCLEBIN, purges all objects that belong to the user executing the PURGE command. If you have the DBA role or the SYSDBA privilege, PURGE DBA_RECYCLEBIN removes all objects from the recycle bin in all tablespaces.

If more than one copy of a table or an index is in the recycle bin, the PURGE command using the object's original name removes the oldest copy from the recycle bin first in a FIFO fashion. In other words, using the original object name, you must execute the PURGE command as many times as there are copies of the object in the recycle bin.

Bypassing the Recycle Bin

In situations where you want to bypass the recycle bin, you can add the PURGE keyword to the DROP TABLE command, as in the following example:

```
SQL> drop table order_items purge;
Table dropped.
```

When you use the command DROP TABLESPACE...INCLUDING CONTENTS, the dropped objects in the tablespace are not placed in the recycle bin; since each tablespace has its own logical recycle bin, dropping the tablespace drops its associated recycle bin and any objects currently in the recycle bin.

DROP USER...CASCADE operates similarly to dropping a tablespace with INCLUDING CONTENTS. The user and all of the objects owned by the user are dropped; any objects in the recycle bin belonging to the dropped user are purged.

Recycle Bin Considerations and Limitations

The recycle bin has a few limitations: Only non-SYSTEM locally managed tablespaces can have a recycle bin. However, dependent objects in a dictionary managed tablespace are protected if the dropped object is in a locally managed tablespace.

In addition, tables using Fine Grained Auditing (FGA) or Virtual Private Database (VPD) policies defined on them cannot reside in a recycle bin, regardless of the type of tablespace in which they reside.

A table's dependent objects are saved in the recycle bin when the table is dropped, except for the following objects:

- Bitmap join indexes
- Referential integrity constraints (foreign key constraints)
- Materialized view logs

Finally, indexes are protected only if the table is dropped first; explicitly dropping an index does not place the index into the recycle bin by itself.

Flashback Query

Flashback Query has been enhanced to include two new types: Flashback Versions Query and Flashback Transaction Query. Flashback Versions Query, as the name implies, retrieves all versions of all rows in a table between two time stamps or SCNs; Flashback Transaction Query provides a different point of view by retrieving all rows affected by a particular transaction.

In the following sections, you'll see how each of these new flashback options can make recoverability more transparent, impacting availability less and putting more recovery tools in the hands of the end user. You will also see how you can use both Flashback Versions Query and Flashback Transaction Query together in a recovery scenario.

Flashback Versions Query

Flashback Versions Query provides an easy way to show all versions of all rows in a table between two SCNs or time stamps, whether the rows were inserted, deleted, or updated. Even if a row was deleted and reinserted several times, all of these changes are available with Flashback Versions Query.

The syntax of the Flashback Query command is as follows:

```
SELECT [pseudo_columns]...FROM table_name
   VERSION BETWEEN
    {SCN | TIMESTAMP {expr | MINVALUE} AND
                     {expr | MAXVALUE}}
   [AS OF {SCN|TIMESTAMP expr}]
WHERE [pseudo_column | column] . . .
```

Real World Scenario

User Education and New Features

Whenever our data center installs a new version of Oracle, a number of our users embrace all the new features as time-savers whereas most users just want their queries to run the same way they did in previous versions. Oracle 10*g* was no exception: after a very smooth upgrade from Oracle 9*i*, we would get an occasional phone call from one of our "bleeding-edge" users asking how to use Flashback Transaction Query or the new `MERGE` options.

Other users, however, were complaining that the new recycle bin functionality was not working: They had to re-create the indexes every time they retrieved a table from the recycle bin with the `FLASHBACK TABLE...TO BEFORE DROP` command. Knowing that the recycle bin holds all dependent objects in addition to the dropped table, we were puzzled. We stepped through one of the user's scripts and noticed that they were dropping the index explicitly before dropping the table. As a result, the index was not being placed in the recycle bin.

The moral to this story is that you need to evaluate the new features to make sure that they will not impact existing processes and cause more problems than they solve; in addition, you need to educate the users about how to use the new features effectively for each new release. A small investment in training up front saves you headaches down the road.

If you don't know the oldest SCN or time stamp of the oldest available flashback data, you can use `MINVALUE`; similarly, `MAXVALUE` represents the most recent SCN or time stamp. Using the `AS OF` clause leverages the flashback features introduced in Oracle 9*i* to run this query from the perspective of a point of time in the past.

The pseudo-columns available with this syntax are as follows:

VERSIONS_STARTSCN The SCN at which this version of the row was created

VERSIONS_STARTTIME The time stamp at which this version of the row was created

VERSIONS_ENDSCN The SCN at which this row no longer existed (either changed or deleted)

VERSIONS_ENDTIME The time stamp at which this row no longer existed (either changed or deleted)

VERSIONS_XID The transaction ID of the transaction that created this version of the rows

VERSIONS_OPERATION The operation done by this transaction: `I`=Insert, `D`=Delete, `U`=Update

The pseudo-columns `VERSIONS_STARTSCN` and `VERSIONS_STARTTIME` are `NULL` if the SCN or time stamp is outside the range specified or outside the undo retention period; `VERSIONS_ENDSCN` and `VERSIONS_ENDTIME` are `NULL` if the version of the row is still intact as of the query time or if it has been deleted.

In the following example, you are investigating the reason why the salary of employee number 124 has doubled. The HR Department said it noticed it sometime earlier this morning, so you use midnight as your starting point for the Flashback Versions Query, as in the following example:

```
SQL> select versions_startscn startscn,
  2    versions_endscn endscn,
  3    versions_xid xid, versions_operation oper,
  4    employee_id empid, last_name name, salary sal
  5  from hr.employees
  6    versions between timestamp trunc(systimestamp)
  7       and systimestamp
  8  where employee_id = 124;

STARTSCN    ENDSCN XID      O   EMPID NAME            SAL
-------- --------- -------- - ------- ---------- --------
 7119027           01002900 U     124 Mourgos       11600
                   23160000
 7117480   7119027 04000900 U     124 Mourgos       11600
                   BE1D0000
           7117480                124 Mourgos        5800

3 rows selected.
```

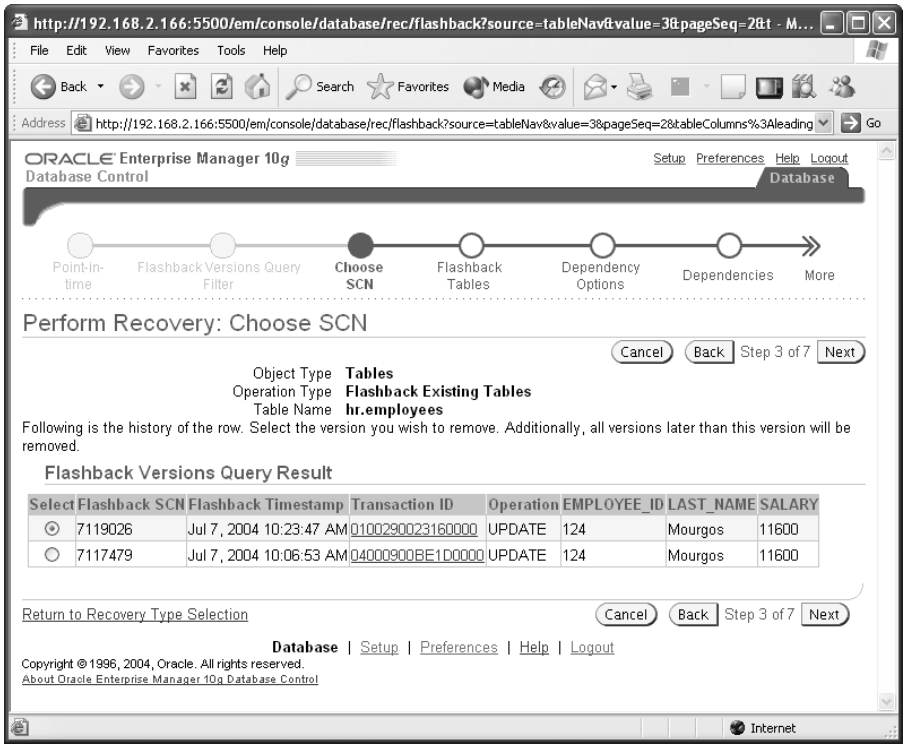
Between midnight and the time you ran this query, two update operations in two separate transactions made changes to the row for employee ID 124, one of which doubled the salary. You will use the transaction ID (`VERSIONS_XID`) in the next section to reveal the SQL statements necessary to undo the changes to this row.

As with most every feature of Oracle 10*g*, you can use the EM Database Control to execute a Flashback Versions Query and browse changed rows, as you can see in Figure 7.11, on the Perform Recovery: Choose SCN page.

Flashback Versions Query has a few limitations. It cannot be used to query external tables, temporary tables, or fixed tables. In addition, you cannot use Flashback Versions Query to query a view, although a view definition can have a Flashback Versions Query as part of its definition. Finally, you cannot retrieve rows in a Flashback Versions Query if the SCN or time stamp range includes structural changes to the table being flashed back.

Flashback Versions Query works on index-organized tables (IOTs) as well, however, an `UPDATE` operation on an IOT may be translated into pairs of `INSERT` and `UPDATE` operations on the IOT.

FIGURE 7.11 Perform Recovery: Choose SCN page



Flashback Transaction Query

Flashback Transaction Query, in contrast, drills down into the history of table changes based on a transaction ID. Using Flashback Versions Query, you found out which transaction changed the salary information, but you don't know who made the change. Flashback Transaction Query provides this additional level of detail.

In contrast to referencing the actual table in Flashback Versions Query, Flashback Transaction Query uses the data dictionary view `FLASHBACK_TRANSACTION_QUERY` to retrieve transaction information for all tables involved in a transaction. This view provides the SQL statements that you can use to undo the changes made by a particular transaction. In previous versions of Oracle, LogMiner provided some of the same information; however, Flashback Transaction Query data is indexed for faster access to undo data.

The columns available in the view FLASHBACK_TRANSACTION_QUERY are as follows:

XID The transaction ID number

START_SCN The SCN for the first DML in the transaction

START_TIMESTAMP The time stamp of the first DML in the transaction

COMMIT_SCN The SCN when the transaction was committed

COMMIT_TIMESTAMP The time stamp when the transaction was committed

LOGON_USER The user who owned the transaction

UNDO_CHANGE# The undo SCN

OPERATION The DML operation performed: DELETE, INSERT, UPDATE, BEGIN, or UNKNOWN

TABLE_NAME The table changed by DML

TABLE_OWNER The owner of table changed by DML

ROW_ID The row modified by DML

UNDO_SQL The SQL statement to undo the DML operation

To use this view, you need to have the SELECT ANY TRANSACTION system privilege. Note also that COMMIT_SCN and COMMIT_TIMESTAMP are NULL for an active transaction.

In the following example, you use the transaction identifier from the Flashback Versions Query in the previous section to find out more about the salary information changes to employee number 124:

```
SQL> select start_scn, commit_scn, logon_user,
  2       operation, table_name, undo_sql
  3  from flashback_transaction_query
  4  where xid = hextoraw('04000900BE1D0000');

START_SCN COMMIT_SCN LOGON_USER OPERATION  TABLE_NAME
--------- ---------- ---------- ---------- ---------------
UNDO_SQL
------------------------------------------------------------

  7117445    7117480 RJB        UPDATE     EMPLOYEES
  7117445    7117480 RJB        BEGIN

update "HR"."EMPLOYEES" set "SALARY" = '5800' where ROWID
='AAAMAeAAFAAAABUAA1';

2 rows selected.
```

The output from this query shows that the user RJB made the change to the salary information along with the SQL command necessary to reverse the update. To correct the problem with the salary information, you can cut and paste the query provided in the UNDO_SQL column into SQL*Plus, as follows:

```
SQL> update "HR"."EMPLOYEES" set "SALARY" = '5800'
  2     where ROWID ='AAAMAeAAFAAAABUAA1';
1 row updated.

SQL> commit;
Commit complete.
```

For any given transaction, you may choose to execute some or all of the SQL commands provided in the UNDO_SQL column, depending on the user requirements.

If you need to track transactions for chained rows and cluster tables, you may need to enable supplemental log data collection with the following command:

```
SQL> alter database add supplemental log data;
```

Flashback Table

Flashback Table allows you to recover one or more tables to a specific point in time without having to use more time-consuming recovery operations such as point-in-time recovery that may also affect the availability of the rest of the database. Flashback Table happens in place by rolling back only the changes made to the table or tables and their dependent objects, such as indexes. Note that Flashback Table is different from Flashback Drop: Flashback Table undoes recent transactions to an existing table whereas Flashback Drop recovers a dropped table; Flashback Table uses data in the undo tablespace whereas Flashback Drop uses the recycle bin.

The FLASHBACK TABLE command brings one or more tables back to a point in time before any number of logical corruptions have occurred on the tables. To be able to flashback a table, you must enable row movement for the table; because DML operations are used to bring the table back to its former state, the ROWIDs in the table change. As a result, Flashback Table is not a viable option for applications that depend on the table's ROWIDs to remain constant.

In the following example, you find out that someone in the HR Department has accidentally deleted all the employees in department 60, the IT Department, along with the row for IT in the DEPARTMENTS table. Because this happened less than 15 minutes ago, you are sure that there is enough undo information to support a Flashback Table operation; otherwise, you would have to use point-in-time recovery to bring back all the IT employees.

Before performing the Flashback Table operation, you first enable row movement in the two affected tables, as in the following example:

```
SQL> alter table hr.employees enable row movement;
Table altered.

SQL> alter table hr.departments enable row movement;
Table altered.
```

Before running the FLASHBACK TABLE command, you confirm that the row in DEPARTMENTS for the IT Department is still missing using this query:

```
SQL> select * from hr.departments where
  2     department_name = 'IT';

no rows selected
```

Next, you flash back the table to 15 minutes ago, specifying both tables in the same command, as follows:

```
SQL> flashback table hr.employees, hr.departments
  2     to timestamp systimestamp - interval '15' minute;

Flashback complete.
```

Finally, you check to see if the IT Department is truly back in the table:

```
SQL> select * from hr.departments where
  2     department_name = 'IT';

DEPARTMENT_ID DEPARTMENT_NAME    MANAGER_ID LOCATION_ID
------------- ------------------ ---------- -----------
           60 IT                        103        1400

SQL>
```

If you either flashback too far or not far enough, you can simply rerun the FLASHBACK TABLE command with a different time stamp or SCN, as long as the undo data is still available.

While the rest of the database is unaffected by a Flashback Table operation, the FLASHBACK TABLE command acquires exclusive DML locks on the tables involved in the flashback. This is usually not an availability issue, since the same users who would normally use the table are waiting for the flashback operation to complete anyway!

Note also that integrity constraints are not violated when one or more tables are flashed back; this is why you would typically group together tables related by integrity constraints or parent-child relationships in the FLASHBACK TABLE command.

Finally, a couple more things are worth mentioning about Flashback Table. As with Flashback Versions Query and Flashback Transaction Query, Flashback Table operations cannot be used if the flashback operation crosses a table structure change or a table shrink operation.

Guaranteed Undo Retention

Because most of the flashback features rely on undo information in the undo tablespace, you may want to guarantee that undo information is retained for just this purpose: The UNDO_RETENTION initialization parameter is not a guarantee. As a result, you can create or alter an undo tablespace with the RETENTION GUARANTEE clause to ensure that unexpired undo data is preserved even if it means current transactions that need to generate undo may fail. In the following example, you change the retention guarantee for the tablespace UNDOTBS1:

```
SQL> alter tablespace undotbs1 retention guarantee;
Tablespace altered.
```

SCN and Time Mapping Enhancements

With most flashback features, you can specify either an SCN or a time stamp as one of the arguments to the flashback command. Because SCNs are used as the internal mechanism for representing database time, a mapping must occur between time stamps and SCNs. In previous releases of Oracle, this was accurate only to the nearest five minutes. As of Oracle 10*g*, the granularity has been reduced to three seconds to improve the accuracy of flashback operations that specify a time stamp.

In addition, you can retain this mapping information for longer than the previous value of five days by setting the initialization parameter UNDO_RETENTION to a larger value.

Two new built-in functions support conversion between SCNs and time stamps: SCN_TO_TIMESTAMP and TIMESTAMP_TO_SCN. In the following example, you want to find out the SCN corresponding to the current time:

```
SQL> select timestamp_to_scn(systimestamp) from dual;

TIMESTAMP_TO_SCN(SYSTIMESTAMP)
------------------------------
                       7126585
```

Not coincidentally, this SCN is very close to the current timestamp recorded in V$DATABASE.

```
SQL> select current_scn from v$database;

CURRENT_SCN
-----------
    7126590
```

Flashback Privileges

Various system and object privileges are required to use each flashback feature. In Table 7.1, you can see the privileges required for each of the flashback features.

TABLE 7.1 Required Flashback Privileges

Flashback Feature	Required Privileges
Flashback Database	SYSDBA database connection
Flashback Table	FLASHBACK TABLE system privilege and the appropriate object privileges
Flashback Versions Query	FLASHBACK TABLE system privilege and the appropriate object privileges
Flashback Transaction Query	SELECT ANY TRANSACTION system privilege
Flashback Drop	Object privileges for objects in the recycle bin before they were dropped

Summary

In this chapter, we presented an in-depth tour of both the flash recovery area and the new flashback features in Oracle 10*g*.

The flash recovery area helps reduce the amount of time spent managing and restoring RMAN backups; you can back up every type of critical file in the Oracle database to the flash recovery area. The flash recovery area is easy to set up and maintain: only two initialization parameters control the size and location of the flash recovery area: DB_RECOVERY_FILE_DEST_SIZE and DB_RECOVERY_FILE_DEST.

Making extensive use of the flash recovery area, RMAN adds a number of new features in Oracle 10*g*, improving both disk space usage and backup time. Incremental backups can be applied to existing datafile image copies to reduce recovery time; backup time is reduced using the block change-tracking feature to more quickly identify blocks that have changed for an incremental backup instead of reading every block of each datafile. RMAN can also specify a duration for backup, either limiting the amount of time that a backup will occur or spreading a backup over a longer period of time to reduce the impact on the rest of the database. RMAN's support for compressed backups can potentially reduce backup time, I/O usage, network bandwidth, and disk space with a minimal amount of CPU overhead.

Oracle 10*g* introduces a number of new flashback features, giving both DBAs and end users alike an easy way to recover from a number of logical errors. Flashback Database brings the entire database back to a point in time in the past; for logical errors that are isolated to a small number of tables, Flashback Drop and Flashback Table provide recovery from dropped or corrupted tables

with minimal impact on the database and less intervention by the DBA, who now may not need to perform as many point-in-time recovery operations. For logical corruptions at the row level, Flashback Versions Query can retrieve all changes for a particular set of rows during a specified time frame; Flashback Transaction Query provides the user with a way to identify all changes to database tables within a given transaction, along with the SQL statements needed to undo those changes.

Other miscellaneous changes to the granularity of time stamp–to-SCN mapping make recovery operations more precise; changing the undo retention capabilities of the undo tablespace can ensure that undo data is available for these new flashback features in environments where the flashback features are more critical than transactions that may need undo space for long-running transactions.

Exam Essentials

Configure and manage the flash recovery area. Be able to identify and set the values of the initialization parameters that control the location and size of the flash recovery area. Manage the space in the recovery area by monitoring system alerts. Back up the flash recovery area to tape.

Optimize backup operations. Use new RMAN features to apply incremental backups to existing image copies, potentially reducing recovery time. Create incremental backups using a block change-tracking file, reducing backup time. Use compressed backups to reduce disk space requirements.

Understand new `RESETLOGS` options. Be able to retain archived redo logs created before a `RESETLOGS` operation and understand how the new log file format supports multiple database incarnations.

Be able to use Flashback Database effectively. Understand the requirements for using Flashback Database and when this method is preferable to other recovery methods. Configure and enable flashback logs to support Flashback Database.

Identify the characteristics and usage of the recycle bin. Describe how the recycle bin is constructed, how objects are placed in the recycle bin and recovered from the recycle bin, and the retention period for objects in the recycle bin.

Enumerate the key features of Flashback Version Query. Understand which rows are retrieved from Flashback Version Query and describe the pseudo-columns available with the `VERSIONS` keyword.

Use Flashback Transaction Query to undo changes. In combination with Flashback Version Query, use the transaction ID to review changes across all tables for the transaction and use the SQL provided with Flashback Transaction Query to undo some or all of the changes made during a transaction.

Understand new features that support flashback operations. Identify the new and existing system and object privileges necessary to use each flashback feature. Identify the new built-in functions used to convert SCNs to time stamps, and vice versa. Be able to discuss the granularity and retention improvements for SCN to time stamp mappings.

Review Questions

1. Oracle 10*g* supports fast incremental backups. Which of the following is not true about the incremental backup's change-tracking file?
   - **A.** The size if the tracking file is proportional to the size of the database.
   - **B.** If a block tracking file exists, it is no longer necessary for each datafile to be read in its entirety during an incremental backup.
   - **C.** A change-tracking file is created by default when the database is created.
   - **D.** The block tracking file must be at least 10MB in size.
   - **E.** RMAN uses the block change-tracking file to determine which blocks to back up during an incremental backup.

2. Which dynamic performance view or data dictionary view has a column that indicates whether the database is configured for Flashback Database?
   - **A.** `V$DATABASE`
   - **B.** `V$INSTANCE`
   - **C.** `V$FLASHBACK_DATABASE_STAT`
   - **D.** `DATABASE_PROPERTIES`

3. Which two initialization parameters define the flash recovery area?
   - **A.** `DB_RECOVERY_FILE_DEST` and `DB_RECOVERY_FILE_SIZE`
   - **B.** `DB_RECOVERY_FILE_DEST_SIZE` and `DB_RECOVERY_FILE_DEST`
   - **C.** `LOG_ARCHIVE_DEST_10` and `FLASH_RECOVERY_DEST`
   - **D.** `DB_RECOVERY_FILE_DIR_SIZE` and `DB_RECOVERY_FILE_DIR`

4. Which of the following is true about space associated with a dropped table?
   - **A.** The space from the dropped table is reflected in the `DBA_FREE_SPACE` table, but the space is still counted against the table owner's quota.
   - **B.** The space from the dropped table is reflected in the `DBA_FREE_SPACE` table, and the table owner's quota is reduced accordingly.
   - **C.** The space from the dropped table is not reflected in the `DBA_FREE_SPACE` view until the `PURGE TABLE` command is issued.
   - **D.** The space from the dropped table is not reflected in the `DBA_FREE_SPACE` view until the `PURGE USER_RECYCLEBIN` command is issued.

5. You have just run the following RMAN commands:
```
RMAN> configure controlfile autobackup off;
RMAN> backup datafile 1;
```
What are the results?

   A. The first datafile of the SYSTEM tablespace is backed up as an image copy without the control file.

   B. The SYSTEM tablespace is backed up as an image copy along with the control file.

   C. The tablespace containing datafile #1 is backed up without the control file.

   D. The first datafile of the SYSTEM tablespace is backed up along with the control file.

   E. None of the above.

6. Which of the following methods does not show the contents of the recycle bin for a user with DBA privileges?

   A. Query the view USER_RECYCLEBIN.

   B. Use the command SHOW RECYCLEBIN.

   C. Query the view DBA_RECYCLEBIN.

   D. Query the view RECYCLEBIN.

   E. You can use all of the above methods to query the contents of the recycle bin.

7. Which of the following statements is not true about space reclamation and a tablespace's recycle bin?

   A. Free space outside of the recycle bin is used first for new space requests.

   B. If there are objects in the recycle bin, the datafile is autoextended before the contents of the recycle bin are reused.

   C. Recycle bin objects are purged from the recycle bin in a FIFO method when free space outside of the recycle bin is not available.

   D. More free space is available in the tablespace when a PURGE command is issued; however, those objects can no longer be recovered using Flashback Drop.

8. As of Oracle 10*g*, the RMAN COPY command has been deprecated. Which RMAN command should you use instead to back up all the datafiles in the database?

   A. `BACKUP AS BACKUPSET DATABASE;`

   B. `BACKUP AS COPY (TABLESPACE SYSTEM, SYSAUX, USERS, UNDOTBS);`

   C. `BACKUP AS COPY ALL;`

   D. `BACKUP AS COPY DATABASE;`

9. The user SCOTT drops and re-creates the `EMPLOYEES` table four times. How many times must SCOTT issue the `PURGE` command to free up the space occupied by the dropped copies of the `EMPLOYEES` table?

A. Once, if SCOTT specifies the table's original name.

B. Four.

C. SCOTT can use only `PURGE RECYCLEBIN` to remove the dropped tables from the recycle bin.

D. Once, after all the dependent objects in the recycle bin are dropped first.

10. Which of the following backup file types are not backed up when the RMAN `BACKUP RECOVERY AREA` command is issued?

A. Full backup sets

B. Flashback logs

C. Incremental backup sets

D. Datafile copies

E. Archive logs

11. Choose the following statement that is true regarding Flashback Versions Query.

A. All rows that existed between the two SCNs or time stamps specified in the `VERSIONS` clause are returned, including rows that have been deleted and reinserted and rows that have not yet been committed.

B. All rows that existed between the two SCNs or time stamps specified in the `VERSIONS` clause are returned, not including rows that have been deleted and reinserted or uncommitted.

C. All rows that existed between the two SCNs or time stamps specified in the `VERSIONS` clause are returned, including rows that have been deleted and reinserted, but not uncommitted rows.

D. All rows that existed between the two SCNs or time stamps specified in the `VERSIONS` clause are returned, including both rows that have been deleted and reinserted and uncommitted rows in a current transaction.

12. You recently performed an RMAN image copy backup of the USERS tablespace consisting of datafiles #4 and #7. Next, you run the following command in RMAN:
```
RMAN> recover copy of datafile 7;
```
What are the results of this command?

    A. Only the latest image copy of datafile #7 is updated with the contents of all incremental backup files created since the image copy was created.

    B. If the most recent copy of datafile #7 is damaged or missing, it is re-created from an earlier image copy and the subsequent incremental backups; otherwise this command has no effect.

    C. All image copies of datafile #7 are updated with the contents of all incremental backup files created since the image copy was created.

    D. Both datafile #4 and datafile #7 are merged into a single image copy and updated with recent incremental backups.

    E. Datafile #7 in the database area is recovered if a media error has occurred; otherwise this command has no effect.

13. Which of the following columns is not in the FLASHBACK_TRANSACTION_QUERY view?

    A. REDO_SQL

    B. START_SCN

    C. UNDO_SQL

    D. TABLE_OWNER

    E. COMMIT_TIMESTAMP

14. What happens when you execute the following RMAN command?
```
RMAN> backup copy of database;
```

    A. It creates a backup of all datafiles to the flash recovery area as image copies by default.

    B. A copy of all datafiles, control files, archived log files, and SPFILE are copied to the flash recovery area as image copies by default.

    C. A copy of all datafiles, control files, archived log files, and SPFILE are copied to the flash recovery area as backup sets by default.

    D. It creates a backup of previous image copies of all datafiles and control files in the database—in other words, a backup of a previous backup.

15. Identify the two columns of V$RECOVERY_FILE_DEST that are not accessible via the EM Database Control.

A. SPACE_RECLAIMABLE, SPACE_LIMIT

B. SPACE_RECLAIMABLE, NUMBER_OF_FILES

C. SPACE_LIMIT, SPACE_USED

D. SPACE_USED, NUMBER_OF_FILES

16. To ensure that undo data is retained in an undo tablespace for flashback features even if operations that need to generate undo may fail, what clause should be specified in the CREATE UNDO TABLESPACE or ALTER UNDO TABLESPACE?

A. FLASHBACK OFF

B. GUARANTEE RETENTION

C. RETENTION GUARANTEE

D. UNDO_RETENTION

17. Each row in the dynamic performance view V$FLASHBACK_DATABASE_STAT represents what time interval?

A. 24 hours

B. One hour

C. One minute

D. 30 minutes

18. Which of the following is not true about a table recovered from the recycle bin using the FLASHBACK TABLE...TO BEFORE DROP command?

A. All recovered indexes, triggers, and constraints associated with the table are no longer valid and must be re-created before they can be used.

B. If you recover a table that has been dropped several times, only the most recent version of the dropped table is restored unless you specify the name of the table in the recycle bin.

C. If the recovered table has the same name as an existing table, you must use the RENAME TO clause or recover the table to another schema.

D. Assuming that a new table with the same name has not yet been created, recovering a table from the recycle bin using either the original name or the recycle bin name achieves the same result.

19. You place all database files in online backup mode with the following command:
ALTER DATABASE BEGIN BACKUP;
Which of the following is not a requirement when you use this command?

A. You must use RMAN to perform the backup.

B. The database must be mounted and open.

C. The database must be in `ARCHIVELOG` mode.

D. A tablespace cannot be placed into read-only mode when this command is issued.

20. Choose the statement that is not true about space management in the flash recovery area.

A. A warning is issued when the flash recovery area is 85 percent full, and a critical warning is issued when the flash recovery area is 97 percent full.

B. When the flash recovery reaches 100 percent capacity, only files backed up to tape or another disk are considered for deletion to free up space for new backup files.

C. When files are written to the flash recovery area, a message is written to the alert log.

D. Obsolete files are automatically removed from the flash recovery area when the flash recovery area reaches 100 percent capacity.

E. When files are deleted from the flash recovery area, a message is written to the alert log.

Answers to Review Questions

1. C. Change tracking is not enabled by default. When enabled, however, it incurs a slight amount of overhead whenever a block in any datafile is updated. This is offset by the time saved during incremental backup operations.

2. A. The dynamic performance view V$DATABASE contains a new column FLASHBACK_ON that indicates whether Flashback Database is enabled.

3. B. DB_RECOVERY_FILE_DEST_SIZE specifies the maximum size of the flash recovery area, and DB_RECOVERY_FILE_DEST specifies the location of the flash recovery area. DB_RECOVERY_FILE_SIZE, FLASH_RECOVERY_DEST, DB_RECOVERY_FILE_DIR_SIZE, and DB_RECOVERY_FILE_DIR are not valid initialization parameters. LOG_ARCHIVE_DEST_10 points to the flash recovery area by default but does not define the flash recovery area.

4. A. While the space from a dropped table shows up as additional free space in DBA_FREE_SPACE, the space is still counted against the user's quota until the PURGE USER_RECYCLEBIN or PURGE TABLE command is issued.

5. D. The command CONFIGURE CONTROLFILE AUTOBACKUP OFF disables the automatic backup of the control file unless the backup includes any datafiles of the SYSTEM tablespace.

6. E. In addition to the previous methods, the EM Database Control can display the current contents of the recycle bin.

7. B. The objects in the recycle bin are dropped to satisfy space requests before any of the tablespace's datafiles are autoextended.

8. D. The BACKUP AS COPY DATABASE command will copy all datafiles in one command. BACKUP AS BACKUPSET DATABASE will back up the entire database but not in image copy format. BACKUP AS COPY ALL is not a valid RMAN command. BACKUP AS COPY using individual tablespaces will back up only the datafiles for the specific tablespaces in the database and does not include the archived logs, SPFILE, or control files.

9. B. The PURGE command can be issued four times to remove the four copies of the EMPLOYEES table. Alternatively, SCOTT can issue the PURGE RECYCLEBIN command to remove all dropped tables from the recycle bin.

10. B. The RMAN `BACKUP RECOVERY AREA` command backs up all flash recovery files created in the flash recovery area that have not yet been backed up to tape, which includes full and incremental backup sets, control file autobackups, archive logs, and datafile copies; flashback logs, incremental bitmaps, current control file, and online redo log files are not backed up.

11. C. Flashback Versions Query returns only rows that have been committed between two SCNs or time stamps. In addition, rows that have been deleted, reinserted, and committed are also returned.

12. A. The `RECOVER COPY OF DATAFILE` command applies incremental RMAN backups to an image copy of the datafile and potentially reduces the amount of time needed for media recovery of the datafile because fewer archive log files are necessary to bring the datafile up to the latest SCN in the case of a media failure.

13. A. There is no such column `REDO_SQL` in `FLASHBACK_TRANSACTION_QUERY`.

14. D. The `BACKUP COPY OF DATABASE` is usually used to create a copy of a backup already in the RMAN backup destination to another device type, such as tape. The copy can either be another image copy or be a backup set.

15. B. To view the values for `SPACE_RECLAIMABLE` and `NUMBER_OF_FILES`, you must use the dynamic performance view `V$RECOVERY_FILE_DEST`.

16. C. Turning off flashback generation for a tablespace has no effect on undo retention. `GUARANTEE RETENTION` is syntactically incorrect. `UNDO_RETENTION` is an initialization parameter, not an undo tablespace property.

17. B. The dynamic performance view `V$FLASHBACK_DATABASE_STAT` contains statistics that monitor the overhead of logging flashback data in the Flashback Database logs at 1-hour intervals for a total of 24 hours.

18. A. The indexes, triggers, and constraints keep their recycle bin names when the related table is restored, but they are still valid and usable. It is highly recommended, however, that the related structures be re-created or renamed with the original names.

19. A. The `ALTER DATABASE BEGIN BACKUP` command is only used when you are not using RMAN to ensure a consistent backup.

20. B. Obsolete files are also considered for deletion when the flash recovery area reaches 100 percent capacity, even if they have not yet been backed up to tape or another disk device.

Chapter 8

Security and SQL Enhancements

ORACLE DATABASE 10*g* NEW FEATURES FOR ADMINISTRATORS EXAM OBJECTIVES OFFERED IN THIS CHAPTER:

- ✓ **Support for Analytical Applications**
  - Write MERGE statements with the new conditions and extensions
  - Use partitioned outer join syntax for densification
  - Use interrow calculations to enhance SQL for analytical capabilities
  - Use new fast refresh capabilities for Materialized Join Views
- ✓ **Security**
  - Apply a column level VPD policy
  - Apply static and non-static policies
  - Share VPD policy functions
  - Use the unified audit trails
  - Use fine-grained auditing for DML statements

- ✓ **Miscellaneous New Features**
  - Provide greater flexibility by enabling resumable timeout at the instance level
  - Use regular expression support in SQL and PL/SQL for string searching, matching and replacing
  - Use additional linguistic comparison and sorting methods in SQL
  - Aggregate more meaningful statistics across a multitier environment
  - Use SQL to flush the buffer cache

Exam objectives are subject to change at any time without prior notice and at Oracle's sole discretion. Please visit Oracle's training and certification website (`http://www.oracle.com/education/certification/`) for the most current exam objectives listing.

In the last seven chapters, you learned about all the major enhancements to Oracle Database 10*g* (Oracle 10*g*). In this chapter we will cover the miscellaneous enhancements and behavior changes to Oracle 10*g*. SQL and PL/SQL are two areas where every new release always contains enhancements.

One of the significant Oracle 10*g* SQL enhancements is the ability to do spreadsheet-like array computations in SQL statements. It lets you view rows as a multidimensional array, which allows you to do calculations on individual cells or range of cells. We will review this and other SQL enhancements in this chapter. We will also discuss the enhancements made to the Virtual Private Database (VPD) and other miscellaneous database enhancements.

Securing Data

Oracle 10*g* includes new features designed to secure data more effectively within the database. The VPD can now enforce column-level privacy. Oracle 10*g* introduces static and context-sensitive VPD policies that can improve performance.

The auditing of the database operations also has improvements. Fine-grained auditing (FGA), introduced in Oracle 9*i*, supports Data Manipulation Language (DML) statements in Oracle 10*g*. The following sections discuss the security enhancements of Oracle 10*g*.

Leveraging Virtual Private Database

The VPD is an option that comes with the Enterprise Edition of the Oracle 10*g*. VPD was introduced in Oracle 8*i*, which enables row-level security. The database privileges are granted on the object level. If a user has `SELECT` privilege on the table, he can see all the rows in the table. VPD can restrict the rows seen by the user based on a policy defined in the database. The policy determines the predicate to be applied to the `WHERE` clause based on the login ID of the user. The `DBMS_RLS` package manages the row-level security in the database.

When a user directly or indirectly accesses a table, view, or synonym associated with a VPD security policy, the Oracle database server automatically modifies the user's SQL statement to filter the rows. The modification is based on the `WHERE` clause returned by a function, which implements the security policy. The modification to the SQL is dynamic and is transparent to the user.

The following are the new features for VPD in Oracle 10*g*:

- Column-level privacy and column masking
- Static, context-sensitive, and shared policies
- Support for parallel queries

User SYS is always exempt from all VPD policies. Users with the EXEMPT ACCESS POLICY system privilege also are exempt from VPD policies.

In the following sections we will discuss the enhancements made to VPD in Oracle 10g.

Column-Level VPD

Column-level VPD policies give more fine-grained access controls on data. Security policies are applied only when certain columns are accessed in the user's query. You accomplish this by introducing a new parameter SEC_RELEVANT_COLS to the DBMS_RLS.ADD_POLICY procedure. The new parameter is optional; if you omit this parameter, the policy behaves as in Oracle 9*i*, where the policy is applied to all columns.

Column-level privacy enforces row-level access control only when a statement accesses security relevant columns.

Let's learn more about the column-level VPD using an example. The `employee` table has four columns with the following information (the `employee` table is a subset of `employees` table in the HR sample schema):

```
SQL> SELECT * FROM employee;

FIRST_NAME           HIRE_DATE     SALARY DEPARTMENT_ID
-------------------- --------- ---------- -------------
NEENA                21-SEP-89      17000            90
LEX                  13-JAN-93      17000            90
ALEXANDER            03-JAN-90       9000            60
BRUCE                21-MAY-91       6000            60
DAVID                25-JUN-97       4800            60
DANIEL               16-AUG-94       9000            80
JOHN                 28-SEP-97       8200           100
ISMAEL               30-SEP-97       7700            80
ALEXANDER            18-MAY-95       3100            30
SIGAL                24-JUL-97       2800            80
HR                   15-NOV-98       2600            50
KAREN                10-AUG-99       2500            30
KIMBERLY             24-MAY-99       7000            50
```

```
13 rows selected.

SQL>
```

Now, create a policy function that restricts the sensitive information. Here we allow the user to see only his/her own record.

```
SQL> CREATE OR REPLACE FUNCTION EMPLOYEE_PF
  2  (owner VARCHAR2, objname VARCHAR2)
  3  RETURN VARCHAR2
  4  IS
  5  where_clause  VARCHAR2 (2000);
  6  BEGIN
  7  where_clause :=
     'first_name=SYS_CONTEXT(''USERENV'',
                             ''SESSION_USER'')';
  8  RETURN where_clause;
  9  END;
SQL> /

Function created.

SQL>
```

Create a VPD policy using the `DBMS_RLS.ADD_POLICY`; restrict the salary information on the `employee` table using the function we just created.

```
SQL> BEGIN
  2  SYS.DBMS_RLS.ADD_POLICY (
  3  object_schema      => 'HR',
  4  object_name        => 'EMPLOYEE',
  5  policy_name        => 'FILTER_EMP',
  6  function_schema    => 'HR',
  7  policy_function    => 'EMPLOYEE_PF',
  8  sec_relevant_cols  => 'SALARY');
  9 END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

Let's assume user DAVID is trying to access the employee information. The following are a couple of sample queries. You can see that when user DAVID is accessing the salary information, only his record displays; when he is not interested in salary, all information displays.

```
SQL> show user
USER is "DAVID"
SQL> SELECT first_name, salary, department_id
  2  FROM   hr.employee;

FIRST_NAME               SALARY DEPARTMENT_ID
-------------------- ---------- -------------
DAVID                      4800            60

SQL> SELECT first_name, hire_date, department_id
  2  FROM   hr.employee;

FIRST_NAME           HIRE_DATE DEPARTMENT_ID
-------------------- --------- -------------
NEENA                21-SEP-89            90
LEX                  13-JAN-93            90
ALEXANDER            03-JAN-90            60
BRUCE                21-MAY-91            60
DAVID                25-JUN-97            60
DANIEL               16-AUG-94            80
JOHN                 28-SEP-97           100
ISMAEL               30-SEP-97            80
ALEXANDER            18-MAY-95            30
SIGAL                24-JUL-97            80
HR                   15-NOV-98            50
KAREN                10-AUG-99            30
KIMBERLY             24-MAY-99            50

13 rows selected.

SQL>
```

What you see in the previous example is the default behavior of column-level VPD. In the default behavior, the number of rows returned by the query are restricted. Rows with sensitive information are not shown to the user.

Another way of configuring is known as *column-masking behavior*. In column-masking behavior, the sensitive information is `NULL`, but the rest of the information displays. You accomplish column-masking behavior using `DBMS_RLS.ALL_ROWS` as an option to the `ADD_POLICY`

procedure. Let's re-create the policy definition to mask the salary information and hire date rather than restricting the rows.

```
SQL> EXEC dbms_rls.drop_policy('HR','EMPLOYEE',
                                    'FILTER_EMP');

PL/SQL procedure successfully completed.

SQL>
SQL> BEGIN
  2  SYS.DBMS_RLS.ADD_POLICY (
  3  object_schema      => 'HR',
  4  object_name        => 'EMPLOYEE',
  5  policy_name        => 'FILTER_EMP',
  6  function_schema    => 'HR',
  7  policy_function    => 'EMPLOYEE_PF',
  8  sec_relevant_cols  => 'SALARY, HIRE_DATE',
  9  sec_relevant_cols_opt => DBMS_RLS.ALL_ROWS);
 10* END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

Now, when user DAVID queries the employee information, he sees all the rows, but the salary and hire date information displays for only his own record, as shown here:

```
SQL> SELECT first_name, hire_date, salary
  2  FROM   hr.employee
SQL> /

FIRST_NAME           HIRE_DATE     SALARY
-------------------- --------- ----------
NEENA
LEX
ALEXANDER
BRUCE
DAVID                25-JUN-97       4800
DANIEL
JOHN
ISMAEL
```

```
ALEXANDER
SIGAL
HR
KAREN
KIMBERLY

13 rows selected.

SQL>
```

The column-masking behavior applies only to SELECT statements.

VPD Policy Types

The execution of policy functions can consume a lot of system resources; therefore, minimizing the number of times a policy function is executed can improve performance. In Oracle 9*i* and Oracle 8*i*, the policies were dynamic, which means the database executed the policy function for each DML statement. Oracle 10*g* introduces static and context-sensitive policies.

In Oracle 10*g*, you can define five different types of policies.

- Dynamic (default, pre–Oracle 10*g* behavior)
- Static
- Shared-static
- Context-sensitive
- Shared context-sensitive

When defining a policy using the DBMS_RLS.ADD_POLICY procedure, you can specify the type of the policy using the POLICY_TYPE parameter.

We will discuss each of these policy types in the following sections.

Dynamic

This is the default policy type. Policies of this type are created by taking the default of not specifying a policy type or by specifying DBMS_RLS.DYNAMIC as the value to the parameter POLICY_TYPE. The server assumes the policy predicate will be affected by the system and so executes the policy function each time a DML statement is parsed or executed.

Dynamic policy type was the only policy type available in Oracle9i and its behavior in Oracle 10g is not changed.

Static

For static policy types, specify `DBMS_RLS.STATIC` as the value to the parameter `POLICY_TYPE`. For static policy types, the predicate is assumed to be the same regardless of the runtime environment. Static policy functions are executed once and are cached in the Shared Global Area (SGA). This makes the static policies very fast since the database does not have to execute the policy function for each query. Statements accessing the same object do not re-execute the policy function, though each execution could produce different set of results based on attributes such as `SYS_CONTEXT` and `SYSDATE`.

Shared-Static

When a function is used in multiple policies, it is called a shared policy. Shared policies eliminate the need to create one policy function for each object when the business policy is the same for multiple objects. Each policy has its own name, but the policy function used is the same.

For a shared-static policy type, specify `DBMS_RLS.SHARED_STATIC` as the value to the parameter `POLICY_TYPE`. The behavior is same as `STATIC` except that the server first looks for a cached predicate generated by the same policy function of the same policy type.

Context-Sensitive

For content-sensitive policy types, specify `DBMS_RLS.CONTEXT_SENSITIVE` as the value to the parameter `POLICY_TYPE`. Context-sensitive policy functions are reevaluated by the database if it detects a context change since the last use of the cursor. The policy function is evaluated for each session when the statement is first parsed or if there is a related application context change. The resulting policy predicate is cached in the user's session memory.

The policy predicate can change when certain context attributes are changed within the user's session. So a context-sensitive policy assumes that the policy predicate may change after statement parsing for a session, and such change can occur only if there are some session context changes. Therefore, the database evaluates the policy function at statement execution time if it detects context changes since the last use of the cursor. The policy predicate is cached in the session memory.

Here is an example of context-sensitive policy. Assume that you want to add the predicate `WHERE department_id =` *deptno* for all the managers accessing the employee table and for regular users, you want to add `WHERE employee_id =` *empno*. When the user's session is initiated, you could identify the context whether the user is a manager or regular user and determine the values for *deptno* and *empno*. The policy to apply will be determined based on the context of the user.

Shared Context-Sensitive

For shared context-sensitive policy types, specify `DBMS_RLS.SHARED_CONTEXT_SENSITIVE` as the value to the parameter `POLICY_TYPE`. This type is similar to the context-sensitive, except that the function is shared. When a context-sensitive policy shares its policy function, the caching behavior is similar except that the server first looks for a cached policy predicate generated by the same policy function for the same policy type within the same database session.

Other VPD Enhancements

In Oracle 10*g*, the parameter STATEMENT_TYPES in the procedure DBMS_RLS.ADD_POLICY can accept a new type named INDEX. In Oracle 9*i*, the valid values were SELECT, INSERT, UPDATE, or DELETE. The default in Oracle 10*g* is to apply all these types except INDEX. The INDEX type was introduced to enforce security policies on index maintenance operations. Users need full table access to create table indexes.

A user who has privilege to maintain an index can see all the row data even if the user does not have full table access when using a query. The INDEX type in Oracle 10*g* was introduced to prevent users from reading secured data when creating function-based indexes, which would otherwise allow a knowledgeable user to write out values using the index function that the VPD features are supposed to obscure. The INDEX type will ensure that the security policy is applied when creating the index.

Another enhancement made to Oracle 10*g* in the ADD_POLICY procedure is the LONG_PREDICATE parameter. This new parameter has a default value of FALSE, which means the policy function can return up to 4,000 bytes of the predicate value. When this parameter is set to TRUE, the policy function can return a predicate text string up to 32KB.

Auditing Enhancements

Auditing in the Oracle database is the monitoring and recording of selected user actions in the database. Oracle 10*g* has the following types of auditing:

Mandatory auditing The database always records certain actions. Examples are database startup and shutdowns, which are recorded in the alert log file. Connections to the database using the SYSOPER or SYSDBA privilege are also recorded in the operating system audit file usually located at $ORACLE_HOME/rdbms/audit (you can change this destination by setting the AUDIT_FILE_DEST parameter). This provides accountability for users with administrative privileges.

Standard auditing Setting the AUDIT_TRAIL initialization parameter enables auditing on the database. Once auditing is enabled, you can specify the objects and type of actions to be audited. For example, AUDIT UPDATE ON HR.EMPLOYEES statement enables auditing for any updates that are performed on the HR.EMPLOYEES table. The audit information is written to the SYS.AUD$ table and can be queried from DBA_AUDIT_OBJECT dictionary view.

Fine-grained auditing (FGA) *FGA* enables auditing based on data content. FGA uses policies that you add to an object. An audit policy can have sophisticated means to decide whether the database should create an audit record based on the query, the condition, and the data the statement accesses. In Oracle 10*g*, you have the option of auditing only those statements that reference a particular column.

The following sections describe the enhancements in Oracle 10*g* in auditing.

DML Support for Fine-Grained Auditing

FGA was introduced in Oracle 9*i*; it supported only SELECT statements. In Oracle 10*g*, FGA supports INSERT, UPDATE, and DELETE statements. The DBMS_FGA.ADD_POLICY procedure now has a new parameter named STATEMENT_TYPES to specify the type of action to audit.

You set up FGA using the DBMS_FGA.ADD_POLICY procedure. Let's set up an audit on the employee table that we used in the previous section. We will audit the SELECT and UPDATE statements on this table that go against the salary column with rows that have a salary of more than $10,000. You can define the FGA policy as follows:

```
SQL> BEGIN
  2  DBMS_FGA.ADD_POLICY(
  3  policy_name         => 'AUD_EMPLOYEE_SAL',
  4  object_schema       => 'HR',
  5  object_name         => 'EMPLOYEE',
  6  audit_column        => 'SALARY',
  7  audit_condition     => 'SALARY >= 10000',
  8  statement_types     => 'SELECT, UPDATE');
  9  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

Note that we disabled the FILTER_EMP VPD policy for this demonstration using the DBMS_RLS.ENABLE_POLICY('HR', 'EMPLOYEE', 'FILTER_EMP', FALSE) procedure.

User DAVID is now updating and selecting rows from the employee table that meet our audit condition.

```
SQL> show user
USER is "DAVID"
SQL> UPDATE hr.employee
  2  SET    salary = 20000
  3  WHERE  first_name = 'NEENA';

1 row updated.

SQL> SELECT first_name
  2  FROM   hr.employee
  3* WHERE  salary > 15000
SQL> /
```

```
FIRST_NAME
--------------------
NEENA
LEX

SQL>
```

Let's now query the FGA audit log to see the audit information.

```
SQL> SELECT dbuid, lsqltext FROM sys.fga_log$;

DAVID
UPDATE hr.employee
SET    salary = 20000
WHERE  first_name = 'NEENA'

DAVID
SELECT first_name
FROM   hr.employee
WHERE  salary > 15000

SQL>
```

The database inserted the audit record into the FGA_LOG$ table using an autonomous transaction. Even if you roll back the update statement, the update action will still be logged in this table. The FGA_LOG$ table contains other relevant information such as table name, policy name, transaction ID, session and machine information, and so on. Sometimes it may be too much overhead to write the SQL and bind variable information to the FGA_LOG$ table. When defining the policy, you may turn off the extended logging by setting the AUDIT_TRAIL parameter to DBMS_FGA.DB. The DBMS_FGA.DB_EXTENDED is the default for AUDIT_TRAIL and thus populates the LSQLTEXT and LSQLBIND columns of the SYS.FGA_LOG$. AUDIT_TRAIL parameter; this is demonstrated in the next example of DBMS_FGA.ADD_POLICY.

In Oracle 10*g*, you can define a FGA policy with more than one relevant column for the AUDIT_COLUMNS parameter. The default for AUDIT_COLUMNS is NULL, which audits if any column is accessed. When specifying more than one column in the AUDIT_COLUMNS parameter, the statement is audited if any one of the columns is present in the SQL statement.

Sometimes it may make sense only to audit access on a combination of columns. For example, the following query is fairly harmless:

```
SELECT MAX(salary) FROM hr.employee;
```

The query does not identify the employee; it just checks for the maximum salary. Maybe you wanted to audit queries that are a combination of the salary and employee name. To change the default behavior or to specify the behavior, you can specify the values DBMS_FGA.ANY_COLUMNS

or DBMS_FGA.ALL_COLUMNS for the AUDIT_COLUMN_OPTS parameter in the DBMS_FGA.ADD_POLICY procedure. Here is an example of auditing if only all the columns listed in the AUDIT_COLUMNS parameter are accessed in the SQL:

```
SQL> BEGIN
  2  DBMS_FGA.ADD_POLICY(
  3  policy_name        => 'AUD_EMPLOYEE_SAL_FN',
  4  object_schema      => 'HR',
  5  object_name        => 'EMPLOYEE',
  6  audit_column       => 'SALARY, FIRST_NAME',
  7  statement_types    => 'SELECT, UPDATE',
  8  audit_column_opts  => DBMS_FGA.ALL_COLUMNS,
  9  audit_trail        => DBMS_FGA.DB);
 10  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

Let's now perform a query on the employee table and see the entry from the FGA_LOG$ table.

```
SQL> SHOW USER
USER is "SCOTT"
SQL> SELECT salary FROM hr.employee
  2  WHERE  first_name = 'SIGAL';

   SALARY
---------
     2800

SQL>
SQL> SELECT oshst, dbuid, obj$name
  2  FROM   sys.fga_log$
  3  WHERE  policyname = 'AUD_EMPLOYEE_SAL_FN';

OSHST           DBUID         OBJ$NAME
--------------- ------------- --------------------
linux           SCOTT         EMPLOYEE

SQL>
```

When the AUDIT_CONDITION is omitted or specified as NULL (default), it is evaluated as TRUE. In Oracle 9*i*, this parameter was mandatory, and we used to specify 1=1 to satisfy the condition.

When FGA policy is defined for DML statements, the statement is audited if the data rows (new and old) being manipulated meet the policy predicate criteria. For DELETE statements, specifying relevant columns is ignored, because all columns are accessed for deleting a row. The FGA supports the MERGE statements by auditing the underlying INSERT or UPDATE operation that is performed by the MERGE statement.

Uniform Audit Trail

Oracle 10*g* tracks the same columns for standard and fine-grained auditing. The database audit trail is a single table in the SYS schema named the AUD$, which is stored in the SYSTEM tablespace. The FGA audit trail is also a single table in the SYS schema named FGA_LOG$, which is stored in the SYSTEM tablespace. Oracle provides many predefined views that show the relevant information based on the type of audit. These views are shown in Table 8.1.

TABLE 8.1 DBA Dictionaries with Audit Information

View Name	Description
DBA_AUDIT_TRAIL	Displays all audit trail entries for standard auditing
DBA_AUDIT_EXISTS	Displays audit trail entries produced by AUDIT EXISTS and AUDIT NOT EXISTS
DBA_AUDIT_OBJECT	Displays audit trail records for all objects in the database (DML and DDL audit)
DBA_AUDIT_SESSION	Displays audit trail entries for session connects and disconnects (AUDIT SESSION)
DBA_AUDIT_STATEMENT	Displays audit trail records for GRANT, REVOKE, AUDIT, NOAUDIT, and ALTER SYSTEM statements
DBA_OBJ_AUDIT_OPTIONS	Describes the auditing options in the database for the objects audited
DBA_FGA_AUDIT_TRAIL	Displays all audit trail entries for fine-grained auditing
DBA_AUDIT_POLICIES	Displays the fine-grained audit policies defined in the database

TABLE 8.1 DBA Dictionaries with Audit Information *(continued)*

View Name	Description
DBA_AUDIT_POLICY_COLUMNS	Displays the policy name and column name for the policies in the database.
DBA_COMMON_AUDIT_TRAIL	Displays audit records for both standard and fine-grained auditing

The exact SQL statement executed by the user and the bind variables used with the SQL are collected in the audit trail when the initialization parameter AUDIT_TRAIL is set to DB_EXTENDED. The DB or TRUE value will not populate the SQLTEXT and SQLBIND columns of the AUD$ table.

In the previous section you learned how to populate the similar columns LSQLTEXT and LSQLBIND of the FGA_LOG$ table.

Many new columns have been added to the DBA_AUDIT_TRAIL and DBA_FGA_AUDIT_TRAIL views to allow them to store additional audit information and to have uniform consistent information in both views.. The following are the new columns added to the DBA_AUDIT_TRAIL view:

EXTENDED_TIMESTAMP Time stamp of when the audit trail entry was created, in UTC (Coordinated Universal Time) time.

PROXY_SESSIONID Proxy session serial number if the session was logged in through a proxy mechanism.

GLOBAL_UID Global user identifier for the user, if the user has logged in as an enterprise user. The USERNAME column shows the user's identity in the database, and the GLOBAL_UID column shows the same user's global identity (when using an LDAP-compliant directory).

INSTANCE_NUMBER Instance number as specified by the INSTANCE_NUMBER initialization parameter (applicable only to Real Application Clusters [RAC]).

OS_PROCESS Operating system process identifier of the Oracle process.

TRANSACTIONID Transaction identifier of the transaction in which the object is accessed. This helps to group audit records of a single transaction.

SCN System change number of the SQL. Added to complement the FGA audit trail.

SQL_BIND Bind variable data of the query. The SQLBIND column of the AUD$ table is the CLOB data type, and it is converted using TO_NCHAR in this column.

SQL_TEXT SQL text of the query. The SQLTEXT column of the AUD$ table is the CLOB data type, and it is converted using TO_NCHAR in this column.

The following are the new columns added to the DBA_FGA_AUDIT_TRAIL view (many of the columns now complement the DBA_AUDIT_TRAIL):

STATEMENT_TYPE Statement type of the SQL: SELECT, INSERT, UPDATE or DELETE.

EXTENDED_TIMESTAMP Time stamp of the SQL in UTC time.

PROXY_SESSIONID Proxy session serial number, if user logged in through proxy mechanism.

GLOBAL_UID Global user identifier if the user logged in as an enterprise user. The DB_USER column shows the user's identity in the database, and the GLOBAL_UID column shows the same user's global identity.

INSTANCE_NUMBER Instance number as specified by the INSTANCE_NUMBER initialization parameter (applicable only to RAC).

OS_PROCESS Operating system process identifier of the Oracle process.

TRANSACTIONID Transaction identifier of the transaction in which the object is accessed.

STATEMENTID Numeric ID for each statement run.

ENTRYID Numeric ID for each audit trail entry in the session. The combination of STATEMENTID and ENTRYID makes each entry unique.

A new view DBA_COMMON_AUDIT_TRAIL is available in Oracle 10*g*. It combines the information in the AUD$ and FGA_AUD$ tables (or the DBA_AUDIT_TRAL and DBA_FGA_AUDIT_TRAL views). The AUDIT_TYPE column identifies the audit trail type. This view is very useful to get all the audit information in a query instead of performing a UNION between DBA_AUDIT_TRAIL and DBA_FGA_AUDIT_TRAIL.

The following example enables standard auditing on the hr.employee table for any updates to the employee table. Remember we still have the AUD_EMPLOYEE_SAL_FN fine-grained policy defined to audit SELECT and UPDATE on first_name and salary columns of this table.

```
SQL> AUDIT UPDATE ON hr.employee;

Audit succeeded.

SQL> SHOW USER
USER is "HR"
SQL> UPDATE hr.employee
  2  SET    hire_date = '30-JAN-90'
  3  WHERE  hire_date = '03-JAN-90';

1 row updated.

SQL>
SQL> SHOW USER
USER is "SCOTT"
```

```
SQL> UPDATE hr.employee
  2  SET    salary = 3000
  3  WHERE  first_name = 'SIGAL';

1 row updated.

SQL>
```

Let us now query the DBA_AUDIT_TRAIL, DBA_FGA_AUDIT_TRAIL and DBA_COMMON_AUDIT_TRAIL views to see the audit records in each view for the `employee` table. Notice that the update done by HR is not showing in the DBA_FGA_AUDIT_TRAIL because the columns updated were not part of the fine-grained auditing. The SCN column is displayed for each record to compare the results. There is a lot more information available in these views, due to space limitation we are showing only few columns.

```
SQL> SELECT username, timestamp, action_name, scn
  2  FROM   dba_audit_trail
  3  WHERE  owner = 'HR'
  4  AND    obj_name = 'EMPLOYEE';

USERNAME      TIMESTAMP ACTION_NAME                SCN
------------- --------- ----------------- -----------
HR            23-AUG-04 SESSION REC           4196929
SCOTT         23-AUG-04 SESSION REC           4197496

SQL>
SQL> SELECT db_user, timestamp, policy_name, scn
  2  FROM   dba_fga_audit_trail
  3  WHERE  object_schema = 'HR'
  4  AND    object_name = 'EMPLOYEE';

DB_USER    TIMESTAMP POLICY_NAME                     SCN
---------- --------- ----------------------- ----------
DAVID      15-JUN-04 AUD_EMPLOYEE_SAL            2916018
DAVID      15-JUN-04 AUD_EMPLOYEE_SAL            2916049
SCOTT      23-AUG-04 AUD_EMPLOYEE_SAL_FN         4196894
SCOTT      23-AUG-04 AUD_EMPLOYEE_SAL_HD         4196894
SCOTT      23-AUG-04 AUD_EMPLOYEE_SAL            4196894
HR         23-AUG-04 AUD_EMPLOYEE_SAL_FN         4197448
HR         23-AUG-04 AUD_EMPLOYEE_SAL            4197448
SCOTT      23-AUG-04 AUD_EMPLOYEE_SAL_FN         4197496
SCOTT      23-AUG-04 AUD_EMPLOYEE_SAL            4197496

SQL>
```

```
SQL> SELECT audit_type, db_user, policy_name, scn
  2  FROM   dba_common_audit_trail
  3  WHERE  object_schema = 'HR'
  4  AND    object_name = 'EMPLOYEE';

AUDIT_TYPE         DB_USER POLICY_NAME               SCN
------------------ ------- -------------------- -------
Standard Audit     HR                           4196929
Standard Audit     SCOTT                        4197496
Fine Grained Audit DAVID   AUD_EMPLOYEE_SAL     2916018
Fine Grained Audit DAVID   AUD_EMPLOYEE_SAL     2916049
Fine Grained Audit SCOTT   AUD_EMPLOYEE_SAL_FN  4196894
Fine Grained Audit SCOTT   AUD_EMPLOYEE_SAL_HD  4196894
Fine Grained Audit SCOTT   AUD_EMPLOYEE_SAL     4196894
Fine Grained Audit HR      AUD_EMPLOYEE_SAL_FN  4197448
Fine Grained Audit HR      AUD_EMPLOYEE_SAL     4197448
Fine Grained Audit SCOTT   AUD_EMPLOYEE_SAL_FN  4197496
Fine Grained Audit SCOTT   AUD_EMPLOYEE_SAL     4197496
```

In the next section we will discuss the major enhancements to SQL in Oracle 10*g*.

Introducing SQL New Features

Every new release of the Oracle database comes with a lot of SQL enhancements, and Oracle 10*g* is no exception. We covered many of the new SQL syntax in earlier chapters; for example, the new SQL statements used to manage Automatic Storage Management (ASM) disks or the syntax in `ALTER SYSTEM` to flush the buffer cache. In the following sections we will discuss some of the new features in Oracle 10*g* SQL that relate to data manipulation and application development, including the following:

- The `MERGE` command allows conditional extensions and the `DELETE` clause.
- You can convert dense data to sparse data using Partition Outer Join.
- You can perform inter-row calculations using the `MODEL` clause.
- It supports regular expressions.
- New data types introduced to support floating-point numbers.
- You can perform case- and accent-insensitive searches.
- You can use the quote operator.

MERGE Improvements

Oracle 9*i* introduced the `MERGE` command as an "Upsert" statement, where you can perform inserts and updates to a table in a single SQL statement. `MERGE` selects rows from one or more

sources for updating or inserting into one or more tables. The conditions specify whether to insert or update the target table. The MERGE statement has the following major improvements in Oracle 10*g*:

- The UPDATE or INSERT clause is optional.
- You can do a conditional UPDATE for a MERGE.
- You can perform a conditional INSERT using the WHERE clause.
- It has a new ON constant filter predicate to insert all rows to the target without joining source and target tables.
- An optional DELETE clause can remove rows while performing updates.

Since MERGE performs INSERT, UPDATE, and DELETE actions on the target table, you must have the appropriate privilege on the target table to perform the operation. Let's discuss the enhancements in detail with examples. Each example in this section uses the PRODUCTS and NEWPRODUCTS tables, which have the following sample data:

```
SQL> SELECT * FROM products;

PRODUCT_ID PRODUCT_NAME         CATEGORY
---------- -------------------- ----------
      1501 VIVITAR 35MM         ELECTRNCS
      1502 OLYMPUS IS50         ELECTRNCS
      1600 PLAY GYM             TOYS
      1601 LAMAZE               TOYS
      1666 HARRY POTTER         DVD

SQL> SELECT * FROM newproducts;

PRODUCT_ID PRODUCT_NAME         CATEGORY
---------- -------------------- ----------
      1502 OLYMPUS CAMERA       ELECTRNCS
      1601 LAMAZE               TOYS
      1666 HARRY POTTER         TOYS
      1700 WAIT INTERFACE       BOOKS

SQL>
```

After demonstrating each example in the following sections, the changes are rolled back. Before each example, the contents of products and newproducts table look as above.

Omitting *UPDATE* or *INSERT* Clause

In Oracle 9*i*, the MERGE statement required that you specify both INSERT and UPDATE clauses. In Oracle 10*g*, you can omit either the INSERT or UPDATE clause. The following example updates the PRODUCTS table with information from the NEWPRODUCTS table if the PRODUCT_ID matches:

```
SQL> MERGE INTO products p
  2  USING newproducts np
  3  ON (p.product_id = np.product_id)
  4  WHEN MATCHED THEN
  5  UPDATE
  6  SET  p.product_name = np.product_name,
  7       p.category     = np.category;

3 rows merged.

SQL> SELECT * FROM products;

PRODUCT_ID PRODUCT_NAME         CATEGORY
---------- -------------------- ----------
      1501 VIVITAR 35MM         ELECTRNCS
      1502 OLYMPUS CAMERA       ELECTRNCS
      1600 PLAY GYM             TOYS
      1601 LAMAZE               TOYS
      1666 HARRY POTTER         TOYS
SQL>
SQL> ROLLBACK;

Rollback complete.

SQL>
```

In the example, the rows affected by the MERGE statement are product ids 1502, 1601 and 1666. Their product name and category are updated with the values from `newproducts` table.

The following example omits the UPDATE clause, and it inserts into the PRODUCTS table when a PRODUCT_ID is new in the NEWPRODUCTS table; no action is taken when the PRODUCT_ID matches. You can see from the example, product id 1700 is added to the `products` table.

```
SQL> MERGE INTO products p
  2  USING newproducts np
  3  ON (p.product_id = np.product_id)
  4  WHEN NOT MATCHED THEN
  5  INSERT
```

```
  6  VALUES (np.product_id, np.product_name,
  7          np.category);

1 row merged.

SQL> SELECT * FROM products;

      1501 VIVITAR 35MM         ELECTRNCS
      1502 OLYMPUS IS50         ELECTRNCS
      1600 PLAY GYM             TOYS
      1601 LAMAZE               TOYS
      1666 HARRY POTTER         DVD
      1700 WAIT INTERFACE       BOOKS
```

Conditional Updates and Inserts

You can add an optional `WHERE` clause to the `UPDATE` or `INSERT` clause of the `MERGE` statement to skip an update or insert operation for certain rows. The following example updates the `PRODUCTS` table with information from the `NEWPRODUCTS` table only when the `CATEGORY` matches:

```
SQL> MERGE INTO products p
  2  USING newproducts np
  3  ON (p.product_id = np.product_id)
  4  WHEN MATCHED THEN
  5  UPDATE
  6  SET p.product_name = np.product_name
  7  WHERE p.category = np.category;

2 rows merged.

SQL> SELECT * FROM products;

PRODUCT_ID PRODUCT_NAME         CATEGORY
---------- -------------------- ----------
      1501 VIVITAR 35MM         ELECTRNCS
      1502 OLYMPUS CAMERA       ELECTRNCS
      1600 PLAY GYM             TOYS
      1601 LAMAZE               TOYS
      1666 HARRY POTTER         DVD

SQL>

SQL> rollback;
```

In the example, product ids 1502, 1601 and 1666 match the ON condition but the category for 1666 does not match. So the MERGE statement updates only two rows.

The next example demonstrates using the WHERE clause in the UPDATE and INSERT clauses of the MERGE statement:

```
SQL> MERGE INTO products p
  2  USING newproducts np
  3  ON (p.product_id = np.product_id)
  4  WHEN MATCHED THEN
  5  UPDATE
  6  SET p.product_name = np.product_name,
  7      p.category     = np.category
  8  WHERE p.category = 'DVD'
  9  WHEN NOT MATCHED THEN
 10  INSERT
 11  VALUES (np.product_id, np.product_name, np.category)
 12  WHERE  np.category != 'BOOKS'
SQL> /

1 row merged.

SQL> SELECT * FROM products;

PRODUCT_ID PRODUCT_NAME         CATEGORY
---------- -------------------- ----------
      1501 VIVITAR 35MM         ELECTRNCS
      1502 OLYMPUS IS50         ELECTRNCS
      1600 PLAY GYM             TOYS
      1601 LAMAZE               TOYS
      1666 HARRY POTTER         TOYS

SQL>
```

Notice that the INSERT did not insert any rows to PRODUCTS because of the WHERE condition. The only row that satisfied the WHEN NOT MATCHED condition did not satisfy the WHERE clause of the INSERT. The MERGE updated product ID 1666.

Unconditional Inserts

You can insert rows from the source table to the target table without joining the source and target. This is useful when you want to insert all rows from the source to the target. Oracle 10*g* supports the constant filter predicate in the ON clause condition. An example of constant filter

is ON (1=0). The following example inserts rows from the source to the PRODUCTS table without checking its existence in the PRODUCTS table:

```
SQL> MERGE INTO products p
  2  USING newproducts np
  3  ON (1=0)
  4  WHEN NOT MATCHED THEN
  5  INSERT
  6  VALUES (np.product_id, np.product_name, np.category)
  7  WHERE  np.category = 'BOOKS'
SQL> /

1 row merged.

SQL> SELECT * FROM products;

PRODUCT_ID PRODUCT_NAME         CATEGORY
---------- -------------------- ----------
      1501 VIVITAR 35MM         ELECTRNCS
      1502 OLYMPUS IS50         ELECTRNCS
      1600 PLAY GYM             TOYS
      1601 LAMAZE               TOYS
      1666 HARRY POTTER         DVD
      1700 WAIT INTERFACE       BOOKS

6 rows selected.

SQL>
```

In the example, notice that the row with product id 1700 is added because it is the only row that satisfies the WHERE np.category = 'BOOKS' condition in the newproducts table.

New *DELETE* Clause

MERGE in Oracle 10*g* provides the option to cleanse rows while performing data operations. You can include the DELETE clause along with WHEN MATCHED THEN UPDATE clause. The DELETE clause must have a WHERE condition to remove rows that match certain conditions. Rows that match the DELETE WHERE condition but do not match the ON condition are not deleted from the table.

The following example demonstrates the DELETE clause. Here we merge the rows from NEWPRODUCTS into PRODUCTS and delete any rows from PRODUCTS whose category is ELECTRNCS. The contents of PRODUCTS and NEWPRODUCTS are listed again to help understand the result.

```
SQL> SELECT * FROM products;

PRODUCT_ID PRODUCT_NAME         CATEGORY
---------- -------------------- ----------
      1501 VIVITAR 35MM         ELECTRNCS
      1502 OLYMPUS IS50         ELECTRNCS
      1600 PLAY GYM             TOYS
      1601 LAMAZE               TOYS
      1666 HARRY POTTER         DVD

SQL> SELECT * FROM newproducts;

PRODUCT_ID PRODUCT_NAME         CATEGORY
---------- -------------------- ----------
      1502 OLYMPUS CAMERA       ELECTRNCS
      1601 LAMAZE               TOYS
      1666 HARRY POTTER         TOYS
      1700 WAIT INTERFACE       BOOKS

SQL> MERGE INTO products p
  2  USING newproducts np
  3  ON (p.product_id = np.product_id)
  4  WHEN MATCHED THEN
  5  UPDATE
  6  SET p.product_name = np.product_name,
  7      p.category     = np.category
  8  DELETE WHERE (p.category = 'ELECTRNCS')
  9  WHEN NOT MATCHED THEN
 10  INSERT
 11  VALUES (np.product_id, np.product_name, np.category)
SQL> /

4 rows merged.

SQL> SELECT * FROM products;

PRODUCT_ID PRODUCT_NAME         CATEGORY
---------- -------------------- ----------
      1501 VIVITAR 35MM         ELECTRNCS
      1600 PLAY GYM             TOYS
      1601 LAMAZE               TOYS
      1666 HARRY POTTER         TOYS
      1700 WAIT INTERFACE       BOOKS

SQL>
```

The product ID 1502 was deleted from PRODUCTS because it matched the ON condition and the DELETE WHERE condition. The product ID 1501 matched the DELETE WHERE condition but did not match the ON condition, so it was not deleted. The product ID 1700 did not match the ON condition, so it was inserted into the PRODUCTS table. The product IDs 1601 and 1666 matched the ON condition but did not match the DELETE condition, so they were updated with the new values from the NEWPRODUCTS table.

The MERGE statement in Oracle 10*g* is more flexible and can accomplish several tasks in one step. Let's now move onto the next new feature: partitioned outer joins.

Partitioned Outer Join

A partitioned outer join, also known as a *group outer join*, is an excellent method to convert sparse data into a dense form. In data warehouse schemas that use dimension and fact tables, time-specific data is normally stored in a sparse form in the database; if no value exists for specific time period, no row exists in the fact table. Time series calculations are easier when dense data fill a consistent number of rows for each period.

You can use the partitioned outer join syntax to fill the gaps in time series by extending the conventional outer join syntax to apply the outer join to each partition defined in the query. It is similar to a regular outer join except the outer join is applied to each partition. The Oracle database logically partitions the rows in your query based on the expression you specify in the PARTITION BY clause. The result of a partitioned outer join is a UNION of the outer joins of each of the groups in the logically partitioned table with the table on the other side of the join.

The PARTTION BY...RIGHT OUTER JOIN has the following syntax:

```
SELECT select_expression
FROM   table_reference
PARTITION BY (expr [, expr ]... )
RIGHT OUTER JOIN table_reference
```

The LEFT OUTER JOIN...PARTTION BY has the following syntax:

```
SELECT select_expression
FROM   table_reference
LEFT OUTER JOIN table_reference
PARTITION BY {expr [,expr ]...)
```

To demonstrate the partitioned outer join, let's consider the following data. The DB_DOWNTIME table records instances when a database is not available.

```
SQL> SELECT * FROM db_downtime;

DBNAME   DOWN_STARTTIME       DOWN_ENDTIME
-------- -------------------- --------------------
DALP01   07-JUN-2004 11:47:38 07-JUN-2004 12:47:38
DALP01   06-JUN-2004 11:48:02 06-JUN-2004 13:48:02
DALP01   16-JUN-2004 11:48:17 16-JUN-2004 13:18:17
```

```
FTWP01   06-JUN-2004 11:48:26 06-JUN-2004 13:18:26
FTWP01   15-JUN-2004 11:48:39 15-JUN-2004 16:48:39

SQL>
```

The following example densifies the missing data of downtime minutes in the last 15 days for each date and each database using the new `PARTITION BY...OUTER JOIN` syntax.

```
SQL> SELECT pdate, dbname,
  2         NVL((down_endtime-down_starttime)*24*60,0)
            as downminutes
  3  FROM   db_downtime dbd
  4  PARTITION BY (dbname)
  5  RIGHT OUTER JOIN (
  6  SELECT TRUNC(sysdate)-15+rownum pdate
  7  FROM all_objects
  8  WHERE rownum <= 15) alldates
  9  ON trunc(dbd.down_starttime) = alldates.pdate
 10  ORDER BY 1
SQL> /

PDATE                DBNAME   DOWNMINUTES
-------------------- -------- -----------
02-JUN-2004 00:00:00 DALP01             0
02-JUN-2004 00:00:00 FTWP01             0
03-JUN-2004 00:00:00 DALP01             0
03-JUN-2004 00:00:00 FTWP01             0
04-JUN-2004 00:00:00 DALP01             0
04-JUN-2004 00:00:00 FTWP01             0
05-JUN-2004 00:00:00 DALP01             0
05-JUN-2004 00:00:00 FTWP01             0
06-JUN-2004 00:00:00 DALP01           120
06-JUN-2004 00:00:00 FTWP01            90
07-JUN-2004 00:00:00 DALP01            60
07-JUN-2004 00:00:00 FTWP01             0
<< output truncated >>
15-JUN-2004 00:00:00 DALP01             0
15-JUN-2004 00:00:00 FTWP01           300
16-JUN-2004 00:00:00 DALP01            90
16-JUN-2004 00:00:00 FTWP01             0
```

```
30 rows selected.

SQL>
```

In the example notice that there are no records for many dates between 2-JUN-2004 and 15-JUN-2004 in the db_downtime table. The query using the partition outer join method densifies the result with all missing dates. The down minutes for the records generated are NULL, but using a NVL function, we interpreted the NULL values as zero. Since we do not have a table with all the dates of the month, we used the ALL_OBJECTS view and ROWNUM to generate the continuous dates.

Once you have the dense data available, you can use it to perform analytical calculations or to plot charts.

The partitioned outer join supports only RIGHT OUTER JOIN and LEFT OUTER JOIN. It does not support FULL OUTER JOIN. The new syntax has been accepted by ANSI and ISO to be included in the SQL standard.

Using Partitioned Outer Joins with Analytic Functions

A partitioned outer join will return rows with NULL values in some queries, but you may want those rows to hold the most recent non-NULL value in the series. That is, you may want to have NULLs replaced with the first non-NULL value you see as you scan upward in a column.

Let's consider an example. The DB_TABSIZE table tracks the size of the table each month, and if the size does not change, no information is entered in the table. The table has the following data:

```
SQL> SELECT * FROM db_tabsize;

OWNER      TABNAME              STATDATE     TABSIZE
---------- -------------------- --------- ----------
BILL       SALES                01-JAN-04     262144
BILL       SALES                01-MAR-04     524288
BILL       SALES                01-MAY-04    1048576
BILL       SALES                01-JUN-04    2097152
BILL       INVENTORY            01-JAN-04     262144
BILL       INVENTORY            01-MAR-04     524288
BILL       INVENTORY            01-APR-04   10485760
BILL       INVENTORY            01-JUN-04   20971520

SQL>
SQL> SELECT * FROM months;

MONTHDATE
```

```
---------
01-JAN-04
01-FEB-04
01-MAR-04
01-APR-04
01-MAY-04
01-JUN-04

SQL>
```

Here you see that if an event does not exist, then no row exists for the table for that month. The table SALES has no row for February and April, and the table INVENTORY has no row for February and May because their sizes remained the same. Let's try to make this data dense using the partition outer join.

```
SQL> SELECT owner, tabname, monthdate, tabsize
  2  FROM   db_tabsize
  3  PARTITION BY (owner, tabname)
  4  RIGHT OUTER JOIN months
  5  ON (db_tabsize.statdate = months.monthdate)
SQL> /

OWNER      TABNAME              MONTHDATE    TABSIZE
---------- -------------------- --------- ----------
BILL       INVENTORY            01-JAN-04     262144
BILL       INVENTORY            01-FEB-04
BILL       INVENTORY            01-MAR-04     524288
BILL       INVENTORY            01-APR-04   10485760
BILL       INVENTORY            01-MAY-04
BILL       INVENTORY            01-JUN-04   20971520
BILL       SALES                01-JAN-04     262144
BILL       SALES                01-FEB-04
BILL       SALES                01-MAR-04     524288
BILL       SALES                01-APR-04
BILL       SALES                01-MAY-04    1048576
BILL       SALES                01-JUN-04    2097152

12 rows selected.

SQL>
```

But this is not the data we want. When we make the time dimension dense, we want to see a size value for each month. When using the partition outer join, we see a NULL, which is not the size value. We want the size of the table SALES in April to be displayed as being the same as it was in March. You can accomplish this by using the new keyword IGNORE NULLS introduced in the FIRST_VALUE and LAST_VALUE analytic functions in Oracle 10*g*.

```
SQL> SELECT owner, tabname, monthdate,
  2         LAST_VALUE(tabsize IGNORE NULLS)
  3         OVER (PARTITION BY owner, tabname
  4               ORDER BY monthdate) tabsize
  5  FROM   (
  6  SELECT owner, tabname, monthdate, tabsize
  7  FROM db_tabsize
  8  PARTITION BY (owner, tabname)
  9  RIGHT OUTER JOIN months
 10  ON (db_tabsize.statdate = months.monthdate))
 11  ORDER BY owner, tabname, monthdate
SQL> /

OWNER      TABNAME              MONTHDATE    TABSIZE
---------- -------------------- --------- ----------
BILL       INVENTORY            01-JAN-04     262144
BILL       INVENTORY            01-FEB-04     262144
BILL       INVENTORY            01-MAR-04     524288
BILL       INVENTORY            01-APR-04   10485760
BILL       INVENTORY            01-MAY-04   10485760
BILL       INVENTORY            01-JUN-04   20971520
BILL       SALES                01-JAN-04     262144
BILL       SALES                01-FEB-04     262144
BILL       SALES                01-MAR-04     524288
BILL       SALES                01-APR-04     524288
BILL       SALES                01-MAY-04    1048576
BILL       SALES                01-JUN-04    2097152

12 rows selected.

SQL>
```

As you can see, the PARTITION...OUTER JOIN syntax is useful in doing analytic calculations. Combining the partition outer join with several analytic functions and using it with hierarchical cubes can yield results faster in Oracle 10*g*. The dense data makes it simple to use analytic functions such as LAG or LEAD, which perform better when a row exists for each combination of dimensions. The performance of the partitioned outer join syntax is several times faster and improves the overall calculation performance.

Spreadsheet Computations Using the *MODEL* Clause

The SQL MODEL *clause* is a significant new feature of the Oracle 10*g* database in the business intelligence area. This clause will help accountants who like to take data out of Oracle and put it into a spreadsheet to perform analytic functions. The purpose of the SQL MODEL clause is to give SQL statements the ability to create a multidimensional array from the results of a normal SELECT statement and then perform several interdependent inter-row and inter-array calculations on this SQL spreadsheet. You can use the results of the MODEL clause to update the base tables using the INSERT, UPDATE, and MERGE statements.

The MODEL clause defines a multidimensional array by mapping the columns of a query into three groups: partitions, dimensions, and measures. *Partitions* define logical blocks of the result set and are viewed as an independent array. *Dimensions* identify each measure cell within a partition. These columns are identifying characteristics such as date and product name. *Measures* are the actual data cells. They are analogous to the measures of a fact table in a star schema. Measures typically contain numeric values such as sales units or revenue. You can access each cell within its partition by specifying its full combination of dimensions. Table 8.2 demonstrates these components.

TABLE 8.2 Sample Data to Demonstrate MODEL Clause

Partition	Dimension	Dimension	Measure
Country	Company	Year	Revenue
C1	ABC	2002	450
C1	ABC	2001	455
C2	ABC	2002	500
C2	ABC	2001	550
C1	XYZ	2002	67
C1	XYZ	2001	78

TABLE 8.2 Sample Data to Demonstrate MODEL Clause *(continued)*

Partition	Dimension	Dimension	Measure
C2	XYZ	2002	85
C2	XYZ	2001	80

The MODEL clause of the SELECT statement has several options. The MODEL clause is processed after all the other clauses of the SELECT statement but before the ORDER BY clause. The core syntax of the MODEL clause is as follows:

```
<prior clauses of SELECT statement>
MODEL  [RETURN [UPDATED | ALL] ROWS]
[reference models]
[PARTITION BY (<cols>)]
DIMENSION BY (<cols>)
MEASURES (<cols>) [IGNORE NAV] | [KEEP NAV]
[RULES
[UPSERT | UPDATE]
[AUTOMATIC ORDER | SEQUENTIAL ORDER]
[ITERATE (n) [UNTIL <condition>] ]
( <cell_assignment> = <expression> ... )
```

The previous syntax is the most simplified version.

Refer to *Oracle 10g SQL Reference Manual* for the complete syntax of the SELECT statement MODEL clause.

We will demonstrate the use of MODEL clause using examples. For simplicity let's consider you have the previous data in a single table.

```
SQL> SELECT * FROM revenues;

COUNTRY  COMPANY        YEAR    REVENUE
-------- -------- ---------- ----------
C1       ABC            2002        450
C1       ABC            2001        455
C2       ABC            2002        500
C2       ABC            2001        550
C1       XYZ            2002         67
```

```
C1       XYZ            2001         78
C2       XYZ            2002         85
C2       XYZ            2001         80

SQL>
```

The revenue data for years 2001 and 2002 are available; we can use the `MODEL` clause to project the 2003 revenues using 2001 and 2002 data. Let's say the 2003 projection is going to be the total revenue of 2001 and 2002 for company XYZ and 20 percent higher than 2002 for company ABC. The `MODEL` clause would be as follows:

```
SQL> SELECT country, company, year, revenue
  2  FROM   revenues
  3  MODEL
  4  PARTITION BY (country)
  5  DIMENSION BY (company, year)
  6  MEASURES (revenue)
  7  RULES (
  8    revenue['ABC',2003] = revenue['ABC',2002]*1.2,
  9    revenue['XYZ',2003] = revenue['XYZ',2001] +
 10                          revenue['XYZ',2002])
 11  ORDER BY country, company, year
SQL> /

COUNTRY  COMPANY        YEAR    REVENUE
-------- -------- ---------- ----------
C1       ABC            2001        455
C1       ABC            2002        450
C1       ABC            2003        540
C1       XYZ            2001         78
C1       XYZ            2002         67
C1       XYZ            2003        145
C2       ABC            2001        550
C2       ABC            2002        500
C2       ABC            2003        600
C2       XYZ            2001         80
C2       XYZ            2002         85
C2       XYZ            2003        165

12 rows selected.

SQL>
```

The MODEL clause is the last query clause, executed after the WHERE and GROUP BY clauses but before the ORDER BY clause.

The result shows the new rows generated by the MODEL clause as well as the existing rows. If you're interested only in the new rows created by the query, use the RETURN UPDATED ROWS clause, as in the following example:

```
SQL> SELECT country, company, year, revenue
  2  FROM   revenues
  3  MODEL RETURN UPDATED ROWS
  4  PARTITION BY (country)
  5  DIMENSION BY (company, year)
  6  MEASURES (revenue)
  7  RULES (
  8    revenue['ABC',2003] = revenue['ABC',2002]*1.2,
  9    revenue['XYZ',2003] = revenue['XYZ',2001] +
 10                          revenue['XYZ',2002])
 11  ORDER BY country, company, year
SQL> /

COUNTRY  COMPANY        YEAR    REVENUE
-------- -------- ---------- ----------
C1       ABC            2003        540
C1       XYZ            2003        145
C2       ABC            2003        600
C2       XYZ            2003        165

SQL>
```

A full discussion of all these options is outside the scope of the OCP exam and this book, but a brief example of cell addressing is discussed in the next section for demonstration purposes.

The MODEL clause does not update existing data in tables, and it does not insert new data into tables. To change values in a table, you must supply the MODEL results to an INSERT, UPDATE, or MERGE statement.

Addressing Cells and Values

Understanding cell reference is important to get the most out of the MODEL clause. By default the rules in the MODEL clause have "Upsert" semantics. If the cell that is indicated by the left side on

the rule exists, it is updated; otherwise a new row containing that cell is generated. Again, the base table is not updated or inserted with new values, they are shown as a result of the operation. You must use appropriate INSERT or UPDATE statements to perform the update or insert to the base table. A reference to a cell must qualify all dimensions listed in the `DIMENSION BY` clause. You can use either positional reference or symbolic reference. Cell references are discussed in the following sections.

Positional Cell Reference

In positional reference, each value provided in the brackets matches the dimension in the equivalent position of the `DIMENSION BY` clause. The following is an example of a query that uses positional cell reference to match the appropriate dimension based on its position in the expression: The `DIMENSION BY` clause determines the position assigned to each dimension. In this example, the first position is the company, and the second position is the year. The revenue for company ABC year 2001 is updated to 1000 when showing the result. Notice that the value for revenue for this record in the base table is 455.

```
SQL> SELECT country, company, year, revenue
  2  FROM   revenues
  3  WHERE  country = 'C1'
  4  MODEL RETURN UPDATED ROWS
  5  PARTITION BY (country)
  6  DIMENSION BY (company, year)
  7  MEASURES (revenue)
  8  RULES (
  9    revenue['ABC',2001] = 1000)
SQL> /

COUNTRY  COMPANY        YEAR    REVENUE
-------- -------- ---------- ----------
C1       ABC            2001       1000

SQL>
```

Symbolic Cell Reference

With symbolic cell reference, a single dimension value is qualified by a SQL Boolean condition. You can use conditions such as <, >, `IN`, and `BETWEEN`. You need to include as many conditions inside the brackets as there are dimensions in the `DIMENSIONS BY` clause. Symbolic references are solely for updating existing cells, and they cannot create new cells. The following SQL is an

example of symbolic reference. Here we reference all the rows that belong to company ABC and are above year 2000 using the symbolic reference. For such rows, we update the revenue to 100.

```
SQL> SELECT country, company, year, revenue
  2  FROM   revenues
  3  WHERE  country = 'C1'
  4  MODEL RETURN UPDATED ROWS
  5  PARTITION BY (country)
  6  DIMENSION BY (company, year)
  7  MEASURES (revenue)
  8  RULES (
  9    revenue[company='ABC',year>2000] = 100)
SQL> /

COUNTRY  COMPANY        YEAR    REVENUE
-------- -------- ---------- ----------
C1       ABC            2002        100
C1       ABC            2001        100

SQL>
```

Using Current Value Function

The current value function (`CV()`) is a powerful tool used on the right side of formulas to copy left-side specifications that refer to multiple cells. This allows for compact and flexible multicell formulas. You can consider the `current value` function as a SQL join condition that is compact and readable.

In the following example, we add 20 percent to the revenue of XYZ Company in country C2 and make that the revenue of company ABC. The `CV(year)` function returns the year dimension value of the cell currently referenced on the left side.

```
SQL> SELECT country, company, year, revenue
  2  FROM   revenues
  3  WHERE  country = 'C2'
  4  MODEL RETURN UPDATED ROWS
  5  PARTITION BY (country)
  6  DIMENSION BY (company, year)
  7  MEASURES (revenue)
  8  RULES (
  9     revenue['ABC', year BETWEEN 2001 and 2002] =
 10     revenue['XYZ', CV(year)] * 1.2)
SQL> /
```

```
COUNTRY  COMPANY        YEAR    REVENUE
-------- -------- ---------- ----------
C2       ABC            2002        102
C2       ABC            2001         96

SQL>
```

The current value function takes the dimension key as the argument. It is also possible to use CV function without any arguments, as in CV(), which causes positional referencing.

Miscellaneous *MODEL* Clause Options

The MODEL clause includes several options and subclasses that make the MODEL clause a powerful tool for analytical applications. In the following sections we will discuss a few of the important options.

FOR Loop

The FOR construct can be useful in applying a single formula to generate multiple cells. In the following example, the cells for year 2005 are generated for the company C2 using a FOR construct:

```
SQL> SELECT country, company, year, revenue
  2  FROM   revenues
  3  WHERE  country = 'C2'
  4  MODEL RETURN UPDATED ROWS
  5  PARTITION BY (country)
  6  DIMENSION BY (company, year)
  7  MEASURES (revenue)
  8  RULES (
  9     revenue [FOR company IN ('ABC','XYZ'), 2004 ]
 10             = 2 * revenue [CV(company), 2002])
SQL> /

COUNTRY  COMPANY        YEAR    REVENUE
-------- -------- ---------- ----------
C2       XYZ            2004        170
C2       ABC            2004       1000

SQL>
```

Rules Ordering

By default, rules are evaluated in the order they appear in the MODEL clause (the default is SEQUENTIAL ORDER). The AUTOMATIC ORDER clause evaluates the dependencies in the RULES and processes them in the order the values are evaluated. The following two queries demonstrate

the order and the difference in results. Notice that in the first SQL example, the second rule is executed before the first rule. In the second SQL example, the values are NULL, because revenue ['XYZ',2004] is evaluated to NULL.

```
SQL> SELECT country, company, year, revenue
  2  FROM   revenues
  3  MODEL RETURN UPDATED ROWS
  4  PARTITION BY (country)
  5  DIMENSION BY (company, year)
  6  MEASURES (revenue)
  7  RULES AUTOMATIC ORDER (
  8     revenue ['ABC', 2004] =
        revenue ['ABC', 2002] + revenue ['XYZ',2004],
  9     revenue ['XYZ', 2004] =
        revenue ['ABC', 2001] + revenue ['XYZ',2001])
SQL> /

COUNTRY  COMPANY        YEAR    REVENUE
-------- -------- ---------- ----------
C2       XYZ            2004        630
C2       ABC            2004       1130
C1       XYZ            2004        533
C1       ABC            2004        983

SQL>
SQL> SELECT country, company, year, revenue
  2  FROM   revenues
  3  MODEL RETURN UPDATED ROWS
  4  PARTITION BY (country)
  5  DIMENSION BY (company, year)
  6  MEASURES (revenue)
  7  RULES SEQUENTIAL ORDER (
  8     revenue ['ABC', 2004] =
        revenue ['ABC', 2002] + revenue ['XYZ',2004],
  9     revenue ['XYZ', 2004] =
        revenue ['ABC', 2001] + revenue ['XYZ',2001])
SQL> /

COUNTRY  COMPANY        YEAR    REVENUE
-------- -------- ---------- ----------
C2       ABC            2004
```

```
C2        XYZ             2004         630
C1        ABC             2004
C1        XYZ             2004         533

SQL>
```

Ignoring *NULL*s

You can use the `IGNORE NAV` option to ignore `NULL` and substitute a value for the `NULL` value. When a `NULL` is involved in calculations, the dependent results are `NULL`. The `IGNORE NAV` options will prevent `NULL` values from propagating through a set of related calculations. When you use the `IGNORE NAV` option, Oracle assigns the following values for `NULL` values:

- Zero for numeric data types
- 01-JAN-2000 for date and time stamp data types
- An empty string for character data types
- `NULL` for all other data types

Let's apply the `IGNORE NAV` clause to the previous example and see the results. Notice how the `revenue` values for ABC `company` are now displayed as 500, instead of `NULL` as before.

```
SQL> SELECT country, company, year, revenue
  2  FROM   revenues
  3  MODEL IGNORE NAV RETURN UPDATED ROWS
  4  PARTITION BY (country)
  5  DIMENSION BY (company, year)
  6  MEASURES (revenue)
  7  RULES SEQUENTIAL ORDER (
  8     revenue ['ABC', 2004] =
        revenue ['ABC', 2002] + revenue ['XYZ',2004],
  9     revenue ['XYZ', 2004] =
        revenue ['ABC', 2001] + revenue ['XYZ',2001])
SQL> /

COUNTRY  COMPANY        YEAR    REVENUE
-------- -------- ---------- ----------
C2       ABC             2004        500
C2       XYZ             2004        630
C1       ABC             2004        450
C1       XYZ             2004        533

SQL>
```

Reference Models

In a single MODEL clause, you can reference multiple multidimensional arrays. The multidimensional array that has existing cells updated and new cells added is called the *main model*. Along with the main model, you can define one or more multidimensional arrays called the *reference models*. The reference models are read-only and are used as lookup tables.

Reference models are similar to the main SQL model where you have a query block with DIMENSION BY and MEASURES clauses. The reference model cannot have a PARTITION clause. A MODEL clause can have more than one reference model, but each reference model must have a different name.

The following example uses the conversion rate of currency as a reference model and uses it in the MODEL clause to show base revenue and converted revenue:

```
SQL> SELECT * FROM conversion_rate;

COUNTRY        C_RATE
---------- ----------
C1               1.75
C2                  5

SQL> SELECT country, year, locrevenue, convrevenue
  2  FROM   revenues
  3  GROUP BY country, year
  4  MODEL RETURN UPDATED ROWS
  5  REFERENCE conv_rate_model ON (
  6    SELECT country, c_rate AS cr
  7    FROM   conversion_rate)
  8  DIMENSION BY (country)
  9  MEASURES (cr)
 10  MAIN main_model
 11  DIMENSION BY (country, year)
 12  MEASURES (SUM(revenue) revenue,
              0 locrevenue, 0 convrevenue)
 13  RULES (
 14     locrevenue ['C1', 2004] =
 15         revenue ['C1', 2002] + revenue ['C1',2001],
 16     convrevenue ['C1', 2004] =
 17         (revenue ['C1', 2002] + revenue ['C1',2001]) *
 18                              conv_rate_model.cr['C1'],
 19     locrevenue ['C2', 2004] =
 20         revenue ['C2', 2002] + revenue ['C2',2001],
 21     convrevenue ['C2', 2004] =
 22         (revenue ['C2', 2002] + revenue ['C2',2001]) *
```

```
 23                            conv_rate_model.cr['C2']
 24         )
SQL> /

COUNTRY         YEAR LOCREVENUE CONVREVENUE
-------- ---------- ---------- -----------
C2              2004       1215        6075
C1              2004       1050      1837.5

SQL>
```

Cyclic References and Iterations

Using the `ITERATE` option of the `MODEL` clause, you can evaluate formulas iteratively a specified number of times. The number of iterations is specified as an argument to the `ITERATE` clause. Optionally, you can specify a termination condition to stop formula evaluation before reaching the maximum iteration. This condition is specified in the `UNTIL` option of the `ITERATE` clause and is checked at the end of each iteration.

In the next section we will discuss another major SQL improvement, the regular expression support for string searching.

Regular Expressions

Regular expressions are a powerful, efficient text-processing feature for searching and manipulating complex patterns. Regular expressions can be as simple as a search command in a text editor or as powerful as a text-processing language.

In Oracle 10*g*, both SQL and PL/SQL support regular expressions. Regular expression implementation in Oracle 10*g* complies with the POSIX standard for pattern matching and Unicode regular expression guidelines.

Regular expressions in Oracle are especially useful to validate data such as phone numbers, ZIP codes, e-mail addresses, and so on. They are also useful in searching for Hypertext Markup Language (HTML) tags, dates or e-mail addresses.

The following four functions support regular expressions:

- `REGEXP_LIKE`
- `REGEXP_INSTR`
- `REGEXP_REPLACE`
- `REGEXP_SUBSTR`

REGEXP_LIKE

`REGEXP_LIKE` is used in SQL as a Boolean operator, similar to the `LIKE` operator. You must use `REGEXP_LIKE` in SQL in the `WHERE` or `HAVING` clause, again similar to the `LIKE` operator. You can use the `REGEXP_LIKE` function as a function that returns Boolean result in PL/SQL.

The syntax of REGEXP_LIKE is as follows:

```
REGEXP_LIKE ( source_string, pattern [, match_parameter] )
```

The *source_string* is the search value, which can be a string literal or a character column (CHAR, VARCHAR2, NCHAR, NVARCHAR2, CLOB, or NCLOB). The *pattern* is the regular expression you're trying to match in the *source_string*. The *match_parameter* changes the default matching behavior. The match_parameter can be one or more of the following values:

- i specifies case-insensitive matching.
- c specifies case-sensitive matching.
- n allows the period (.) to match a new line character.
- m treats the source string as multiple lines, where ^ and $ are identified as the start and end of the line.

If the data type of the regular expression is different from the data type of the search string, the regular expression is implicitly converted to the data type of the search string.

The following example queries the EMPLOYEES table in the HR sample schema to find the first names of employees whose first names start with a vowel, whose second character is an L, and whose first name is at least six characters long. The ^ represents the beginning of line and we check for a vowel immediately following the ^. The i option is used to ignore the case while comparing. The :alpha: checks that the character is an alphabet, the "6," is interpreted as at least 6 characters.

```
SQL> SELECT first_name, last_name
  2  FROM   employees
  3  WHERE  REGEXP_LIKE (first_name, '^[aeiou]l','i')
  4  AND    REGEXP_LIKE (first_name, '[[:alpha:]]{6,}')
SQL> /

FIRST_NAME           LAST_NAME
-------------------- -------------------------
Elizabeth            Bates
Alexis               Bull
Alberto              Errazuriz
Alexander            Hunold
Alyssa               Hutton
Alexander            Khoo
Oliver               Tuvault
```

```
7 rows selected.

SQL>
```

This second example looks for employees with a space in their last names. It also makes sure at least one character appears before and after the space, as we do not want to take into account the leading or trailing spaces if there are any. `[[:alpha:]]` matches any alphabet, `.+` matches one or more characters, and `.*` matches zero or more characters. The `{}` specifies the width of the matching string, which is `1`, and means 1 or more.

```
SQL> SELECT first_name, last_name
  2  FROM   employees
  3  WHERE  REGEXP_LIKE
       (last_name, '[[:alpha:]]{1,} [[:alpha:]]{1,}')
SQL> /

FIRST_NAME           LAST_NAME
-------------------- -------------------------
Lex                  De Haan

SQL> SELECT first_name, last_name
  2  FROM   employees
  3  WHERE  REGEXP_LIKE (last_name, '.+ .+')
SQL> /

FIRST_NAME           LAST_NAME
-------------------- -------------------------
Lex                  De Haan

SQL> SELECT first_name, last_name
  2  FROM   employees
  3  WHERE  REGEXP_LIKE (last_name, '.*[[:space:]].*')
SQL> /

FIRST_NAME           LAST_NAME
-------------------- -------------------------
Elizabeth             Bates
Lex                  De Haan

SQL>
```

Discussing all the metacharacters of regular expression pattern matching requires a book by itself. Please refer to *Oracle Regular Expressions Pocket Reference* and *Mastering Regular Expressions, Second Edition* to learn more about pattern matching and regular expressions.

REGEXP_INSTR

The REGEXP_INSTR function is similar to the INSTR function, but it extends the INSTR functionality by searching the string for a regular expression pattern. The function returns the position where the match is found. The syntax of REGEXP_INSTR is as follows:

```
REGEXP_INSTR (source_string, pattern
              [,position [,occurrence
              [,return_option [,match_parameter ] ] ] ])
```

The following example shows the position of the second occurrence (*occurrence* = 2) of a vowel (*pattern* = [aeiou]) in the first name of employees, with case-insensitive (*match_parameter* = i) searching from the first character (*position* = 1). The *return_option* of 0 is the default, which returns the position of the first character of the occurrence; 1 returns the position of the character following the occurrence.

```
SQL> SELECT first_name, REGEXP_INSTR(first_name,
  2                '[aeiou]', 1, 2, 0, 'i') reginstr
  3  FROM   employees
  4  WHERE  last_name like 'S%'
SQL> /

FIRST_NAME             REGINSTR
-------------------- ----------
Nandita                       5
Ismael                        4
John                          0
Sarath                        4
Lindsey                       6
William                       5
Stephen                       6
Martha                        6
Patrick                       5

9 rows selected.

SQL>
```

REGEXP_REPLACE

REGEXP_REPLACE searches for a regular expression pattern and replaces it with a replacement string. It extends the functionality of the REPLACE function. The syntax of REGEXP_REPLACE is as follows:

```
REGEXP_REPLACE (source_string, pattern
        [,position [,occurrence [,match_parameter ] ] ])
```

The following two examples demonstrate the REGEXP_REPLACE function. The first example adds a space after each character, and the second example changes the "last name, first name" format to "first name, last name" format.

```
SQL> SELECT REGEXP_REPLACE
            ('United States', '(.)', '\1 ') repl
  2  FROM   dual
SQL> /

REPL
--------------------------
U n i t e d   S t a t e s

SQL>
SQL> SELECT REGEXP_REPLACE
        ('Ellison, Larry', '(.+), (.*)', '\2 \1') name
  2 FROM   dual
SQL> /

NAME
-------------
Larry Ellison

SQL>
```

REGEXP_SUBSTR

REGEXP_SUBSTR searches for a regular expression pattern within a given string and returns the matched substring. This function extends the functionality of the SUBSTR function. The syntax of REGEXP_SUBSTR is similar to REGEXP_REPLACE.

```
REGEXP_SUBSTR (source_string, pattern
       [,position [,occurrence [,match_parameter ] ] ])
```

The following example extracts the domain name from an e-mail address:

```
SQL> SELECT REGEXP_SUBSTR ('xyz@sybex.com', '@.*') dname
  2  FROM   dual
SQL> /

DNAME
----------
@sybex.com

SQL>
```

Data Type Enhancements

In the earlier releases of Oracle, the maximum size for LOB columns (CLOB, BLOB, and NCLOB data types) was 4GB. In Oracle 10*g*, the maximum size has been increased to (4GB –1byte)*DB_BLOCK_SIZE. Since the DB_BLOCK_SIZE can vary from 2KB to 32KB, the LOB size could range between 8TB to 128TB.

All procedures in the DBMS_LOB package support the terabyte-sized LOBs. A new function—DBMS_LOB.GET_STORAGE_LIMIT—returns the storage limit for the database. All the Oracle call interface (OCI) APIs also support the new larger LOB size.

In the following sections we will discuss the implicit LOB conversion and the new floating-point data types introduced in Oracle 10g.

Implicit LOB Conversion

Explicit conversion between CLOB and NCLOB data types were available in Oracle 9*i* using the TO_CLOB and TO_NCLOB functions. Oracle 10*g* introduces implicit conversion for SQL IN and OUT bind variables for queries and DML operations and well as for PL/SQL function and procedure parameter passing. The following example demonstrates this conversion.

Note that in the SELECT and INSERT statements CLOB value is selected and inserted with NCLOB, and vice versa, to show the implicit conversion.

```
SQL> CREATE TABLE clob_conversion (
  2  clob_col    CLOB,
  3  nclob_col   NCLOB);

Table created.
```

```
SQL> DECLARE
  2    clob_var  CLOB;
  3    nclob_var NCLOB;
  4  BEGIN
  5    clob_var := 'Clob Value';
  6    nclob_var:= clob_var;
  7    INSERT INTO clob_conversion
  8       VALUES (nclob_var, clob_var);
  9    SELECT nclob_col, clob_col
 10    INTO   clob_var, nclob_var
 11    FROM   clob_conversion;
 12  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

In Oracle 9*i*, accessing the :NEW attribute value for a LOB inside a before row INSERT or UPDATE trigger failed. In Oracle 10*g*, this shortcoming has been corrected, and the behavior of the database trigger on a table with a LOB is like any other data type.

Native Floating-Point Data Types

Oracle 10*g* supports two new numeric data types: BINARY_FLOAT and BINARY_DOUBLE. The BINARY_FLOAT is single precision 32-bit, and BINARY_DOUBLE is double precision 64-bit. These data types are based on the IEEE 754 standard for binary floating-point arithmetic and are more efficient than the NUMBER data type. These floating-point data types are widely accepted by the majority of numerical computation users. They also work well with Extensible Markup Language (XML) and Java. While the NUMBER data type is implemented in the Oracle software, floating-point arithmetic operations are the standard numeric format on most hardware platforms.

SQL and PL/SQL offer full support for BINARY_FLOAT and BINARY_DOUBLE data types. BINARY_FLOAT data types require 5 bytes of storage, and BINARY_DOUBLE data types require 9 bytes; the NUMBER data type can take anywhere between 1 and 22 bytes. The new data types support numbers that are much larger and much smaller than the numbers supported by the NUMBER data type.

The following example shows using the BINARY_FLOAT and BINARY_DOUBLE data types when creating a table and when using DML statements:

```
SQL> CREATE TABLE binary_example (
  2  bf  BINARY_FLOAT,
  3  bd  BINARY_DOUBLE);
```

```
Table created.

SQL> DESCRIBE binary_example
 Name                  Null?    Type
 --------------------- -------- ---------------
 BF                             BINARY_FLOAT
 BD                             BINARY_DOUBLE

SQL> INSERT INTO binary_example VALUES (3.0f, 4.0d);

1 row created.

SQL> INSERT INTO binary_example VALUES (5, 9);

1 row created.

SQL> SELECT * FROM binary_example;

        BF         BD
---------- ----------
  3.0E+000   4.0E+000
  5.0E+000   9.0E+000

SQL>
```

New syntax has been added to SQL to support literal values representing floating-point numbers. As shown in the previous example, floating-point literals can use `f` or `d` as the suffix. Untagged numeric literals are parsed as `NUMBER`.

Arithmetic Operations

Arithmetic operations on `BINARY_FLOAT` and `BINARY_DOUBLE` data types produce a numeric value or a special value. The special values can be zero (`0`), positive infinity (`+INF`), negative infinity (`-INF`), and not-a-number (`NaN`). Predefined constants are available in SQL and PL/SQL to represent the special values. The constants are as follows:

- `BINARY_FLOAT_NAN`
- `BINARY_FLOAT_INFINITY`
- `DOUBLE_FLOAT_NAN`
- `DOUBLE_FLOAT_INFINITY`

The following new functions were introduced in Oracle 10*g* to support the new data types:

TO_BINARY_FLOAT Converts a `BINARY_DOUBLE`, `NUMBER`, `VARCHAR2`, or `CHAR` value to `BINARY_FLOAT` value

TO_BINARY_DOUBLE Converts a BINARY_FLOAT, NUMBER, VARCHAR2, or CHAR value to BINARY_DOUBLE value

IS [NOT] NAN Determines whether a floating-point value is NaN

IS [NOT] INFINITE Determines whether a floating-point value is infinite

NANVL Translates NaN to a specified value

NaN is considered as the largest value, and -INF is considered the smallest value in the floating-point arithmetic.

Case- and Accent-Insensitive Queries

Oracle 10*g* supports case-insensitive and accent-insensitive queries and sorts. This is supported through the NLS_SORT parameter, affixing _AI for accent-insensitive sorts and _CI for case-insensitive sorts. You can change the value of NLS_SORT at the session level. If the NLS_SORT value is BINARY, the collating sequence for the sort is based on the numeric value of characters and thus requires less system overhead.

You can also change the NLS_SORT value using the NLSSORT function in the ORDER BY clause of the query, instead of changing it at the session level.

The following are some examples of sorting behavior:

```
SQL> SELECT name FROM empl
  2  ORDER BY name;

NAME
--------------------
SteVen
Stephen
Steven

SQL> SELECT name FROM empl
  2  ORDER BY NLSSORT(name, 'NLS_SORT=BINARY_CI');

NAME
--------------------
Stephen
Steven
SteVen

SQL> ALTER SESSION SET NLS_SORT=FRENCH_M_CI
```

```
SQL> /

Session altered.

SQL> SELECT name FROM empl
  2  ORDER BY name
SQL> /

NAME
--------------------
Stephen
Steven
SteVen

SQL>
```

Setting the NLS_SORT to anything other than BINARY causes a sort to use a full table scan, regardless of the path chosen by the optimizer.

The following SQL clauses support the NLS_SORT setting:

- WHERE
- ORDER BY
- START WITH
- HAVING
- IN and NOT IN
- BETWEEN
- CASE...WHEN

Quote Operator

In the pre-Oracle 10*g* releases, to have a single quotation mark in the string, you had to specify two quotation marks. In Oracle 10*g*, you can specify your own delimiter using the quote operator q, thus eliminating the confusion in strings with quotation marks. The delimiter chosen by you can be the CHAR or NCHAR literal or any of the [], {}, (), or <> pairs.

The following example shows the pre–Oracle 10*g* method and then contrasts that with a query using the new quote operator:

```
SQL> SELECT 'Don''t look at John''s bike' EX
  2  FROM dual;
```

```
EX
-------------------------
Don't look at John's bike

SQL> SELECT q'!Don't look at John's bike!' EX
  2  FROM dual;

EX
-------------------------
Don't look at John's bike

SQL> SELECT q'!Look at John's bike! Wow!' EX
  2* FROM dual
SQL> /

EX
------------------------
Look at John's bike! Wow

SQL>
```

The ! is used as a delimiter and is qualified with the quote operator q. Notice that the string is enclosed in '! and !'. You could have a ! inside the string as in the third example, which is considered part of the string

Introducing Miscellaneous Database Enhancements

In the following sections we will cover the database enhancements introduced in Oracle 10*g* that were not covered in earlier chapters. There are many major and minor enhancements to the Oracle 10g database. All the major enhancements have been discussed in the earlier chapters. Here we discuss the enhancements that are relevant to the OCP exam. In Oracle10g, you can flush the data buffer cache, enable resumable space allocation at the database level, consider list partitioning for partition change tracking, connect to the database without any configuration files, and there are more enhancements worth knowing. We discuss these enhancements in these sections.

MAXTRANS Ignored

Prior to Oracle 10*g*, MAXTRANS specified the maximum number of concurrent update transactions for a data block belonging to the table, index, or cluster segment. In Oracle 10*g*, this parameter

is ignored when specified with the physical storage attributes. In Oracle 10*g*, objects are preconfigured for maximum concurrency, which means that the database allows up to 255 concurrent update transactions for any data block, depending on the available space in the block.

Flushing the Buffer Cache

In the previous releases of Oracle, you were able to flush the shared pool using the `ALTER SYSTEM FLUSH SHARED_POOL` statement. In Oracle 10*g*, you can also flush the buffer cache portion of the SGA using the `ALTER SYSTEM FLUSH BUFFER_CACHE` statement.

Flushing the buffer cache is not intended for production databases during normal operation. The intent of flushing the database buffer cache is to provide for an identical starting point for comparison of rewritten SQL statements. Once you execute the `ALTER SYSTEM FLUSH BUFFER_CACHE` statement, you will have 100 percent cache miss for the next SQL statement.

The benefit of this feature is to allow a consistent testing environment. In prior releases, you had to shut down and restart the instance every time to start with a clean buffer cache.

Resumable Space Allocation

Oracle 9*i* introduced resumable space allocation to suspend a session when an out-of-space condition occurred in the database. The resumable space allocation feature must be turned on in the session level using the `ALTER SESSION ENABLE RESUMABLE` statement. In Oracle 10*g*, a new parameter `RESUMABLE_TIMEOUT` was introduced, where the resumable space allocation feature can be turned on at the database level.

The `RESUMABLE_TIMEOUT` parameter specifies the time in seconds for a session to be suspended when an out-of-space condition occurs. The default for this parameter is `0`, which means the resumable timeout is not enabled. The parameter is modifiable using `ALTER SESSION` or `ALTER SYSTEM`, as in the following example:

```
SQL> ALTER SYSTEM SET
  2  RESUMABLE_TIMEOUT = 3600 SCOPE=BOTH
SQL> /

System altered.

SQL> ALTER SESSION DISABLE RESUMABLE;

Session altered.

SQL>
```

When a session is suspended, an error is reported in the alert log file, and the Resumable Session Suspended alert is triggered. If a trigger is defined for the `AFTER SUSPEND` event, it is also fired. You can obtain information on the suspended session by querying the `DBA_RESUMABLE` view.

Materialized View Enhancements

Oracle 10*g* incorporates several enhancements to materialized views. In this section we will discuss the following:

- Partition change tracking (PCT) materialized views for fast refresh
- Refresh using trusted constraints to provide reliable data
- Fast refreshing of the materialized join view without aggregation
- Detecting if the refresh of the materialized view is dependent on the refresh of other materialized views
- Tuning materialized views using the `DBMS_ADVISOR.TUNE_MVIEW` procedure

Partition Change Tracking Materialized Views

PCT is the ability to identify which rows in a materialized view are affected by DML activity on the partition of detail tables that comprise that materialized view. PCT was introduced in Oracle 9*i*, but it supported only the `RANGE` and `RANGE-HASH` partitioning schemes. In Oracle 10*g*, PCT supports the `LIST` partitioning scheme.

In Oracle 10*g*, at materialized view creation time, `LIST`-partitioned detail tables are recognized as a qualified PCT partition scheme; hence, relevant PCT information is recorded in the materialized view metadata.

Another enhancement related to PCT is that Oracle 10*g* now supports `ROWID` as a PCT column. In the previous releases, table partition keys and partition markers (`PMARKER`) were considered as PCT columns at the materialized view creation time and were used by the PCT refresh to identify a table partition. In Oracle 10*g*, you can use a PCT-based refresh if the materialized view contains a join dependent expression of one of its detail tables. A join dependent expression is an expression consisting of columns from tables directly or indirectly joined through equijoins to the partitioned detail table on the partitioning key.

In Oracle 9*i*, the PCT refresh always executes a `DELETE` statement to remove rows from the materialized view. In Oracle 10*g*, you make the refresh operation efficient by using the `TRUNCATE PARTITION` to remove rows from the materialized when it is partitioned like the PCT detail table. You can use the `TRUNCATE PARTITION` PCT refresh method when these conditions are true:

- The partition method of both the detail table and the materialized view are `RANGE`, and the partition method is the same in the detail table and the materialized view.
- The materialized view is partitioned on its single PCT key column.
- A one-to-one relationship exists between detail table partitions and materialized view partitions.

The PCT refresh using `TRUNCATE PARTITION` is nonatomic, meaning the `TRUNCATE PARTITION` is a DDL statement and cannot be rolled back. So the PCT refresh cannot be done in a single transaction.

The `DBMS_MVIEW.REFRESH` procedure can accept a new value `P` for the refresh methods to force a refresh of a materialized view using the PCT refresh method. This is in addition to the values `C` (complete), `F` (fast), and `?` (force).

Refresh Using Trusted Constraints

Primary key/foreign key relationships created using the RELY option or reliance on dimension hierarchies may result in inconsistent results when refreshing a materialized view, because these constraints are not enforced by the Oracle 10*g* database. These can cause unreliable query rewrites.

You can now specify whether query rewrites can occur in cases where these unenforced trusted constraints are being used. When creating the materialized view, you can specify either the USING ENFORCED CONSTRAINTS or USING TRUSTED CONSTRAINTS clause. You can also modify these clauses using the ALTER MATERIALIZED VIEW statement.

A TRUSTED materialized view can use unenforced relationships for a refresh. An ENFORCED materialized view can be refreshed using only validated relationships that are known to return correct data. The DBA_MVIEWS data dictionary view contains a new column, UNKNOWN_TRUSTED_FD. If this column is set to Y, it indicates that the materialized view is in an unknown state because trusted functional dependencies were used for the refresh. You can use such materialized views for rewrite in TRUSTED or STALE_TOLERATED modes only.

Materialized Join View Fast Refresh Enhancements

Oracle 9*i* supported fast refreshes for materialized join views that contained joins with aggregations. Oracle 10*g* supports fast refresh for materialized join views (MJV) with no aggregation for the following cases:

- If the MJV has multiple instances of a table in the FROM clause, ROWID columns for each instance must be included in the SELECT clause of the materialized view definition.
- The associated materialized view log also contains the ROWID column.
- The Oracle server must be able to do complete view merging for any inline or named views in the FROM clause of the MJV. Also, the merged MJV must meet the requirements for a fast refresh. Materialized view logs must be present on all base tables of any merged view.
- If the MJV has remote tables in the FROM clause, all tables in the FROM clause must be located on that same site.
- The COMPATIBLE parameter must be set to 10.0.1 or higher.

Dependent Materialized View Refreshes

In Oracle 10*g*, you can create materialized views with the BUILD DEFERRED option if some materialized views depend on the result of another materialized view. Oracle 10*g* detects the dependencies and refreshes the materialized views in the proper order.

Once the materialized views are created with the BUILD DEFERRED option, they are not populated with data until a DBMS_MVIEW.REFRESH or DBMS_MVIEW.REFRESH_DEPENDENT procedure is executed. When these refresh procedures are executed, Oracle determines the hierarchical relationships between the views and refreshes them based on those relationships.

Tuning Materialized Views

The Oracle 9*i* database introduced the DBMS_MVIEW.EXPLAIN_MVIEW procedure to determine if a materialized view is fast refreshable or eligible for a query rewrite. Oracle 10*g* introduces a new procedure, DBMS_ADVISOR.TUNE_MVIEW, to identify and advise any materialized view log problems and provide an optimized way of defining queries to enable fast refreshes and general query rewrites.

You can query the results of the advisor findings from the DBA_TUNE_MVIEW dictionary view.

The following example demonstrates a tuning task. It shows that to enable fast refresh, you cannot use TRUNC(TIME_ID,'MON') in the SELECT clause and also shows the syntax required creating the materialized view logs:

```
SQL> DECLARE
  2   taskname varchar2 (20) := 'tunemviewtask';
  3  BEGIN
  4  DBMS_ADVISOR.TUNE_MVIEW (taskname,
  5  'CREATE MATERIALIZED VIEW monthly_prod_sales
  6  REFRESH FAST WITH ROWID ENABLE QUERY REWRITE
  7  AS
  8  SELECT TRUNC(TIME_ID,''MON'') smonth,
            PROD_ID, SUM(AMOUNT_SOLD)
  9  FROM   sales
 10  group by TRUNC(TIME_ID,''MON'') , PROD_ID');
 11  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
SQL> SELECT statement
  2  FROM   dba_tune_mview
  3  WHERE  task_name = 'tunemviewtask'
  4  ORDER BY script_type, action_id
SQL> /

STATEMENT
-----------------------------------------------------------
CREATE MATERIALIZED VIEW LOG ON "SH"."SALES" WITH ROWID
, SEQUENCE ("PROD_ID","TIME_ID","AMOUNT_SOLD")
```

```
INCLUDING NEW VALUES

ALTER MATERIALIZED VIEW LOG FORCE ON "SH"."SALES" ADD
ROWID, SEQUENCE ("PROD_ID","TIME_ID","AMOUNT_SOLD")
INCLUDING NEW VALUES

CREATE MATERIALIZED VIEW SH.MONTHLY_PROD_SALES   REFRES
H FAST WITH ROWID ENABLE QUERY REWRITE AS SELECT SH.SAL
ES.TIME_ID C1, SH.SALES.PROD_ID C2, SUM("SH"."SALES"."A
MOUNT_SOLD") M1, COUNT("SH"."SALES"."AMOUNT_SOLD") M2,
COUNT(*) M3 FROM SH.SALES GROUP BY SH.SALES.TIME_ID, SH
.SALES.PROD_ID

DROP MATERIALIZED VIEW SH.MONTHLY_PROD_SALES

SQL>
```

You need the ADVISOR privilege to execute the DBMS_ADVISOR.TUNE_MVIEW procedure.

Other MV Enhancements

Oracle 10*g* includes a new hint, REWRITE_OR_ERROR, that you can use in the queries that must be rewritten. If for some reason the query is not rewritten, an error (ORA-30393) is returned. This is useful when you know that if the SQL is not rewritten using the materialized view, it would take a long time to execute. You can use the DBMS_MVIEW.EXPLAIN_REWRITE procedure to identify why the rewrite failed.

In Oracle 9*i*, you performed the partition maintenance operations on the materialized view container tables using the ALTER TABLE statement. In Oracle 10*g*, you can perform the partition maintenance operations on materialized views using the ALTER MATERIALIZED VIEW statement. The ALTER MATERIALIZED VIEW statement supports the following:

- Truncate partition
- Drop partition
- Exchange partition with table

The execution plan using materialized views in Oracle 10*g* shows the keywords MATERIALIZED VIEW instead of TABLE in the PLAN_TABLE and V$SQL_PLAN views. The execution plans also show the difference between the materialized view used directly and the optimizers using the materialized view for the query rewrite. For query rewrite plans, the keywords MATERIALIZED VIEW REWRITE would display in the explain plan.

Database Connectivity Improvements

Oracle 10*g* introduces improvements to database connectivity. Now you can connect to a database without configuration files. The configuration of the shared server is also made simple in this release. Let's discuss these in the following sections.

Connecting without Configuration Files

Using an Oracle 10*g* client, you can connect to a database without a `tnsnames.ora` file or a `sqlnet.ora` file. You can specify the host, port, and Session identifier (SID) name directly in the connect string to connect to the database. This will work only for TCP/IP networks. If the listener is using the standard 1521 port, you do not need to specify the port number. You can connect to the Oracle 8*i* or 9*i* database using an Oracle 10*g* client with this method. The syntax of the new connect method is as follows:

```
CONNECT username/password@[//]host[:port][/service_name]]
```

In the following example, we connect to an Oracle 8*i* database using the hostname and SID syntax (since the listener is using port 1521, the port number is not provided as part of the connect string):

```
$ sqlplus /nolog
SQL*Plus: Release 10.1.0.2.0 - Production on Mon Jul 12
Copyright (c) 1982, 2004, Oracle.  All rights reserved.
SQL> connect dbastats/dbastats@//ftw1hp/FTWP000D
Connected.
SQL> select * from v$version;
BANNER
----------------------------------------------------------------
Oracle8i Enterprise Edition Release 8.1.7.4.0
            - 64bit Production
PL/SQL Release 8.1.7.4.0 - Production
CORE    8.1.7.0.0       Production
TNS for HPUX: Version 8.1.7.4.0 - Production
NLSRTL Version 3.4.1.0.0 - Production
SQL>
```

The hostname is mandatory. If the host lookup fails, an error is returned. The default for `service_name` is whatever the host is set to be. Advanced features such as load balancing or connect time failover are not available with this method.

Simplified Shared-Server Configuration

In prior versions of Oracle, at least one dispatcher was required to be configured to use Oracle's *shared-server* (multithreaded server) feature. Oracle 10*g* is shared-server aware by default, and

a value greater than zero for SHARED_SERVERS parameter will enable the feature. The SHARED_SERVERS parameter is dynamic and hence can be enabled or disabled using the ALTER SYSTEM statement. The following code demonstrates changing the value of SHARED_SERVERS for the current instance and making the change permanent by changing the spfile also (SCOPE=BOTH changes the memory and initialization file).

```
SQL> ALTER SYSTEM SET SHARED_SERVERS=4 SCOPE=BOTH;

System altered.

SQL>
```

In Oracle 10*g*, one TCP protocol dispatcher starts up automatically, making the instance shared-server aware regardless of the parameter settings. In the shared-server architecture, the listener assigns each new client session to one of the available dispatchers. As the user makes a request, the dispatcher sends the request to a shared server. It is possible that different shared servers could handle the requests from one session.

Several Multi-threaded server (MTS) parameters have been deprecated in Oracle 10*g* and replaced by new parameters. Table 8.3 shows these parameters. Notice that the new parameters were introduced in Oracle 9*i*, but the MTS parameters are obsolete in Oracle 10*g*. All the new parameters are dynamic.

TABLE 8.3 Shared-Server Configuration Parameters

Obsolete Parameter	Replaced by Parameter
MTS_SERVERS	SHARED_SERVERS
MTS_MAX_SERVERS	MAX_SHARED_SERVERS
MTS_DISPATCHERS	DISPATCHERS
MTS_MAX_DISPATCHERS	MAX_DISPATCHERS
MTS_CIRCUITS	CIRCUITS
MTS_SESSIONS	SHARED_SERVER_SESSIONS
MTS_SERVICE	SERVICE_NAMES
MTS_LISTENER_ADDRESS	LOCAL_LISTENER
MTS_MULTIPLE_LISTENERS	LOCAL_LISTENER

A new view V$DISPATCHER_CONFIG is available in Oracle 10*g* that gives information on the existing dispatchers. You can join the CONFIG_INDX column of this view with V$DISPATCHER to see detailed information on the dispatcher. Here is an example:

```
SQL> SELECT dispatchers, connections, pool,
  2         listener
  3  FROM   v$dispatcher_config
SQL> /

DISPATCHERS CONNECTIONS POOL LISTENER
----------- ----------- ---- ------------------------------
          1         972 OFF  (ADDRESS=(PROTOCOL=TCP)(HOST=
                             linux)(PORT=1521))


SQL>
```

LogMiner Enhancements

In Oracle 10*g*, if the LogMiner is used against the same database that generated the redo log files, LogMiner can automatically determine the redo log files required for mining based on the start time or start SCN you provide. LogMiner adds the redo log files from the mining database by default. You have no need to explicitly map the time frame to redo log files when the CONTINUOUS_MINE option is used with the STARTTIME or STARTSCN. Here is an example:

```
SQL> BEGIN
  2  DBMS_LOGMNR.START_LOGMNR (options=>
     DBMS_LOGMNR.CONTINUOUS_MINE, starttime =>
     to_date('12-JUL-04 10:00','DD-MON-YY HH24:MI'));
  3  END;
SQL> /

PL/SQL procedure successfully completed.

SQL>
```

Transaction Rollback Monitoring

Oracle 10*g* provides methods to monitor the transaction rollback and the transactions recovered by SMON. In the previous releases, the parallel transaction recovery could be monitored using V$FAST_START_SERVERS and V$FAST_START_TRANSACTIONS views.

In Oracle 10*g*, in addition to viewing normal transaction rollback and transaction recovery by SMON in real time, you can view historical information about transaction recovery and transaction rollback. Using the historical transaction recovery, you can calculate the average rollback duration. When you have the current state of recovery, determining how much has been done and how much more work remains is possible. The V$FAST_START_TRANSACTIONS view contains progress information on the transaction recovery. The STATE column will have the value RECOVERING for transactions that are being recovered; the value will be RECOVERED for the recovered transactions. You can run the following query immediately after the instance startup to see the progress of transaction recovery:

```
SELECT usn, pid, state, undoblocksdone,
       undoblockstotal, cputime
FROM   v$fast_start_transactions;
```

You can join the V$FAST_START_TRANSACTIONS view to the V$FAST_START_SERVERS view, using the XID column common to both views, to see information on all the servers working on the transaction recovery.

Tracing Enhancements

Tracing in Oracle 10*g* has been enhanced to include end-to-end application tracing and to better trace the information from shared-server connections where you have than one session to trace. *Statistics aggregation* was introduced in Oracle 9*i* Release 2, but it has been enhanced to monitor performance on individual clients and services. We will discuss end-to-end application tracing and statistics aggregation in the following sections.

End-to-End Application Tracing

End-to-End application tracing enables you to diagnose performance problems in multitier environments where a request from a user is sent to the database by the middle tier using many sessions. End-to-end application tracing uses a client identifier to uniquely trace a specific client through all tiers to the database server. Once the tracing information is written to files, the files can be consolidated using the `trcsess` utility and analyzed using the `tkprof` utility.

Prior to Oracle 10*g* no easy way existed to keep track of a client process across different database sessions. The CLIENT_IDENTIFIER attribute, which is carried across on all tiers and sessions uniquely, identifies the client session. The client identifier is visible in the new CLIENT_IDENTIFIER column of the V$SESSION view. You can also use the following query to obtain the client identifier for the current session:

```
SELECT SYS_CONTEXT('USERENV','CLIENT_IDENTIFIER')
FROM   dual;
```

Oracle provides a graphical screen to enable and disable application tracing. We will discuss using the EM for end-to-end application tracing in the next section.

Using EM for End-to-End Application Tracing

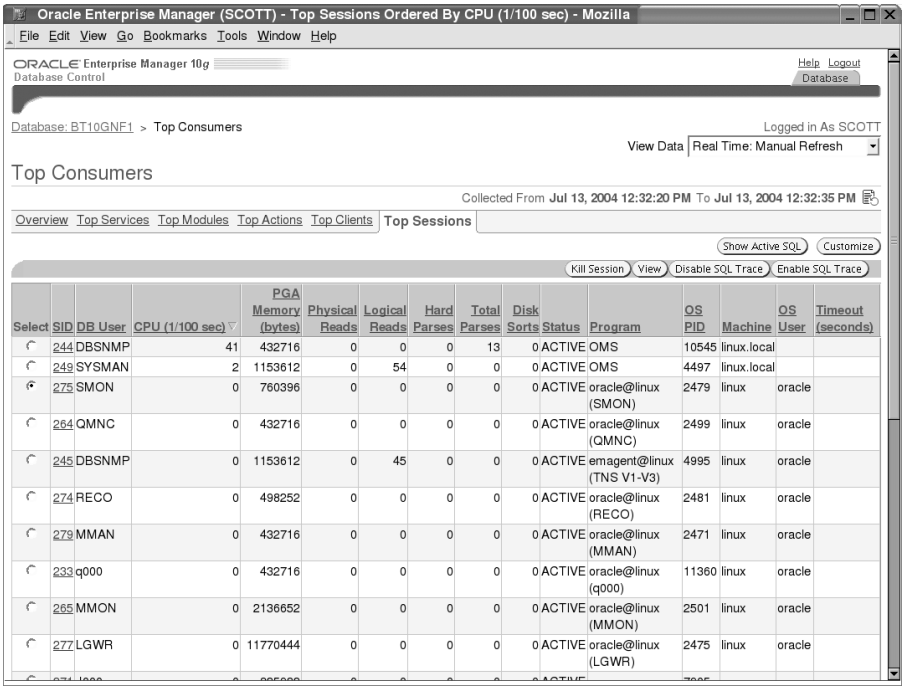
The Enterprise Manager (EM) is the primary tool for enabling and disabling end-to-end application tracing. From the Database Central home page, click the Performance link. From the Performance page, click the Top Consumers link. Figure 8.1 shows the Overview tab of the Top Consumers screen.

From the Overview tab, you can navigate to the Top Services, Top Modules, Top Actions, Top Clients, and Top Sessions tabs. In each of these tab you have buttons to enable and disable tracing. Figure 8.2 shows the Top Sessions tab. Notice the Enable SQL Trace and Disable SQL Trace buttons along with other session management buttons.

The tracing will be in effect until the session disconnects or you turn off tracing by using the Disable SQL Trace button. The trace files are written to the directory specified in the `USER_DUMP_DEST` parameter.

FIGURE 8.1 Top Consumers screen, Overview tab

FIGURE 8.2 Top Sessions tab



Trace Using *DBMS_MONITOR*

You can use the DBMS_MONITOR package to enable tracing at a global (database) level or at a session level. You can enable the trace using a specified client identifier or a hierarchical combination of the service name, module name, and action name. The DBMS_MONITOR.CLIENT_ID_TRACE_ENABLE parameter enables tracing, and DBMS_MONITOR.CLIENT_ID_TRACE_DISABLE disables a trace that uses the client identifier. You can also monitor WAITS and BINDS using these procedures. In earlier versions of Oracle, the DBMS_SUPPORT.START_TRACE_IN_SESSION procedure gave this ability to trace WAITS and BINDS (event 10046 trace) on a specific session.

The following code shows how to enable tracing and how to query the information on enabled traces from the DBA_ENABLED_TRACES view:

```
SQL> exec dbms_monitor.client_id_trace_enable -
            ('HR', WAITS=>TRUE, BINDS=>TRUE);

PL/SQL procedure successfully completed.
```

```
SQL>
SQL> SELECT trace_type, waits, binds, primary_id
  2  FROM   dba_enabled_traces;

TRACE_TYPE  WAITS BINDS PRIMARY_ID
----------- ----- ----- -------------------------
CLIENT_ID   TRUE  FALSE SCOTT@linux.local@Mozilla
CLIENT_ID   TRUE  TRUE  HR

SQL>
```

Table 8.4 shows the columns in DBA_ENABLED_TRACES.

TABLE 8.4 *DBA_ENABLED_TRACES* Columns

Column Name	Description
TRACE_TYPE	Values are CLIENT_ID, SESSION, SERVICE, SERIVCE_MODULE, and SERVICE_MODULE_ACTION, based on the type of tracing enabled.
PRIMARY_ID	Specific client identifier or service name.
QUALIFIER_ID1	Specific module name.
QUALIFIER_ID2	Specific action name.
WAITS	TRUE if waits are traced (default is TRUE for the tracing procedures).
BINDS	TRUE if bind variables are traced (default is FALSE for the tracing procedures).
INSTANCE_NAME	Instance name where tracing is enabled (used for RAC).

Different procedures are available in the DBMS_MONITOR package to enable and disable tracing. Table 8.5 shows the tracing procedures in the DBMS_MONITOR package.

TABLE 8.5 *DBMS_MONITOR* Tracing Procedures

Procedure Name	Purpose	Parameters
CLIENT_ID_TRACE_ENABLE	Enable tracing based on client identifier.	Client_id, waits, binds
CLIENT_ID_TRACE_DISABLE	Disable client identifier tracing.	Client_id

TABLE 8.5 *DBMS_MONITOR* Tracing Procedures *(continued)*

Procedure Name	Purpose	Parameters
SESSION_TRACE_ENABLE	Enable tracing based on SID and SERIAL# of V$SESSION.	session_id, serial_num, waits, binds
SESSION_TRACE_DISABLE	Disable session tracing.	session_id, serial_num
SERV_MOD_ACT_TRACE_ENABLE	Enable tracing for a given combination of service name, module, and action.	service_name, module_name, action_name, waits, binds, instance_name
SERV_MOD_ACT_TRACE_DISABLE	Disable service, module, and action tracing.	service_name, module_name, action_name, instance_name

Using the *trcsess* Utility

In shared-server environments, you could end up with several trace files when tracing is enabled. You can use the new `trcsess` utility to combine all the relevant trace files based on the session or client identifier or the service name, module name, and action name hierarchy combination. You can format the output file from the `trcsess` utility using the `tkprof` utility.

Typing **`trcsess`** without any argument shows the parameters that can be used to pass into this utility, as follows:

```
$ trcsess
Session Trace Usage error: Wrong parameters passed.
trcsess [output=<output file name >]
   [session=<session ID>]
   [clientid=<clientid>]
   [service=<service name>]
   [action=<action name>]   [module=<module name>] <trace file names>
output=<output file name> output destination
       default being standard output.
session=<session Id> session to be traced.
    Session id is a combination of session Index &
    session serial number e.g. 8.13.
clientid=<clientid> clientid to be traced.
service=<service name> service to be traced.
action=<action name> action to be traced.
module=<module name> module to be traced.
<trace_file_names> Space separated list of trace
    files with wild card '*' supported.
```

The following example shows how to combine the trace files generated by the module name SQL*Plus and analyze them using `tkprof`:

```
$ trcsess output=b.trc module='SQL*Plus' *.trc
$ tkprof b.trc b.out sys=no
```

Statistics Aggregation

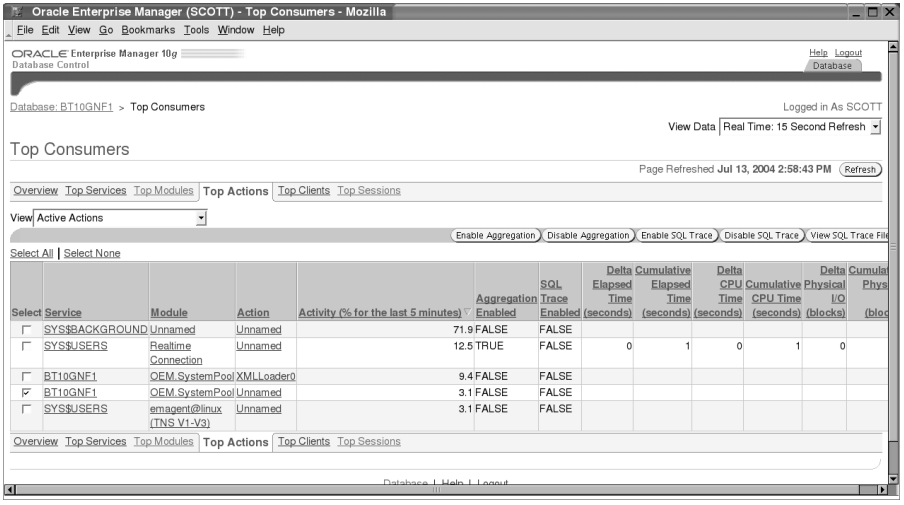
Statistics aggregation is useful in identifying performance issues. By default statistics are gathered at the SQL level, session level, and instance level. New procedures in the Oracle 10*g* `DBMS_MONITOR` package enable statistics aggregation at the client identifier or at the service name or service, module, and action name hierarchical combination levels.

These additional dimensions make statistics accumulation for multitier architectures using connection pooling or shared-server configuration more meaningful. You can enable and disable statistics aggregation using the Enterprise Manager or using the `DBMS_MONITOR` package.

Using the EM for Statistics Aggregation

You'll see buttons to enable statistics aggregation on the tabs on the Top Consumers screen. We reviewed this screen previously (please refer to Figure 8.1). The Enable Aggregation and Disable Aggregation buttons are available in the Top Modules, Top Actions, and Top Clients tabs. Figure 8.3 shows the Top Actions tab.

FIGURE 8.3 Top Actions tab



Using *DMBS_MONITOR* for Statistics Aggregation

Similar to various procedures available for tracing the sessions, procedures are available in DBMS_MONITOR to gather aggregate statistics. Statistics gathering is global for the database and persistent across instance starts and restarts. Table 8.6 lists the procedures available for statistics aggregation.

TABLE 8.6 Procedures for Statistics Aggregation

Procedure Name	Description	Parameters
CLIENT_ID_STAT_ENABLE	Enables statistics gathering for a given client identifier	client_id
CLIENT_ID_STAT_DISABLE	Disables statistics gathering for client identifier	client_id
SERV_MOD_ACT_STAT_ENABLE	Enables statistics gathering for a given combination of service name, module, and action name	service_name,module_name,action_name
SERV_MOD_ACT_STAT_DISABLE	Disables statistics gathering for service name, module, and action hierarchical combination	service_name, module_name, action_name

You can view the statistics aggregations gathered from the data dictionary using the views listed in Table 8.7.

TABLE 8.7 Querying Statistics Aggregation Values

View Name	Description
DBA_ENABLED_AGGREGATIONS	Shows global statistics for the currently enabled statistics
V$CLIENT_STATS	Shows statistics for a client identifier
V$SERVICE_STATS	Shows statistics for a specified service
V$SERV_MOD_ACT_STATS	Shows statistics for a combination of specified service, module, and action
V$SVCMETRIC	Shows statistics for elapsed time of database calls and for CPU

The following is a query from the DBA_ENABLED_AGGREGATIONS view: There are two aggregations enabled in the database. The first is using the client identifier and the second is using the service, module, action. PRIMARY_ID is the qualifier - either the client id or service name.

```
SQL> SELECT aggregation_type, primary_id
  2  FROM   dba_enabled_aggregations;

AGGREGATION_TYPE      PRIMARY_ID
--------------------- -------------------------
CLIENT_ID             SCOTT@linux.local@Mozilla
                      /5.0 (X11; U; Linux i686;
                       en-US; rv:1.

SERVICE_MODULE_ACTION SYS$USERS

SQL>
```

Summary

We covered several new features and enhancements of Oracle 10*g* in this chapter. Virtual Private Database (VPD) is enhanced to include column-level VPD in order to enforce row-level access control based on the access on certain columns. The statements are rewritten by VPD only when they access relevant secure columns. You use the new parameter SEC_RELEVANT_COLS in DBMS_RLS.ADD_POLICY to enforce column-level VPD.

Another enhancement to VPD is the introduction of different policy types. In Oracle 9*i* only the dynamic policy type was available; Oracle 10*g* introduces these additional types: static, shared static, context-sensitive, and shared context-sensitive. When a static policy is applied, VPD always enforces the same predicate regardless of user. The database executes the policy function only once for static policies. A context-sensitive policy is evaluated at statement execution time for context changes and executes the policy function if a context change is detected.

Auditing in Oracle 10*g* has been enhanced to have uniform audit trails for database auditing and fine-grained auditing. The DBA_COMMON_AUDIT_TRAIL view combines the standard and fine-grained audit log records. Also, Oracle 10*g* supports fine-grained auditing for DML statements such as INSERT, UPDATE, DELETE, and MERGE.

The MERGE statement has several improvements. In Oracle 10*g*, MERGE allows conditional updates and inserts by using a WHERE clause in the UPDATE and INSERT clauses. The UPDATE clause is enhanced to include an optional DELETE clause to delete rows that meet certain criteria.

Partitioned outer join is a feature in Oracle 10*g* that overcomes the problem of sparse data when performing certain SQL analytical functions. Partitioned outer joins extend the conventional

outer join syntax by applying the outer join to each logical partition defined in the query. The result of a partitioned outer join is a union of the outer joins of each of the groups in the logically partitioned table with the table on the other side of the join.

The MODEL clause is another significant enhancement in Oracle 10*g* for spreadsheet-like array computations. The MODEL clause allows symbolic cell addressing, and it does not update existing data in the tables. In Oracle 10*g*, you can perform regular expression searches using the REGEXP_LIKE function. Oracle's implementation of regular expression complies with the POSIX standard for pattern matching and Unicode regular expression guidelines. The other functions available for regular expression manipulation are REGEXP_SUBSTR, REGEXP_INSTR, and REGEXP_REPLACE.

Oracle 10*g* supports terabyte-sized LOB data types. BINARY_FLOAT and BINARY_DOUBLE are two new data types introduced in Oracle 10*g* for floating-point arithmetic. Case- and accent-insensitive queries are possible by setting the NLS_SORT parameter with the _CI or _AI suffix. You can use the quote operator q to define your own delimiter in SQL strings.

When creating tables, indexes, and clusters, the physical storage attribute MAXTRANS defaults to the maximum value of 255 based on the space available in the block. Oracle 10*g* does not error out if you specify this clause; it just ignores it. You can enable the resumable timeout for sessions at the database level by setting the RESUMABLE_TIMEOUT parameter to a nonzero value.

Oracle 10*g* made several enhancements to materialized views. The materialized join views now support fast refreshes for self-joins, views that can be flattened, and data access from tables in remote databases. The partition change tracking also supports the LIST partitioning scheme. In Oracle 10*g*, you can make the refresh operation efficient by using TRUNCATE PARTITION to remove rows from the materialized when the materialized view is partitioned like the PCT detail table.

In Oracle 10*g*, you can specify whether query rewrites can occur in cases where unenforced trusted constraints are being used. A TRUSTED materialized view can use unenforced relationships for refreshes. An ENFORCED materialized view can be refreshed only using validated relationships that are know to return correct data. You can tune materialized views using the DBMS_ADVISOR.TUNE_MVIEW procedure.

The new syntax *username/password@//hostname:port/service_name* is available in Oracle 10*g* to connect to databases without network configuration files such as tnsnames.ora and sqlnet.ora. The Oracle 10*g* database by default is shared-server aware, and setting SHARED_SERVERS parameter to a nonzero value enables shared-server connectivity to the database.

You have no need to specify each redo log filename when using LogMiner in the same database to which the redo log files belong. You can use the CONTINUOUS_MINE option with the STARTSCN or STARTTIME parameter to mine redo logs.

The V$FAST_START_TRANSACTIONS view contains progress information on the transaction recovery. You can find the numbers of undo blocks recovered and remaining to recover from this dynamic view.

With the introduction of CLIENT_IDENTIFIER, end-to-end application tracing is possible. The DBMS_MONITOR package has procedures to enable detailed level traces and to collect statistics aggregation. You can use the EM to enable and disable tracing and aggregation.

Exam Essentials

Know the enhancements in the Virtual Private Database. Learn how to use column-level VPD to enforce row-level access control based on accessed security columns. Know how to create static, context-sensitive, and shared policies and when they should be used.

Understand the new features introduced in auditing. Describe the types of auditing options available in the database. Enumerate the benefits of uniform audit trail for standard auditing and fine-grained auditing. Fine-grained auditing supports DML statement auditing and supports auditing on more than the relevant column.

Identify the SQL enhancements for business intelligence applications. The `MERGE` command allows conditional updates and inserts, and an optional `DELETE` clause was introduced. Know how to convert dense data to a sparse form using the partitioned outer join syntax. Learn the options available with the new `MODEL` clause for spreadsheet-like array computations.

Describe the enhancements to materialized views. Understand the situations when a materialized join view is fast refreshable. Know the query rewrite enhancements. Tune materialized views using the `DBMS_ADVISOR.TUNE_MVIEW` procedure. Identify when partition change tracking will be supported for fast refreshes.

Understand the initialization parameter improvements. Know the parameter used to set a resumable timeout at the database level. Identify the new shared-server parameters.

Know the functions that are available for regular expressions support. Be able to identify the `REGEXP_` functions and their purposes.

Understand the usage of quote operator and case-insensitive sorts. Know how to enable accent-insensitive and case-insensitive sorts. Be able to use the quote operator. Be able to monitor the transaction rollback progress.

Learn how to enable statistics and tracing at a global level. Know the pages of the EM to gather tracing and statistics aggregation. Identify the procedures in `DBMS_MONITOR` to enable tracing and statistics aggregation. Understand the dimensions of statistic aggregation.

Review Questions

1. Column-level privacy enforces row-level access control only when a statement accesses security relevant columns. Which procedure is used to set up column-level VPD in Oracle 10*g*?
   - **A.** DBMS_VPD.ADD_POLICY
   - **B.** DBMS_RLS.ADD_POLICY
   - **C.** DBMS_POLICY.ADD_RLS
   - **D.** DBMS_POLICY.ADD_VPD
2. In fine-grained auditing, which one of the following is not a valid statement type?
   - **A.** DELETE
   - **B.** INSERT
   - **C.** UPDATE
   - **D.** MERGE
   - **E.** INDEX
   - **F.** SELECT
3. Which policy type in fine-grained auditing reevaluates the policy function at statement execution for context changes since the last use of the cursor and looks for a cached predicate generated by the same policy function of the same policy type in the same session?
   - **A.** STATIC
   - **B.** DYNAMIC
   - **C.** CONTEXT_SENSITIVE
   - **D.** SHARED_STATIC
   - **E.** SHARED_CONTEXT_SENSITIVE
4. Which table or view contains audit trail from standard database auditing and fine-grained auditing?
   - **A.** AUD$
   - **B.** FGA_LOG$
   - **C.** DBA_AUDIT_TRAIL
   - **D.** DBA_COMMON_AUDIT_TRAIL

5. In the MERGE statement, you can optionally use the DELETE clause when which of the following is true?
   - **A.** In the WHEN MATCHED section
   - **B.** In the WHEN NOT MATCHED section
   - **C.** In both the WHEN MATCHED and WHEN NOT MATCHED sections
   - **D.** By itself, without an INSERT or UPDATE clause

6. Which clause in Oracle 10*g* makes the sparse data dense?
   - **A.** MODEL
   - **B.** PARTITION BY
   - **C.** PARTITION BY...OUTER JOIN
   - **D.** PARTITIONED OUTER JOIN

7. The MODEL clause enables spreadsheet-like array computations using SQL. Choose the three groups that define the multidimensional array.
   - **A.** Facts
   - **B.** Measures
   - **C.** Partitions
   - **D.** Blocks
   - **E.** Dimensions

8. Which procedure can obtain the materialized views definition that is eligible for a fast refresh?
   - **A.** DBMS_MVIEW.EXPLAIN_MVIEW
   - **B.** DBMS_MVIEW.EXPLAIN_REWRITE
   - **C.** DBMS_MVIEW.TUNE_MVIEW
   - **D.** DBMS_ADVISOR.TUNE_MVIEW
   - **E.** DBMS_ADVISOR.EXPLAIN_MVIEW

9. Which physical attribute is ignored by the Oracle database when creating a table?
   - **A.** INITRANS
   - **B.** MAXTRANS
   - **C.** PCTFREE
   - **D.** PCTUSED
   - **E.** STORAGE

10. Which four methods enable resumable space allocation?

A. `ALTER SYSTEM ENABLE RESUMABLE`

B. `ALTER SESSION ENABLE RESUMABLE`

C. `ALTER SYSTEM SET RESUMABLE_TIMEOUT = 72000`

D. `ALTER SYSTEM SET RESUMABLE_TIMEOUT = 72000 SCOPE=BOTH`

E. `ALTER SESSION SET RESUMABLE_TIMEOUT = 72000`

11. Which is the new syntax available to connect to a database using the Oracle 10*g* client?

A. *username/password@hostname:port:service_name*

B. *username/password@//hostname:port:service_name*

C. *username/password@//hostname/port/service_name*

D. *username/password@//hostname:port/service_name*

12. What is the maximum supported size for a LOB column?

A. 128GB

B. 4GB

C. 128TB

D. Unlimited

13. Which function is best suitable to find if the phone numbers in a table follow the *nnn-nnn-nnnn* format, where *n* is a digit?

A. `SUBSTR`

B. `REGEXP_SUBSTR`

C. `LIKE`

D. `REGEXP_LIKE`

14. Which parameter would you set to enable case-insensitive sorts?

A. `NLS_SORT`

B. `NLS_LANGUAGE`

C. `NLS_SORT_CI`

D. `NLS_COMP`

15. Which option in the DBMS_LOGMNR.START_LOGMNR procedure automatically adds redo log files for mining if the redo log files belong to the same database where mining is done?
    A. DBMS_LOGMNR.AUTO_ADD_REDO
    B. DBMS_LOGMNR.CONTINUOUS_MINE
    C. DBMS_LOGMNR.STARTTIME
    D. DBMS_LOGMNR.STARTSCN

16. Which data dictionary view contains information on the progress of the rollback transactions the Oracle server (SMON) is recovering?
    A. V$FAST_START_SERVERS
    B. V$FAST_START_TRANSACTIONS
    C. V$FAST_START_ROLLBACK
    D. V$WAITSTAT

17. Oracle 10*g* is shared-server aware by default. Which parameter replaces the MTS_SESSIONS parameter in Oracle 10*g*?
    A. The SESSIONS parameter.
    B. The SHARED_SESSIONS parameter.
    C. The SHARED_SERVER_SESSIONS parameter.
    D. Oracle 10*g* has no equivalent parameter, because the database is shared-server aware by default.

18. Which data dictionary view contains information on the traces enabled in the database?
    A. V$SESSION
    B. V$TRACE
    C. V$SESSION_TRACE
    D. DBA_ENABLED_TRACES

19. Choose three dimensions where statistics aggregation can be enabled using the DBMS_MONITOR package.
    A. Session
    B. Client Identifier
    C. Service name
    D. Service name, module name, action name
    E. Instance name

20. Which one of the following is a valid use of the quote operator to assign John's book to a variable in PL/SQL?

A. `VS := quoteJohn's Bookendquote`

B. `VS := bq'John's Book'eq`

C. `VS := q'[John's Book]'`

D. `VS := q'[John's Book]'q`

Answers to Review Questions

1. B. The DBMS_RLS (row level security) package is used for fine-grained auditing. The ADD_POLICY procedure has a new parameter, SEC_RELEVANT_COLUMNS, that specifies the column names to be secured.

2. D. MERGE is not a valid statement type in DBMS_RLS.ADD_POLICY. MERGE is enforced by the underlying INSERT and UPDATE statement types. By default the policy applies to SELECT, INSERT, UPDATE, and DELETE. Default does not apply to INDEX.

3. E. For shared policy types, Oracle server looks for cached predicate generated by the same policy function. For STATIC policies, VPD always enforces the same predicate for access control regardless of the user. STATIC policies are executed once, and the predicate result is cached in the SGA. For CONTEXT_SENSITIVE policies, VPD reevaluates the policy function at statement execution time for context changes and executes the policy function if it detects any context changes.

4. D. In Oracle 10*g*, you have uniform audit trail, which means the same type of information is available for standard and fine-grained audit trails. The standard audit trail information is available in AUD$ and DBA_AUDIT_TRAIL. The fine-grained audit trail information is available in FGA_LOG$ and DBA_FGA_AUDIT_TRAIL. DBA_COMMON_AUDIT_TRAIL has information on both standard and fine-grained auditing.

5. A. Oracle 10*g* introduced the DELETE clause in the WHEN MATCHED THEN UPDATE section of the MERGE statement. The DELETE clause can optionally delete rows that match the ON condition and the WHERE condition.

6. C. The partitioned outer join clause makes sparse data dense. It is used to replace missing values, mostly along the time dimension. The Oracle database logically partitions the rows in the query based on the expression in the PARTITION BY clause.

7. B, C, E. Partitions, measures, and dimensions are the three groups. Partitions define logical blocks of the result set. Measures typically contain numerical data and are analogous to the measures of a fact table in a star schema. Dimensions identify each measure cell within a partition.

8. D. The DBMS_ADVISOR.TUNE_MVIEW procedure shows how to restate the materialized view in a way that is more advantageous for fast refreshes and query rewrites. It also shows how to fix materialized view logs and to enable query rewrites. Using the DBMS_MVIEW.EXPLAIN_MVIEW procedure, you can determine if a materialized view is fast refreshable and what types of query write you can perform. You can then use the DBMS_MVIEW.EXPLAIN_REWRITE procedure to learn why a query failed to rewrite or which MV will be used to rewrite.

9. B. In Oracle 10*g*, objects are preconfigured for maximum concurrency, and the system allows for up to 255 concurrent update transactions per block, depending on the available space.

10. B, C, D, E. The `RESUMABLE_TIMEOUT` parameter can be set at the instance level to enable resumable timeout. The parameter is dynamic and can be modified using `ALTER SYSTEM` and `ALTER SESSION`. The `ALTER SESSION ENABLE RESUMABLE` syntax used in Oracle 9*i* is still supported in Oracle 10*g*.

11. D. The new syntax does not rely on configuration files such as `tnsnames.ora`. The hostname is the only mandatory part after `@`. The default port is 1521, and the default *`service_name`* is whatever the host is. The new connect identifier can be used only on platforms that support TCP/IP.

12. C. For the database with 32KB block size, the maximum size for a LOB column is 128TB. For a 2KB block size database, the maximum LOB size is 8TB. You can use the function `DBMS_LOB.GET_STORAGE_LIMIT` to find the storage limit for the database.

13. D. Oracle 10*g* supports regular expressions using the functions `REGEXP_LIKE`, `REGEXP_SUBSTR`, `REGEXP_INSTR`, and `REGEXP_REPLACE`. Regular expressions are best suited for pattern matching.

14. A. The `NLS_SORT` parameter specifies the linguistic sort name. Adding the suffix `_CI` to the linguistic sort name enables case-insensitive sorts. For accent-insensitive sorts, add suffix `_AI` as in, `NLS_SORT= JPAPANESE_CI` or `NLS_SORT=BINARY_AI`.

15. B. You use the `DBMS_LOGMNR.CONTINUOUS_MINE` option with the `STARTIME` or `STARTSCN` parameter to add redo log files automatically for mining.

16. B. The `V$FAST_START_TRANSACTIONS` view has information about the transactions the Oracle server is recovering and recovered.

17. C. The `MTS_SESSIONS` parameter is replaced by the `SHARED_SERVER_SESSIONS` parameter in Oracle 10*g*. The dynamic parameter `SHARED_SERVERS` can be adjusted to enable and disable the shared-server architecture.

18. D. You can determine the `DBA_ENABLED_TRACES` view to determine the traces enabled. It also shows the trace type and whether waits and binds are being included in the trace file.

19. B, C, D. Statistics aggregation is provided by default at the session, instance, and SQL levels. Additional statistics aggregation can be enabled by using the `DBMS_MONITOR.CLIENT_ID_STAT_ENABLE` and `DBMS_MONITOR.SERV_MOD_ACT_STAT_ENABLE` procedures.

20. C. The quote operator eliminates the need for additional quotation strings in character literals by choosing your own quotation mark delimiter. The quotation mark delimiter is defined using the quote operator `q` followed by single quote.

Appendix

A

SQL*Plus Enhancements

This appendix discusses the enhancements made to SQL*Plus in Oracle Database 10*g* (Oracle 10*g*). For more information on these features, please refer to the Oracle documentation *SQL*Plus User's Guide and Reference* Release 10.1. The Oracle documentation is available at `http://technet.oracle.com`.

The following are the major enhancements to SQL*Plus:

- The `DESCRIBE` command validates invalid objects.
- The SQL*Plus profile files have changed in behavior.
- White spaces allowed in file names.
- The `SPOOL` command had changed.
- It includes new predefined variables.
- It includes a new `SHOW` command option.
- The process of invoking SQL*Plus has changed.

Enhancements to the *DESCRIBE* Command

The `DESCRIBE` command lists the column definitions for tables, views, types, and synonyms or the specifications for functions, procedures, and packages.

In Oracle 9*i* and previous releases, if you describe an object that is invalid in the database, the `DESCRIBE` command fails with an error. In Oracle 10*g*, `DESCRIBE` will try to validate the object first, and if the object is still invalid after validation, it gives the "Invalid object for describe" error. If the validation is successful, the `DESCRIBE` command will be successful.

Changes to Profile File Calls

The `glogin.sql` and `login.sql` files are the profile files used to customize your SQL*Plus environment when you log into the database. The `glogin.sql` file is the site profile file (located in the `$ORACLE_HOME/sqlplus/admin` directory), which enables you to set up the SQL*Plus environment defaults for all users of SQL*Plus. The `login.sql` file is the user profile and is executed after the `glogin.sql` file. SQL*Plus searches for `login.sql` in the directories specified by the `SQLPATH` environment variable.

If Oracle 10*g*, the `glogin.sql` and `login.sql` scripts are executed after each successful `CONNECT` command. In earlier releases, they were executed only when SQL*Plus was started.

Supporting Whitespace in Filenames

Oracle 10*g* supports whitespace in filenames and paths. The `START`, `@`, `@@`, `RUN`, `SPOOL`, `SAVE`, and `EDIT` commands recognize the whitespace in the file/pathnames. To reference files or paths containing whitespace, enclose the name in double quotes as in the following example (shows both UNIX and Windows path references):

```
SQL> SPOOL "/Oracle Reports/monthly report.txt"
SQL> SAVE "C:\My Documents\montly report.txt"
```

Changes to the *SPOOL* Command

The `SPOOL` command stores query results in a file. In Oracle 10*g*, the `SPOOL` command includes the `APPEND` extension to add the contents of the buffer to the end of a file. The following are examples of using the `SPOOL` command:

```
SQL>  SPOOL example.txt
SQL>  SELECT * FROM employees;
SQL>  SPOOL OFF
SQL>  SPOOL example.txt APPEND
SQL>  SELECT * FROM departments;
SQL>  SPOOL OFF
```

Similar to `APPEND`, you can use `CREATE` or `REPLACE` to create or replace the file. The default behavior is `REPLACE`.

Introducing New Predefined Variables

Oracle 10*g* SQL*Plus includes three new predefined variables. They are _DATE, _PRIVILEGE, and _USER. Table A.1 lists all the predefined variables of SQL*Plus.

TABLE A.1 SQL*Plus Predefined Variables

Variable Name	Description
_CLIENT_IDENTIFIER	Connection identifier used to connect to the database
_DATE	Current date
_EDITOR	Default editor name used by the EDIT command
_O_VERSION	Current version of the Oracle database
_O_RELEASE	Full release number of the Oracle database
_PRIVILEGE	Privilege level of the current connection
_SQLPLUS_RELEASE	Full release number of the SQL*Plus tool
_USER	Username used to connect to the database

The following are some examples of using the predefined variables in the SET SQLPROMPT command and using the DEFINE command to list the current value:

```
SQL> set SQLPROMPT "_DATE SQL>"
18-JUL-04 SQL>
18-JUL-04 SQL>set SQLPROMPT "_DATE _USER SQL> "
18-JUL-04 SCOTT SQL>
18-JUL-04 SCOTT SQL> connect HR/HR
Connected.
18-JUL-04 HR SQL>
18-JUL-04 HR SQL> DEFINE _USER
DEFINE _USER           = "HR" (CHAR)
18-JUL-04 HR SQL> DEFINE _DATE
DEFINE _DATE           = "18-JUL-04" (CHAR)
18-JUL-04 HR SQL> DEFINE _PRIVILEGE
DEFINE _PRIVILEGE      = "" (CHAR)
18-JUL-04 HR SQL>
```

Changes to the *SHOW* Command

The SHOW command displays the value of a SQL*Plus environment variable. In Oracle 10*g* you can use the SHOW RECYCLEBIN command to display the objects in the Recycle Bin that can be reverted with the FLASHBACK BEFORE DROP command. Here is an example of using the SHOW RECYCLEBIN command:

```
SQL> DROP TABLE EMPL;

Table dropped.

SQL> SHOW RECYCLEBIN
ORIGINAL NAME    RECYCLEBIN NAME
OBJECT TYPE  DROP TIME
---------------- ------------------------------
EMPL             BIN$34f+0SUClbTgMAB/AgBZ6w==$0
TABLE        2004-07-18:20:21:58
SQL>
```

You can follow the SHOW RECYCLEBIN command with the original name of the table to see details of a specific table, as in the following example:

```
SQL> SHOW RECYCLEBIN empl
```

The default for the PAGESIZE system variable has changed to 14 from 24 in Oracle 10*g*.

Invoking SQL*Plus

In earlier releases, you had to enclose / as SYSDBA or *user* AS SYSDBA in quotes when the connect information was provided with sqlplus. In Oracle 10*g*, you do not need to enclose the connect information in quotes. For example:

```
linux:oracle>sqlplus scott as sysdba

SQL*Plus: Release 10.1.0.2.0 - Production on Sun Jul 18 20:27:19 2004

Copyright (c) 1982, 2004, Oracle.  All rights reserved.
```

```
Enter password:

Connected to:
Oracle Database 10g Enterprise Edition Release 10.1.0.2.0 - Production
With the Partitioning, OLAP and Data Mining options

SQL>
```

You can set the SQL*Plus compatibility when calling SQL*Plus using the `-c` option. This allows you to set the `SQLPLUSCOMPATIBILITY` variable before executing the `glogin.sql` or `login.sql` profile file. Here is an example:

```
linux:oracle>sqlplus -c 9.2 / as sysdba

SQL*Plus: Release 10.1.0.2.0 - Production on Sun Jul 18 20:32:04 2004

Copyright (c) 1982, 2004, Oracle.  All rights reserved.

Connected to:
Oracle Database 10g Enterprise Edition Release 10.1.0.2.0 - Production
With the Partitioning, OLAP and Data Mining options

SQL> SHOW SQLPLUSCOMPATIBILITY
sqlpluscompatibility 9.2.0
SQL> SET SQLPLUSCOMPATIBILITY 10.1
SQL> SHOW SQLPLUSCOMPATIBILITY
sqlpluscompatibility 10.1.0
SQL>
```

Appendix

B

New and Obsolete Initialization Parameters

This appendix gives the new initialization parameters introduced in Oracle 10*g* and the obsolete parameters. For more information on the new parameters, please refer to the *Oracle Database Reference 10g* Release 1 documentation.

New Parameters

The following are the new initialization parameters in Oracle 10g:

asm_diskgroups Specifies a list of names of disk groups to be mounted by an Automatic Storage Management instance at instance startup or when an `ALTER DISKGROUP ALL MOUNT` statement is issued.

asm_diskstring Specifies an operating system–dependent value used by ASM to limit the set of disks considered for discovery.

asm_power_limit Specifies the maximum power of an ASM instance for disk rebalancing.

create_stored_outlines Determines whether Oracle automatically creates and stores an outline for each query submitted during the session.

db_flashback_retention_target Specifies the upper limit in minutes on how far back in time the database may be flashed back.

db_recovery_file_dest Specifies the default location for the flash recovery area.

db_recovery_file_dest_size Specifies in bytes the hard limit on the total space used by target database recovery files created in the flash recovery area.

db_unique_name Specifies a globally unique name for the database.

ddl_wait_for_locks Specifies whether DDL statements wait and complete instead of timing out if the statement is not able to acquire all the required locks.

fileio_network_adapters Specifies a list of network adapters that can be used to access the disk storage.

gcs_server_processes Specifies the initial number of server processes in the Global Cache Service to serve the interinstance traffic among RAC instances.

instance_type Specifies whether an instance is a database instance or an ASM instance.

ldap_directory_access Specifies whether Oracle refers to Oracle Internet Directory for user authentication information.

log_archive_config Enables or disables the sending of redo logs to remote destinations and the receipt of remote redo logs.

log_archive_local_first Specifies when the archiver processes (ARC*n*) transmit redo data to remote standby database destinations.

plsql_code_type Specifies the compilation mode (INTERPRETED or NATIVE) for PL/SQL library units.

plsql_debug Specifies whether PL/SQL library units will be compiled for debugging.

plsql_optimize_level Specifies the optimization level that will be used to compile PL/SQL library units. The higher the setting of this parameter, the more effort the compiler makes to optimize PL/SQL library units.

plsql_warnings Enables or disables the reporting of warning messages by the PL/SQL compiler and specifies which warning messages to show as errors.

resumable_timeout Enables or disables resumable statements and specifies resumable timeouts at the system level.

sga_target Specifies the total size for all SGA components. This parameter enables Automatic Shared Memory Management.

skip_unusable_indexes Enables or disables the use and reporting of tables with unusable indexes or index partitions.

smtp_out_server Specifies the SMTP host and port to which UTL_MAIL delivers outbound e-mail.

sqltune_category Specifies the category name for use by sessions to qualify the lookup of SQL profiles during SQL compilation.

streams_pool_size Specifies in bytes the size of stream pool, from which memory is allocated for streams.

Obsolete Parameters

The following initialization parameters are available in Oracle 9*i* Release 2 but are obsolete in Oracle 10*g*:

dblink_encrypt_login Specifies whether attempts to connect to other Oracle databases through database links should use encrypted passwords.

hash_join_enabled Specifies whether the optimizer should consider using a hash join as a join method.

log_parallelism Specifies the level of concurrency for redo allocation within Oracle.

max_rollback_segments Specifies the maximum number of rollback segments that can be kept online. In Oracle 10*g*, always uses the default value.

mts_circuits In Oracle 10*g*, use CIRCUITS instead. All the MTS related new parameters are discussed in Chapter 8.

mts_dispatchers In Oracle 10*g*, use DISPATCHERS instead.

mts_listener_address In Oracle 10*g*, use LOCAL_LISTENER instead.

mts_max_dispatchers In Oracle 10*g*, use MAX_DISPATCHERS instead.

mts_max_servers In Oracle 10*g*, use MAX_SHARED_SERVERS instead.

mts_multiple_listeners In Oracle 10*g*, use LOCAL_LISTENER instead.

mts_servers In Oracle 10*g*, use SHARED_SERVERS instead.

mts_service In Oracle 10*g*, use SERVICE_NAMES instead.

mts_sessions In Oracle 10*g*, use SHARED_SERVER_SESSIONS instead.

optimizer_max_permutations Restricts the number of permutations the optimizer will consider in queries with joins. In Oracle 10*g*, this parameter is hidden.

oracle_trace_collection_name Specifies the Oracle Trace collection name for the instance.

oracle_trace_collection_path Specifies the directory where the trace collection definition (.cdf) and data collection (.dat) files are located.

oracle_trace_collection_size Specifies in bytes the maximum size of the Oracle Trace collection file (.dat).

oracle_trace_enable Enables or disables the Oracle Trace collection.

oracle_trace_facility_name Specifies the event set that Oracle Trace collects.

oracle_trace_facility_path Specifies the directory where the Oracle Trace facility definition (.cdf) files are located.

partition_view_enabled Specifies whether the optimizer uses partition views.

plsql_native_c_compiler Specifies a full directory name of a C compiler that is used to compile the generated C file into an object file.

plsql_native_linker Specifies the full directory of a linker such as ld in Unix.

plsql_native_make_file_name Specifies the full directory name of a make file.

plsql_native_make_utility Specifies the full directory name of a make utility such as make in Unix.

row_locking Specifies whether row locks are acquired during UPDATE operations.

transaction_auditing Determines whether to record user information, operating system information, and client information in the redo logs. In Oracle 10*g*, the behavior is similar to a TRUE value.

undo_suppress_errors Enables users to suppress errors while executing manual undo management mode operations. In Oracle 10*g*, the behavior is similar to a TRUE value.

Deprecated Parameters

You can query the deprecated parameters in Oracle 10*g* from the V$PARAMETER view. The following query provides the name and description of deprecated parameters:

```
SQL> SELECT UPPER(name) parameter_name, description
  2  FROM v$parameter
  3  WHERE isdeprecated = 'TRUE'
SQL> /

PARAMETER_NAME
DESCRIPTION
--------------------------------------------------
LOCK_NAME_SPACE
lock name space used for generating lock names for
 standby/clone database

BUFFER_POOL_KEEP
Number of database blocks/latches in keep buffer pool

BUFFER_POOL_RECYCLE
Number of database blocks/latches in recycle buffer pool

LOG_ARCHIVE_START
start archival process on SGA initialization

PARALLEL_SERVER
if TRUE startup in parallel server mode

PARALLEL_SERVER_INSTANCES
number of instances to use for sizing OPS SGA structures
```

```
FAST_START_IO_TARGET
Upper bound on recovery reads

MAX_ENABLED_ROLES
max number of roles a user can have enabled

GLOBAL_CONTEXT_POOL_SIZE
Global Application Context Pool Size in Bytes

PLSQL_COMPILER_FLAGS
PL/SQL compiler flags

PARALLEL_AUTOMATIC_TUNING
enable intelligent defaults for parallel execution
 parameters

DRS_START
start DG Broker monitor (DMON process)

12 rows selected.

SQL>
```

Appendix

C

PL/SQL Enhancements and New Packages

This appendix provides information on the enhancements to PL/SQL in Oracle 10*g* and the new system packages. In this appendix we will discuss the following:

- Changes to the PL/SQL compiler
- List of enhancements in PL/SQL
- New system packages introduced in Oracle 10*g*

Enhancements to the PL/SQL Compiler

Oracle 10g has a completely redesigned PL/SQL compiler that features code optimization. The new compiler includes all the modern and current industry techniques that provide an immediate improvement in the quality of the code generated, thus improving the execution performance of PL/SQL programs. The new compiler increases the performance of PL/SQL code almost two times faster than the Oracle 8*i* PL/SQL compiler where code is not SQL intensive.

PL/SQL compilation is controlled by the following three parameters, which are dynamic and can be set using `ALTER SESSION` or `ALTER SYSTEM`:

`PLSQL_DEBUG` Specifies whether PL/SQL library units will be compiled for debugging. The default is `FALSE`.

`PLSQL_OPTIMIZE_LEVEL` Specifies the optimization level that will be used to compile PL/SQL library units. The higher the setting of this parameter, the more effort the compiler makes to optimize PL/SQL library units. The valid values are 1 or 2, and the default is 2.

`PLSQL_CODE_TYPE` Specifies if the code is `NATIVE` or `INTERPRETED`. `INTERPRETED` is the default, but `NATIVE` compilation runs faster.

The parameter `PLSQL_COMPILER_FLAGS` is deprecated in Oracle 10*g*.

To change a compiled PL/SQL program object from interpreted to native-type code, you need to first set the parameter `PLSQL_CODE_TYPE` to `NATIVE` and recompile the program. Oracle provides two scripts that can be used to convert all users' PL/SQL programs to native compilation (`dbmsupgnv.sql`) or to convert them to interpreted compilation (`dbmsupgin.sql`).

You can query the PL/SQL compilation settings from `DBA_PLSQL_OBJECT_SETTINGS`, `ALL_PLSQL_OBJECT_SETTINGS`, or `USER_PLSQL_OBJECT_SETTINGS`. The `DBA_PLSQL_OBJECT_SETTINGS` setting has the following information:

```
SQL> DESCRIBE DBA_PLSQL_OBJECT_SETTINGS
 Name                 Null?    Type
 -------------------- -------- ----------------
 OWNER                 NOT NULL VARCHAR2(30)
 NAME                  NOT NULL VARCHAR2(30)
 TYPE                           VARCHAR2(12)
 PLSQL_OPTIMIZE_LEVEL           NUMBER
 PLSQL_CODE_TYPE                VARCHAR2(4000)
 PLSQL_DEBUG                    VARCHAR2(4000)
 PLSQL_WARNINGS                 VARCHAR2(4000)
 NLS_LENGTH_SEMANTICS           VARCHAR2(4000)

SQL>
```

Enhancements to PL/SQL

The following is a summary of enhancements made to PL/SQL in Oracle 10*g*. For more information on these features, please refer to the Oracle documentation, *PL/SQL User's Guide and Reference 10g* Release 1.

- The bulk bind operations have been enhanced to improve performance. It is also possible to use sparse collection and index arrays in bulk operations. Two new bulk bind operations for sparse array syntax were introduced (`INDICES OF` and `VALUES OF`).
- Compiler warnings were introduced to improve productivity and to avoid common coding pitfalls. You can enable and disable this feature using the `PLSQL_WARNINGS` parameter (the default is `DISABLE:ALL`). You can see the warnings after compilation using the `SHOW ERROR` command or querying from the `DBA_ERRORS` or `USER_ERRORS` view. You can use the new package `DBMS_WARNINGS` to change the `PLSQL_WARNINGS` parameter in a more granular basis.
- When the synonym name is changed from one table to another, Oracle 10*g* does not invalidate the dependent objects when certain conditions on columns, privileges, partitions, and so on, are met. This minimizes the downtime during code upgrades or schema changes.
- Oracle 10*g* provide web services for PL/SQL and Java stored procedure calls, SQL queries, and SQL DML.
- PL/SQL supports the new SQL enhancements. Some of the enhancements are the new datatypes `BINARY_FLOAT` and `BINARY_DOUBLE`, the new quote operator `q`, regular expressions, the implicit conversion of `CLOB` and `NCLOB`, flashback query functions, and so on.

New Packages in PL/SQL

The following are the new system packages introduced in Oracle 10g:

DBMS_ADVANCED_REWRITE Contains interfaces for advanced query rewrites to create, drop, and maintain functional equivalence declarations.

DBMS_ADVISOR Contains programs for the Server Manageability suite of advisors.

DBMS_CRYPTO Provides an interface to encrypt and decrypt stored data.

DBMS_DATAPUMP Contains programs for data and metadata movement.

DBMS_DIMENSION Contains programs for verifying dimension relationships and displaying dimension definitions.

DBMS_FILE_TRANSFER Provides procedures to copy a binary file within a database or to transfer a binary file between databases.

DBMS_FREQUENT_ITEMSET Enables frequent item set counting.

DBMS_LDAP Provides access to data from LDAP servers.

DBMS_LDAP_UTIL Contains Oracle LDAP utility functions.

DBMS_MONITOR Contains programs for controlling additional tracing and statistics gathering.

DBMS_SCHEDULER Provides a collection of scheduling functions and procedures.

DBMS_SERVER_ALERT Contains programs to set and get the threshold values for server-generated alerts.

DBMS_SERVICE Contains programs to create, delete, activate, and deactivate services for a single instance.

DBMS_SQLTUNE Provides interface to tune SQL statements.

DBMS_STAT_FUNCS Provides statistical functions.

DBMS_STREAMS_AUTH Provides interfaces for granting and revoking privileges to/from stream administrators.

DBMS_STREAMS_MESSAGING Provides interfaces to enqueue messages into, and dequeue messages from, a `SYS.AnyData` queue.

DBMS_STREAMS_TABLESPACE_ADM Contains administrative interfaces for copying tablespaces between databases and moving tablespace from one database to another. This package uses transportable tablespaces, Data Pump, and `DBMS_FILE_TRANSFER`.

DBMS_WARNING Provides a way to manipulate the behavior of PL/SQL warning messages to control what kinds of warnings are suppressed, displayed, or treated as errors.

DBMS_WORKLOAD_REPOSITORY Contains programs to manage the Workload Repository.

DBMS_XMLSTORE Provides the ability to store XML data in relational tables.

UTL_COMPRES Contains a set of data compression utilities for RAW, BLOB, or BFILE datatypes. The LZ_COMPRESS and LZ_UNCOMPRESS functions use the Lempel-Ziv compression algorithm.

UTL_DBWS Provides database web services.

UTL_I18N Provides a set of services that help developers build multilingual applications.

UTL_LMS Retrieves and formats error messages in different languages.

UTL_MAIL Provides utilities for managing e-mail. This is a noteworthy utility in Oracle 10*g*, which performs a send e-mail operation in one PL/SQL call. It requires the SMTP_OUT_SERVER initialization parameter defined with the correct SMTP host and port to deliver outbound e-mail. This package is not installed by default; you need to run the utlmail.sql and utlmail.plb scripts from the $ORACLE_HOME/rdbms/admin directory to create the UTL_MAIL ackage.

Glossary

A

access path analysis The component of the Automatic Tuning Optimizer that identifies whether a new index will significantly improve the execution plan for one or more tables in a query.

ATO *See* Automatic Tuning Optimizer.

Automatic Database Diagnostic Monitor (ADDM) Automatic Database Diagnostic Monitor (ADDM) lets the Oracle Database diagnose its own performance and determine how identified problems could be resolved. ADDM runs automatically after each AWR statistics capture, making the performance diagnostic data readily available.

Active Session History (ASH) Active session history provides sampled session activity in the instance. Active sessions are sampled every second and are stored in a circular buffer in SGA. Using the Active Session History enables you to examine and perform detailed analysis on both current data in the `V$ACTIVE_SESSION_HISTORY` view and historical data in the `DBA_HIST_ACTIVE_SESS_HISTORY view`.

Automatic Shared Memory Management (ASMM) Automatic Shared Memory Management simplifies the configuration of the SGA. Each component of the SGA is adjusted based on the requirement to maximize memory utilization. To use Automatic Shared Memory Management, set the `SGA_TARGET` initialization parameter to a nonzero value and set the `STATISTICS_LEVEL` initialization parameter to `TYPICAL` or `ALL`.

Automatic Storage Management (ASM) A cluster file system that can be used with either stand-alone Oracle instances or with Oracle RAC to provide a vertically integrated subsystem encapsulating a file system, a volume manager, and a fault-tolerant environment specifically designed for Oracle databases. ASM is a new feature introduced in Oracle 10*g* that manages the disk for database use and tunes I/O automatically. ASM spreads data evenly across all the devices in the disk group to optimize performance and utilization.

Automatic Tuning Optimizer (ATO) A component of the Oracle optimizer that is called by the SQL Tuning Advisor to perform several specific types of analyses in tuning mode to optimize the execution plan of a query.

Automatic Workload Repository (AWR) Automatic Workload Repository (AWR) is a built-in repository in every Oracle Database. At regular intervals (default 1 hour) the MMON process makes a snapshot of all vital statistics of the database and workload information and stores them in AWR.

B

BACKUP AS COPY A new RMAN command option to back up the database, tablespaces, or individual datafiles as an image copy. Replaces the `COPY` command in previous versions of RMAN.

Baselines Basic performance data collected from the database when the database is operating normally.

bigfile tablespace A tablespace consisting of only one datafile with a new `ROWID` format and a larger address space allowing for a maximum size of 128TB. Bigfile tablespaces move the maintenance point up from the datafile to the tablespace.

binary compression Compression algorithm available for backup sets in RMAN to save disk space with minimal CPU overhead. Unlike operating system or tape controller compression, RMAN's binary compression is optimized for Oracle datafiles.

BINARY_DOUBLE `BINARY_DOUBLE` is a new native numeric data type in Oracle 10*g* with 64-bit precision. It's based on the IEEE 754 standard for binary floating-point arithmetic.

BINARY_FLOAT `BINARY_FLOAT` is a new native numeric data type in Oracle 10*g* with 32-bit precision. It's based on the IEEE 754 standard for binary floating-point arithmetic.

C

calendaring expressions Specify the frequency of schedules or jobs. It uses each calendar component.

change-tracking file A binary database file, usually stored with the other database datafiles, that maintains a list of changed blocks in the database since the last backup. This file reduces the amount of time RMAN requires to perform an incremental backup.

coarse striping An ASM striping method for higher-latency objects that uses a stripe size of 1MB.

Common Manageability Infrastructure (CMI) Components of the database that manage and tune the Oracle 10*g* database. The components are Automatic Workload Repository, automated tasks feature, sever generated alerts and advisory framework.

comprehensive mode A mode within the SQL Access Advisor that performs its analysis under the assumption that an entire workload, in contrast to a partial workload or a single SQL statement, is being analyzed.

CTWR A new background process that maintains the change-tracking file for RMAN incremental backups.

D

Data Pump A new feature of Oracle 10*g* that provides fast parallel bulk data and metadata movement between Oracle databases. Data Pump is fully integrated with the Oracle database and is installed automatically during database creation or database upgrade.

Database Configuration Assistant (DBCA) The Database Configuration Assistant (DBCA) is a GUI tool to create a database, configure an existing database, and delete a database. DBCA can also clone an existing database.

DATABASE_PROPERTIES A data dictionary view containing one row for various characteristics of the database, such as NLS parameters, the names of the default permanent and temporary tablespaces, and the default type of tablespace created with `CREATE TABLESPACE`.

Database Upgrade Utility (DBUA) The Database Upgrade Utility (DBUA) is a GUI tool to upgrade an existing database to Oracle 10*g*. DBUA does all the necessary checking prior to the upgrade and performs the upgrade with minimal intervention.

DBMS_FILE_TRANSFER A system package that is used for copying binary files between directories on the same server or between directories on different servers, without leaving the PL/SQL environment.

DBMS_SERVER_ALERT A PL/SQL package to configure and retrieve warning and critical threshold levels for tablespace space usage and other database resources.

Dbtime A unit of measure in which database performance is measured. `DBtime` is the cumulative time spent by the database server in processing user requests, which includes wait time and CPU time.

default permanent tablespace The tablespace assigned to a user to store permanent objects when a permanent tablespace is not explicitly assigned to the user.

disk group A group of disks treated as a unit in an ASM instance for both redundancy and performance.

dynamic rebalancing An ASM feature that automatically reallocates extents within an ASM file when a disk in an ASM disk group is added, deleted, or fails.

dynamic sampling A method of statistics collection, controlled by the initialization parameter `OPTIMZER_DYNAMIC_SAMPLING`, that produces compile-time statistics for query objects that have stale or missing statistics.

E

expdp Oracle Data Pump client utility to export data.

encoded block number A new component of a `ROWID` in a bigfile tablespace, combining the relative datafile number and data block number from the smallfile `ROWID` format to form a block number with a much larger address space.

End-to-end application tracing Tracing sessions from its start at the client to its end at the server. Oracle 10*g* allows tracing client sessions using the client identifier across multiple sessions when a middle-tier or shared-server configuration is involved.

external redundancy For an ASM disk group with only one failure group, relying on the external disk hardware subsystem to provide mirroring.

External Table A type of oracle database table, where the actual data is stored in external files (operating system files). The definition of the table reside in the database dictionary.

F

failure group Disks as part of an ASM disk group that share a common resource whose failure will cause the entire set of disks to be unavailable to the disk group.

fast incremental backups An RMAN backup type that uses the change-tracking file to perform an incremental backup more quickly by reading only those blocks from the database datafiles that have changed.

Fine-grained auditing Auditing user actions at the row level—row-level security. Data changes and queries can be audited at the row level in addition to the object level auditing.

fine striping An ASM striping method for low-latency objects that uses a stripe size of 128KB.

fixed table A table that exists in memory only that typically contains information about instance or memory structures and is presented in the form of a table. These tables often begin with `X$`, are not documented for general use, and are the basis for many of the `V$` dynamic performance views.

flash recovery area A single, unified storage area for all recovery-related files and recovery activities in an Oracle database. Configured with the initialization parameters `DB_RECOVERY_FILE_DEST_SIZE` and `DB_RECOVERY_FILE_DEST`.

flashback buffer Whenever Flashback Database is enabled, this new memory area within the SGA stores changes to data blocks to facilitate Flashback Database. The RVWR process writes the blocks in the flashback buffer to flashback logs in the flash recovery area.

Flashback Database A flashback feature that allows you to quickly revert the entire database to its state as of a previous point in time.

Flashback Drop A flashback feature that retrieves a table after it has been dropped without using other more complicated recovery techniques.

Flashback Table A flashback feature that allows you to recover one or more existing tables to a specific point in time. Flashback Table is done in place by rolling back only the changes made to the table or tables and their dependent objects, such as indexes.

Flashback Transaction Query A recovery technique that retrieves all changes within the database for a specified time period and for a particular transaction number. Uses the data dictionary view FLASHBACK_TRANSACTION_QUERY.

Flashback Versions Query A recovery technique that shows all versions of all rows in a table between two SCNs or time stamps, whether the rows were inserted, deleted, or updated.

full workload An option within the SQL Access Advisor to specify that a workload is the full set of SQL statements run as part of an application or throughout a business day.

G

GET_THRESHOLD A procedure within the package DBMS_SERVER_ALERT to retrieve the threshold levels for a tablespace or other database resource.

Growth Trend Report A report available within the EM Database Control that uses AWR data to show segment growth in the past and predict segment growth in the future.

global script A new type of RMAN script that can be shared between databases.

H

hash-partitioned global indexes Global indexes that use an internal hashing algorithm to assign index entries to partitions in a partitioned global index. Hash-partitioned global indexes increase the performance of parallel queries by allowing multiple parallel processes per partition in a parallel SELECT query.

high redundancy For an ASM disk group, a level of redundancy that requires at least three failure groups in the disk group.

HTML DB HTML DB is a Rapid Application Development (RAD) tool for the Oracle database and has many built-in themes and features. Using only a web browser, developers can build web applications faster.

I

impdp Oracle Data Pump client utility to import data.

incrementally updated backup The process of updating an existing image copy of a datafile with incremental backups to reduce the number of archived redo log files, and therefore the amount of time, needed to recover a datafile.

J

job Specifies what program needs to be executed and the schedule of when.

job class Defines a group of jobs that share the same characteristics and have common resource usage requirements. A job can belong to only one job class.

L

limited mode A mode within SQL Access Advisor that performs its analysis under the assumption that a subset of the entire workload, such as a single SQL statement, is being analyzed.

long query warning alert An alert generated when a user receives a "Snapshot too old" error. This alert is generated at most once per 24-hour period.

M

master control process (MCP) Controls the execution of the Data Pump job; there is one MCP per job. MCP divides the Data Pump job into various metadata and data load or unload jobs and hands them over to the worker processes.

MMAN MMAN is the Memory Manager process responsible for Automatic Shared Memory Management.

MMON A new Oracle background process that checks for tablespace space problems every 10 minutes; alerts are triggered both when a threshold is exceeded and once again when the space usage for a tablespace falls back below the threshold.

MODEL clause A new clause available in the SELECT statement to perform spreadsheet-like array computations.

N

normal mode A mode of the SQL Tuning Advisor that performs much like the optimizer in previous versions of Oracle to provide a reasonable execution plan within limited time constraints.

normal redundancy For an ASM disk group, a level of redundancy that requires at least two failure groups in the disk group.

O

OPTIMIZER_DYNAMIC_SAMPLING A new initialization parameter that controls the level of runtime statistics collection for objects that have stale or missing statistics.

Oracle 10*g* HTTP Server (OHS) The Oracle 10*g* HTTP Server (OHS) is based on the Apache web server 1.3.28 and is designed to take advantage of the latest optimizations and security features.

Oracle Enterprise Manger (EM) The Oracle Enterprise Manager (EM) is a GUI tool to manage the Oracle environment, which includes a database, host server, listener, HTTP Server, and web applications.

Oracle Management Agent The Oracle Management Agent is used by Oracle Enterprise Manager to monitor the database and server. The Oracle Management Agent is responsible for monitoring all targets on the host, for communicating that information to the middle-tier Management Service, and for managing and maintaining the host and its targets.

Oracle Universal Installer (OUI) The Oracle Universal Installer (OUI) is a GUI tool to install the Oracle software. The OUI performs the necessary OS and hardware resources before the install.

ORB*n* In an ASM instance, this performs the actual extent movement between disks in the disk groups managed by the ASM instance. *n* can be from 0 to 9.

P

partial workload An option within the SQL Access Advisor to specify that a workload is only a single SQL statement or a group of problematic SQL statements, as opposed to all SQL statements run during a typical business cycle.

Partition change tracking Partition change tracking (PCT) is the ability to identify which rows in a materialized view are affected by certain detail table partitions.

Partitioned outer join A method in Oracle 10*g* to convert dense data to sparse data in order to better utilize some analytical functions.

program Determines what task needs to be performed. The program is a collection of metadata information about the name of the program, its type, and its arguments.

R

RBAL In an ASM instance, this coordinates the disk activity for disk groups.

Redo Logfile Size Advisor An advisor within the Oracle advisory framework that analyzes redo logfile usage and recommends an optimal redo logfile size to minimize I/O and logfile switches.

recycle bin A logical structure available in all locally managed tablespaces (except for the SYSTEM and SYSAUX tablespaces) that maintains dropped versions of tables. The recycle bin is purged either manually or whenever space pressure exists in the tablespace.

Regular expressions A method of describing both simple and complex patterns for searching and manipulating.

RVWR A background process that writes data from the *flashback buffer* in the SGA to flashback logs in the flash recovery area.

S

Sample schema Sample schemas are schema objects with sample data in them. The sample schema installation has five schemas: HR, IX, OE, PM, and SH. Most of the examples and sample code provided in the Oracle documentation are based on these sample schemas.

Segment Advisor A tool available either via a PL/SQL package or within the EM Database Control that analyzes a segment or all segments within a tablespace and recommends remedial action to optimize the space within the segments.

schedule Specifies when and how often a task (job) will be executed.

Segment Resource Estimation A tool available only within the EM Database Control that can estimate space usage for a new table segment given the column datatypes, sizes, and the estimated row count.

segment shrink The functionality either using `ALTER TABLE` or the EM Database Control interface to reclaim wasted space within a segment and optionally move the HWM down.

SET_THRESHOLD A procedure within the package `DBMS_SERVER_ALERT` to set the threshold levels for a tablespace or other database resource.

Shared server A database architecture where user requests are handled by different server processes. This architecture was formerly known as a *multithreaded server*.

smallfile tablespace The traditional type of tablespace available in both previous releases of Oracle and Oracle 10*g*. Smallfile tablespaces can consist of one or many datafiles. Using all smallfile tablespaces limits the amount of data stored in an Oracle database to 8 petabytes (PB).

sorted hash clusters A hash cluster, either single table or multiple table, that maintains rows ordered by one or more sort keys for each value of the cluster key to minimize memory usage and sort operations when the rows are retrieved from the cluster. Supports applications that process data in a FIFO manner.

SQL Access Advisor A component of the Oracle advisory framework and the DBMS_ADVISOR package that helps to determine which indexes, materialized views, and materialized view logs will help the performance of a single query, an entire workload, or a derived workload based on a specified schema.

SQL profile A collection of additional information about a SQL query that is collected during the automatic tuning of a SQL statement that can be used to improve the execution plan for future executions of the SQL statement.

SQL Tuning Advisor A component of the Oracle advisory framework that automatically calls the Automatic Tuning Optimizer to perform several different types of analyses on a SQL query.

SQL Tuning Set (STS) A construct to store and maintain a set of SQL statements along with its execution information.

SQLTUNE_CATEGORY An initialization parameter used by the SQL Tuning Advisor to specify which category to use when applying a SQL profile to a SQL statement.

stateful alerts As a category of server-generated alerts, stateful alerts are based on a threshold. Alerts are configured by setting a warning and critical threshold values on database metrics.

stateless alerts As a category of server-generated alerts, stateless alerts are based on an event. Alert is sent out when an event such as "resumable session suspended" occurs.

Statistics aggregation Aggregation of key metrics and statistics for problem diagnosis and analysis captured at the session, instance, service, module, or client identifier level.

STS *See* SQL Tuning Set (STS).

SWITCH DATABASE A new feature in RMAN used to quickly recover a database by using datafiles in the flash recovery area as the live database, eliminating any copy operations.

SYSAUX tablespace A companion tablespace to the SYSTEM tablespace designed to offload the metadata from the SYSTEM tablespace as well as to consolidate other applications that previously required their own tablespaces.

T

temporary tablespace group A database object that represents one or more temporary tablespaces. A temporary tablespace group cannot exist without any members. Temporary tablespace groups can be used anywhere that a temporary tablespace can.

Trcsess A new utility to combine the trace files generated by multiple sessions based on a common criteria such as client identifier or service name.

tuning mode A mode of the SQL Tuning Advisor that performs an in-depth analysis of high-load SQL and produces a series of recommended actions to improve the execution plan of the query.

U

Undo Advisor A tool within the Oracle advisory framework that uses past undo usage to recommend settings for the UNDO_RETENTION parameter as well as an optimal size for the undo tablespace.

V

V$SYSAUX_OCCUPANTS A dynamic performance view containing a list of the applications whose metadata resides in the SYSAUX tablespace. Along with the space usage for each application, the column MOVE_PROCEDURE provides the name of the procedure or package that can be used to move the application's metadata out of or into the SYSAUX tablespace.

Virtual Private Database (VPD) Securing privileges of data at a row level. User queries are rewritten by the database to add a WHERE clause to filter rows that are not relevant to the user, which is determined by a policy function.

W

window In the scheduler, can be used to activate different resource plans at different times. The window represents an interval with a well-defined start and end time.Dump FilesFiles written by data pump (expdp) and export (exp) utilities, which contain data and metadata extract from the database.

Window Group In the scheduler, a window group represents a collection of windows.

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Note to the Reader: Throughout this index **boldfaced** page numbers indicate primary discussions of a topic. *Italicized* page numbers indicate illustrations.

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