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Abramson–Abbey–Corey

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Allen

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Introduction

ot too long ago I had a conversation with Scott Rogers, Associate Publisher and Editor in Chief for Oracle Press. Scott was telling me about his vision for a line of books they were calling the 101 Series. When he said the series needed a book on PL/SQL, I interrupted him with "I want to do that book." (Scott, I never apologized for interrupting…sorry about that.) He listened to my ideas for such a book, and the book you are now holding is the result.

In this book, I've tried to present SQL and PL/SQL in a way that makes sense. I have worked to create examples that demonstrate not only *how* to use each feature, but also *why*. I've provided exercises that mirror the kinds of tasks you'll be asked to accomplish if you make SQL and PL/SQL part of your work. And I've done my best to make the writing reasonably interesting to read, so your flame of interest in this fascinating topic stays burning. You can get the scripts used in this book on the Oracle Press Web site, at www.oraclepressbooks.com. If you have ideas about how I could make this book better, e-mail me at **plsql@yahoo.com**. I'll do my best to remember that you're doing me a favor giving positive *or* negative feedback.

All the best in your PL/SQL endeavors,

—Christopher Allen

PART I

Database Basics

CHAPTER 1

Introduction to Databases

elcome to the wonderful world of databases. "Huh?" you might say to yourself. "What's so wonderful about databases?" The answer lies not with databases themselves, but with what they contain: information. Information that can make your life easier, transform a mountain of chaos into a manageable chunk of order, and help you discover things you would never have the time to find out otherwise. When you learn how to use databases knowledgeably, you learn how to control the way you receive information. More and more, this fundamental skill is becoming the difference between getting the answers you need and not.

What Exactly Is a Database?

Stripped down to its most basic form, a *database* is a list of information. Or a set of lists that work together. A *database program* is a fancy list manager.

Databases are a regular part of just about everyone's life. For example, a telephone book is a paper representation of a database. It provides you with specific pieces of information about people, and it sorts that information into an order designed to help you find what you want quickly. If the telephone book contains business listings—often called the "yellow pages"—the information there will be sorted by business type, and within each business type, it will be sorted by name.

You probably have an address book—it's a database, too. So is your checkbook register. If your local television provider has a channel that shows what's playing on each channel, that information is coming from a database.

You have probably used databases on the Internet, too. If you have looked for a book or CD using a web site, the information that came back to you was pulled from a database. (I recently designed just such a database for the world's largest music-publishing company.) Online auction sites are large databases containing information about buyers, sellers, items, bids, and feedback. Internet search engines such as Google and Yahoo! are enormous databases containing key information about millions of web pages.

Tables

Databases are always designed to store a particular type of information. For instance, in the case of a telephone book, the information is about people (in the white pages) and about businesses (in the yellow pages). A database would generally store such information by having one *table* containing all the information about people, and another table containing the information about businesses. Each of these tables would look a lot like a spreadsheet, with individual columns for each type of information being stored (name, address, number, and so on) and a row for each person or business. For instance, Table 1-1 demonstrates a simple employee table.

EMPLOYEE_ID	FIRST_NAME	LAST_NAME	SALARY	HIRE_DATE
1024	Devin	Campbell	63000	15-JAN-04
2048	Alexa	Hammond	67000	17-FEB-05
3072	Blake	Anthony	68000	27-JAN-06
4096	Brianna	Berlin	69000	29-MAY-07

TABLE 1-1. *A simple employee table*

The most important thing to remember about a table is this: *It stores information about **one** type of thing*. A table about people will not store information about lawnmowers! A table about school classes will not store information about the people who take those classes. If a database needs to store information about more than one type of thing—and it almost always will—it does so by using more than one table. For example, to properly track school classes, a database would have (at the very least) a table for faculty, another one for classes, a third one for classrooms, and a fourth one for students. Keeping the different types of information separate allows a database to store information very efficiently, and in a highly organized (and therefore easy-to-use) manner.

Rows/Records

The simple employee table shown earlier contains information about four people. Each person's information is on a line of its own. Each line is called a *row*, and the data it contains is called a *record*. Each row will contain the information for one—and only one—of the items defined by the table's name. For instance, in an employee table, each row contains information for only one employee. Similarly, each employee's information is stored on just one row. You design the table so that it only takes one row to hold all of the information specific to each of whatever the table's name says it holds. (You'll be doing this yourself very soon.)

Columns/Fields

Each row contains several pieces of information. In the employee example, those pieces included employee ID, first name, last name, and so on. In a table, these pieces of information are stored in *columns*. The junction point of a row and a column—for instance, a particular person's first name—is called a *field*. A field contains a single piece of information about something—for instance, a telephone number for one person.

Let's think about a concrete example. Imagine that you want to put information for five of your friends onto 3″ × 5″ index cards. Each friend will get his or her own index card, so you'll use a total of five cards. By doing this, you're creating a small database. It's a physical database, as opposed to one on a computer, but it's a database nonetheless, and the concepts of tables, records, and fields still apply. Figure 1-1 shows the relationships between the index cards and these terms.

Now let's say you've put the information for the same five friends into a spreadsheet. Figure 1-2 shows how the terms you've just learned would apply to that situation.

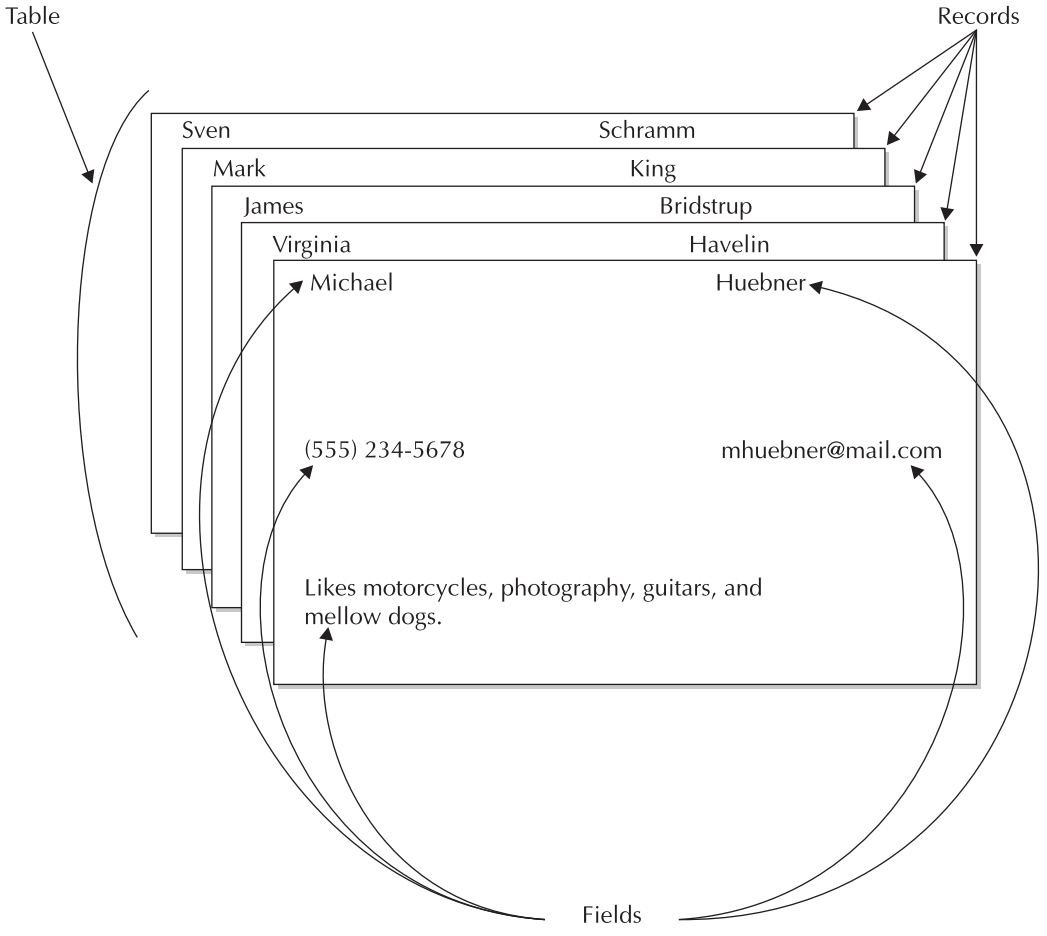


FIGURE 1-1. *Friend information laid out on index cards*

606.xls

	A	B	C	D	E
1	First Name	Last Name	Phone	Email	Comments
2	Michael	Huebner	(555) 234-5678	mhuebner@mail.net	Likes photography, guitars, and mellow dogs
3	Virginia	Havelin	(555) 345-6789	vhavelin@mail.net	Intrepid traveler and all-around cool person
4	James	Bridstrup	(555) 456-7890	jbridstrup@mail.net	Nickname: Mr. Smooove
5	Mark	King	(555) 567-8901	mking@mail.net	If I had a single sister...
6	Sven	Schramm	(555) 678-9012	sschramm@mail.net	Be sure to fly to east coast only when he is NOT working

FIGURE 1-2. *Friend information laid out in a spreadsheet*

How Is a Database Different from a Spreadsheet?

Based on the "list of friends" example, it would be easy to think "Well, why not just keep the list in a spreadsheet?" For a list like the one shown, you could. A database becomes appropriate when the lists get more complicated, or when they need to be used in a more sophisticated environment. What follows are several distinctive features that databases offer.

Many Rows

Since spreadsheets are designed primarily for financial calculations—essentially, they function as ledger sheets with formulas where the answers go—they aren't designed to accommodate the number of rows that a business database will need. It's common for a spreadsheet to have a limit of 65,536 on the number of rows it can contain. While that is a lot of rows for a spreadsheet, it isn't really that many for a database. (For example, I just used a web site to find out how many Internet newsgroup messages contain the world "Oracle." There were approximately 2,330,000 matching messages, and every one of those messages is stored in the web site's database. That web site's database contains over two million records about Oracle messages alone; imagine how many records it contains in total!) It's not uncommon for a business database to contain millions of rows and for large businesses to have databases containing billions of rows. No spreadsheet is going to handle that!

Many Users Simultaneously

Because databases are at the core of many businesses, it's essential that they allow lots of people access to the same data simultaneously. To understand why, imagine a retail store chain that has a hundred computerized cash registers distributed among its stores. On a busy sale day, many of those registers are going to be doing transactions at the same time. If you had to wait for all of the other transactions to be completed before yours could go through, you would probably get frustrated and leave, and so would a lot of other people—and sales would suffer. On a bigger scale, airline reservation systems can deal with thousands of requests every second—if each of those had to wait for all the others, the reservation system would be very slow and annoying. The ability to accommodate large numbers of simultaneous users is one of the key characteristics of a database. A well-designed database can answer requests from thousands—or even millions—of users simultaneously and still provide excellent performance.

Security

Databases contain some of the most sensitive information in a business: salaries, customer information, and project schedules, for instance. If this information were to be deleted, changed, or revealed to coworkers or competitors, it could cause problems ranging from embarrassment to failure of the business itself. Because of this, databases have extremely robust security systems. You won't find any passwords stored in easily snooped text files in a database system; everything is encrypted, including the information sent between the database and a user's computer when he or she logs in.

Even valid users of a database don't necessarily get access to everything the database contains. Users can be given privileges to specific tables, and not to others. It's even possible to make some columns within a table visible to all users, and other columns visible to only a select group. In addition, a database can be instructed to filter a table's rows so that some users see only certain rows, while other users see all rows.

A database's security features go even further. In addition to controlling who can see what information, a database allows you to specify who can insert new information, update existing information, or delete information. This helps ensure that people who have no business reason to change or delete data, for instance, cannot do so accidentally (or not so accidentally).

In a large database system—say, one with 1,000 users or more—managing all of these different kinds of privileges would quickly become impossible if they had to be set on a user-by-user basis. Fortunately, databases like Oracle allow you to gather a specific set of privileges into something called a *role*. That way, whenever users are added to the database, they are assigned one or more roles, and those roles carry the privileges the users can exercise. This works well because businesses generally have specific job descriptions, and the privileges each user will need relate directly to his

or her job description. An accounting clerk will need the ability to enter data from bills, but perhaps only the accounting managers will have the ability to change data once it's been entered. Similarly, perhaps only accounting executives can do anything at all with the company's salary data. Each of these three job descriptions would be a good candidate for a database role. For instance, an "accounting clerk" role would be assigned to all of the accounting clerks. Security roles help ensure that everyone has exactly the privileges they need. Roles also make it very easy to assign a new privilege to a group: You just add the privilege to that group's role, and the job is done.

Relational Abilities

Since a database employs separate tables to store different types of data—remember the example of a school's database having individual tables for faculty, classes, classrooms, and students—there must be a way to connect records in one table with relevant records in the other tables. Databases accommodate this by letting you define *relationships* between the tables.

For example, let's consider an order-entry system. The core of this type of system is the business' inventory, so there will always be a table containing information about products. The PRODUCT table will store each piece of information pertaining to an inventory item, including description, manufacturer, price, and quantity currently in stock. The PRODUCT table will also store a unique identifier for each product, as a way of unquestionably identifying one product as opposed to another. Let's say for the sake of discussion that in the PRODUCT table, the unique identifier is the Stock Keeping Unit (SKU).

Now that we have a table in which to store products, we need another table in which to store orders for those products. Each row in the ORDER table will store the date, time, location, and total order value. The ORDER table must also identify what product the order is for, and it can do this simply by storing the product's SKU as part of the order record. Here's where the relationship comes in: *The only product information an order contains is the product's SKU.* The product's description, price, and other information are not stored in the ORDER table. Why? It would waste space, among other reasons, because each product's description, price, and so on are already available in the PRODUCT table. The only requirement to making this work is that the database must be told how to relate an order's SKU to a unique record in the PRODUCT table. Once it knows that, the database can join information from both tables, and present the combined information on a single line, as if it came from one table.

A database that employs this technique of relating records in separate tables is called a *relational database*. It's not uncommon for business databases to contain tables that have relationships to dozens of other tables. There are many reasons for doing this, and they will be discussed in depth in Chapter 6. The opposite of this approach is a single large table that repeats information every time it is needed. This type of table is called a *flat file*, indicating that it is two-dimensional—just rows and columns, no related tables.

Constraints to Ensure Data Quality

Sometimes the data stored in a database comes directly from other machines: automated sensors, timers, or counters. Most of the data in a database, though, is entered by people. And people make mistakes. (Not you, of course, but I'm sure you know others who do.) When designing a database, it's easy to define *constraints* identifying conditions that data in a particular field must meet before the database accepts the record. The constraint defines what must be true about the data in order for it to be accepted. These constraints can be very simple—like ensuring that a price is a positive number—or more involved, like ensuring that a SKU entered into an order actually exists in the PRODUCT table, or requiring that certain fields in a record be entered if other fields contain specific values. By automating these types of quality-control functions, the database helps guarantee that the data it contains is clean.

Review Questions

1. What is the most significant characteristic of a table?
2. Define the following terms: *row, record, column, field, table, database, constraint*.
3. What are the key features that make a database suitable for storing large amounts of data?

Hands-On Project

1. Gather four blank sheets of paper. The sheets can be any size—index cards will work as well as 8.5" × 11" sheets.
2. On each sheet, write the first name, last name, phone number, and e-mail address of a friend or associate (you will do this for a total of four people—one per sheet).
3. After you have written the information onto the sheets, lay the sheets on a table—separately, so that they do not touch each other.
4. Move the sheets right next to each other, so they form a grid that is two sheets wide and two sheets high. In this arrangement, each sheet will touch two other sheets.
5. Tape the sheets together in this arrangement.
6. Take a pen that is a different color and on the top-left sheet, circle each item that would be stored in a database field. Write the word "Fields" at the bottom of the sheet, and draw arrows to each of the circled fields.

7. Next, put a rectangle around each item in the four-sheet grid that would relate to a row in a database. Write the word "Rows" in the center of the four-sheet grid, and draw arrows from the word to each square.
8. Finally, write "e-mail column" wherever on the four-sheet grid you have some space. Then draw one long line that connects that phrase to every item in the grid that would be stored in a table's e-mail column.

How Will Knowing This Help You?

Everybody is busy these days, and if you are reading a book about PL/SQL, you are probably busier than most. It's reasonable that you will want to know how something is going to help you before investing the time to learn it. What follows is a list of the ways that learning PL/SQL can help you in different situations.

When Doing Database Administration

It's impossible to be an Oracle database administrator (DBA) without knowing the standard database language called Structured Query Language (SQL), and very difficult without knowing Oracle's SQL superset named PL/SQL. This is because many of the tasks that are generally done by a DBA are accomplished using SQL, and quite a few require the programming capabilities of PL/SQL, as well. While Oracle does provide a number of software programs enabling administrators to perform tasks using a nice graphic user interface (GUI), these tools have their fair share of bugs. In addition, some tasks can just be done faster when using SQL directly, and in some database installations, connections to databases are accomplished using text-based terminals that cannot run the pretty GUI tools. The importance of SQL is reflected in the fact that Oracle's own DBA certification program, which consists of five separate exams, devotes the entire first exam to SQL and PL/SQL.

When Developing Software

When writing programs of your own, the chances are good that at some point you will need to write some SQL code to interact with a database directly. Many developers stumble through this, making mistakes that cost them time and performance. Investing the time to learn SQL properly will pay for itself many times over. The documentation supplied with Oracle includes sections dedicated to interacting with Oracle via Java, C, C++, and COBOL.

When Doing Business Analysis

Being able to slice and dice huge mounds of data into the information you need is an essential part of a business analyst's job. Lots of people do this by getting an extract of their company's database, putting it in a spreadsheet, and manually creating the analyses they need. This approach is flexible, but it can be time-consuming. Some

companies also provide their analysts with software tools designed to make data analysis quick and easy. But even these tools don't provide every imaginable way of looking at the information; they provide the subsets that their designers think are the most likely to be used. The chances are good that you will want to look at the data in some way that the tool doesn't support. Often a single SQL query can provide the information you need.

If You Just Want to Know How to Use Databases Better

Recently I visited Silicon Valley and, when I had some free time, decided to go to a movie. I purchased a local newspaper and turned to the movie listings. I was struck by what I saw: *two* sets of listings, one sorted by geographic area, and the other sorted by movie title. So if you wanted to find out what was showing near you, you would use one listing; if you wanted to find out where a specific movie was playing, you would use the other. This simple, powerful idea made the listings a real pleasure to use. I'm positive that it was thought up by someone with database experience, someone who was familiar with the idea that the content of the data and how it is displayed are two different things.

These days, practically everything is built around a database. If you understand how databases work, you understand how a lot of businesses function. This can be extremely useful. For instance, if you call a company's customer service department but don't have your customer number with you, you might think to ask, "What else can you search on to find my record?" When you use a web search site to locate information, you will get the results you want much more quickly if you understand how databases interpret search terms. (My friends are regularly amazed at how quickly I can find relevant information using search sites. My only trick: educated decisions about what to enter as search criteria.) Understanding databases is becoming a lot like being able to do basic math quickly in your head: It isn't essential, but it sure comes in handy a lot.

History of SQL

A little bit of history is useful to give perspective, and the history of SQL parallels the history of relational databases. In 1969, Dr. Edgar F. Codd published an IBM Research Report with the catchy title *Derivability, Redundancy, and Consistency of Relations Stored in Large Data Banks*. This paper described an approach to structuring databases with related tables, which was quite different than the flat-file approach used by databases at the time. The paper was stamped with IBM's Limited Distribution Notice, so it wasn't widely read. Codd revised the concepts and published them in a 1970 article titled "A Relational Model of Data for Large Shared Data Banks" in the journal of the Association of Computer Machinery. The relational model described by Codd was used in a prototype relational database management system (RDBMS) called System R in 1974. Describing the system's query language in a November 1976 article in

the *IBM Journal of R&D*, IBM used the name Structured English QUEry Language (SEQUEL). The language and its name evolved, becoming Structured Query Language (SQL, pronounced either "sequel" or "S-Q-L"). The first commercially available version of SQL was released in 1979 by Oracle Corporation (although the company's name was Relational Software, Inc. at the time).

In 1986, the American National Standards Institute (ANSI) stepped in and published a formal SQL standard, which it identified as ANSI X3.135-1986. The International Standards Organization (ISO) picked up this standard the following year and published it as ISO 9075-1987. The specification was expanded in 1992, and then again in 1999. The current specification is in five parts, named ANSI/ISO/IEC 9051-1-1999 through 9051-5-1999.

SQL has become the de facto standard language for querying databases. Each database company modifies it a bit to suit its needs, but the core SQL functions remain essentially unchanged. This is good news for database users and developers, because the time invested in learning SQL will reap benefits for years to come, across software revision after software revision, and even to other products.

The bottom line is: SQL is a versatile and essential tool for anyone who works with databases regularly.

SQL Command Categories

SQL commands fall into functional groups that help make them easy to remember. These groups include:

- Data Definition
- Data Manipulation
- Data Control
- Data Retrieval
- Transaction Control

Your work with these commands will start in Chapter 2, and will continue throughout the book. Here's an overview of the command categories you will learn to use.

Data Definition

Oracle and all major database programs are database platforms—meaning they provide an environment that supports working with tables very well, but they don't provide any tables already created for your use. You get to define what data will be stored and in what configuration. SQL provides a collection of commands for these purposes: CREATE, ALTER, DROP, RENAME, and TRUNCATE.

These commands fall into a group called Data Definition Language, which is routinely referred to as DDL.

Data Manipulation

Okay, you learn how to create some tables. What's the next step? Putting data into them. SQL provides an INSERT command enabling you to add data to tables. After the data has been inserted, you can change it using the UPDATE command, or remove it using the DELETE command.

This category of commands is called SQL's Data Manipulation Language, more often referred to as DML.

Data Control

Remember the security features discussed earlier in this chapter? (I'm sure you do, but if anyone reading over your shoulder doesn't remember it, it's in the section titled "How Is a Database Different from a Spreadsheet?".) The ability to let some users utilize particular tables while other users cannot is enforced by assigning users *privileges* for specific tables or activities. An *object privilege* allows a user to perform specified actions on a table (or other database object). An example of an object privilege would be the ability to insert records into an EMPLOYEE table. In contrast, a *system privilege* enables a user to perform a particular type of action anywhere in the database. An example of a system privilege would be the ability to insert records into *any* table in the database, or the ability to create a new table.

Database privileges are assigned and removed using the SQL commands GRANT and REVOKE. These commands fall into the category of Data Control Language (DCL).

Data Retrieval

The whole point of putting information into a database is getting it out again in a controlled fashion. There is just one command in this category—SELECT—but it has a wealth of parameters that provide a *lot* of flexibility. The SELECT command is the command you're likely to use more than any other, especially if you plan to use SQL from another programming language.

Transaction Control

Oracle's SQL provides an undo capability enabling you to cancel any recent DML commands before they are applied to the database. (Quick quiz: What commands are DML commands? If you need a reminder, take another look at the section titled "SQL Command Categories" earlier in this chapter.) After performing one or more DML commands, you can either issue a COMMIT command to save your changes to the database, or issue a ROLLBACK command to undo them.

The undo capability provides multiple levels, too: You can reverse just the last DML transaction, or the last several, or whatever level you need. Taking advantage of this multiple-level redo takes a little more forethought than it does in your favorite word processor, however. If you want to be able to undo to intermediate points, you have to mark those points by issuing a SAVEPOINT command at whatever point you want to be able to roll back to.

Chapter Summary

Stripped down to its most basic form, a database is a list of information. Or a set of lists that work together. A database program is a fancy list manager. Familiar databases include telephone books, checkbook registers, and web sites providing online auctions, ordering, and searching.

Databases are always designed to store a particular type of information. For instance, in the case of a telephone book, the information is about people (in the white pages), and about businesses (in the yellow pages). A database would generally store such information by having one table containing all the information about people, and another table containing the information about businesses. Each of these tables would look a lot like a spreadsheet, with individual columns for each type of information being stored (name, address, number, and so on) and a row for each person or business.

The most important thing to remember about a table is this: *It stores information about **one** type of thing*. If a database needs to store information about more than one type of thing—and it almost always will—it does so by using more than one table. Keeping the different types of information separate allows a database to store information very efficiently, and in a highly organized (and therefore easy-to-use) manner.

Each line in a table contains information about one instance of whatever the table is designed to store. Each line is called a *row*, and the data it contains is called a *record*. You design the table so that it only takes one row to hold all of the information that is specific to each item the table contains.

Each row contains several pieces of information. In a table, these pieces of information are stored in *columns*. The junction point of a row and a column—for instance, a particular person's first name—is called a *field*. A field contains a single piece of information about something—for example, the last name for one person.

While a table in a database stores data in rows and columns like a spreadsheet, there are many characteristics that make a database more appropriate when the data gets more complicated, or when it needs to be used in a more sophisticated environment. These include the ability to handle billions of rows, accommodate thousands of simultaneous users, provide object-specific security, relate many tables together, and constrain the content of incoming data to ensure quality information.

Understanding how to use SQL can benefit you in a number of different areas. It's an essential skill if you're planning to be an Oracle DBA, because many DBA tasks are executed using SQL commands. When developing software, it's likely you will need to write SQL commands to insert, select, update, and delete data within programs you write. When doing business analysis, knowing SQL enables you to interact directly with the database, slicing and dicing its information the way you want, without being limited by pre-designed queries created by someone else.

And if you just want to know how to use databases better, understanding SQL will help you understand how to use a variety of products and services used in daily life.

SQL is based on concepts pioneered by Dr. Edgar F. Codd and first published in 1969. It has become the de facto standard language for interacting with all major database programs. Its commands fall into functional categories, which include data definition, data manipulation, data control, data retrieval, and transaction control. The Data Definition Language (DDL) commands are used to define how you want your data to be stored; these commands include CREATE, ALTER, DROP, RENAME, and TRUNCATE. The Data Manipulation Language (DML) commands enable you to work with your data; they include INSERT, UPDATE, and DELETE. The Data Control Language (DCL) commands control who can do what within the database, with object privileges controlling access to individual database objects and system privileges providing global privileges across the entire database. The DCL commands include GRANT and REVOKE. For data retrieval, SELECT is the sole command, but its many variations are likely to make it the most-used command in your arsenal. To control transactions, SQL provides the COMMIT command to save recent DML changes to the database; the ROLLBACK command to undo recent DML changes; and the SAVEPOINT command to let you undo some, but not all, of a string of DML commands.

Chapter Questions

1. **Which of the following are examples of databases that you're likely to encounter in daily life?**

   A. Front page news

   B. Telephone books

   C. Checkbook registers

   D. Web sites providing online auctions, ordering, and searching

   E. Ads with sale prices

   F. Movie listings

2. **What is the most significant characteristic of a table?**

   A. It has rows and columns.

   B. It can be related to other tables.

   C. It stores information about one type of thing.

   D. It contains records and fields.

3. **Relate each term on the left with the appropriate description on the right.**

Term	Description
Row	Stores all information about one type of thing (for instance, people or products)
Record	Defines what must be true about the data in order for it to be accepted by the database
Column	One line in a table
Field	Collection of one type of information stored in a table (for instance, all of the phone numbers or all of the last names)
Table	Data contained in a table row
Database	Contains a single piece of information about something
Constraint	Collection of related tables

4. **Which of the following are reasons why a database is the best choice for handling large quantities of business data?**

   A. Can handle billions of rows

   B. Runs only on PCs

   C. Can accommodate thousands of simultaneous users

   D. Provides object-specific security

   E. Can relate many tables together

   F. Allows you to define constraints defining conditions that data must satisfy before it is accepted into the database

5. **Whose work pioneered relational database theory?**

   A. E. F. Skinner

   B. Edgar Winter

   C. Edgar F. Codd

   D. Edgar Piece

6. **Relate each SQL command category on the left with the appropriate commands on the right.**

SQL Command Category	Commands
Data Definition Language (DDL)	GRANT and REVOKE
Data Manipulation Language (DML)	SELECT
Data Control Language (DCL)	CREATE, ALTER, DROP, RENAME, and TRUNCATE
Data Retrieval	COMMIT, ROLLBACK, and SAVEPOINT
Transaction Control	INSERT, UPDATE, and DELETE

Answers to Chapter Questions

1. B, C, D, F. Telephone books; checkbook registers; web sites providing online auctions, ordering, and searching; and movie listings.

Explanation The essence of a database is a list that can be presented in a chosen order, and filtered to display only selected records. Front page news does not fit this description; it cannot be sorted or filtered. The same is true for ads. However, the other categories do fit this description.

2. C. It stores information about one type of thing.

Explanation Choices A and D are true, but they are also true of spreadsheets, so they cannot be a table's most significant characteristic. B is also true, but its importance does not compare with choice C. The single most important characteristic of a table is that it stores information about one type of thing.

3.

Term	Description
Row	One line in a table
Record	Data contained in a table row
Column	Collection of one type of information stored in a table (for instance, all of the phone numbers or all of the last names)
Field	Contains a single piece of information about something
Table	Stores all information about one type of thing (for instance, people or products)

Term	Description
Database	Collection of related tables
Constraint	Defines what must be true about the data in order for it to be accepted by the database

4. A, C, D, E, F. Can handle billions of rows, can accommodate thousands of simultaneous users, provides object-specific security, can relate many tables together, allows you to define constraints defining conditions that data must satisfy before it is accepted into the database.

Explanation Each of the answers provided is a powerful reason for using a relational database to handle large quantities of information, with the exception of B. Large databases do not run only on PCs—for instance, Oracle is available for computers running Unix, Linux, Windows NT, and a variety of other operating systems. Even if it was available only on PCs, that would be a liability, not an asset, because the other operating systems are designed for industrial-strength use and tend to be more stable than PC-based systems.

5. C. Edgar F. Codd

Explanation Dr. Edgar F. Codd published ground-breaking papers about relational database theory in 1969. He is widely regarded as the father of relational database design.

6.

SQL Command Category	Commands
Data Definition Language (DDL)	CREATE, ALTER, DROP, RENAME, and TRUNCATE
Data Manipulation Language (DML)	INSERT, UPDATE, and DELETE
Data Control Language (DCL)	GRANT and REVOKE
Data Retrieval	SELECT
Transaction Control	COMMIT, ROLLBACK, and SAVEPOINT

CHAPTER 2

Storing and Retrieving Data: The Basics

his chapter is going to be a lot of fun, because you're going to step out of the realm of theory and start getting your hands dirty. The chapter starts with a quick exercise in which you will create a table, insert records into it, view those records, and then delete the table. This exercise is deliberately kept quick and simple; it's like testing the temperature of a lake before jumping in. Next, you will take an extended tour of these activities, learning many details about creating versatile tables, inserting various types of data into them, and viewing the information they contain in a myriad of ways.

Putting Your Toe in the Water

In this section, you will do a quick exercise to see, in a basic way, what a database does. This will be a very simple exercise; databases can do infinitely more than what you will see in the next few pages. The purpose of this step is to give you some of the "big picture" about how basic database techniques fit together. That framework will help you later in the chapter: As you learn more detailed techniques, you can put them into the context of the "big picture."

To perform the steps that follow, you need to be running SQL*Plus, the program supplied by Oracle that lets you communicate with a database. To do that, you will need to be given a user ID, password, and database name by your database administrator, and shown how to start SQL*Plus on your own computer system. (Explaining how to set up an Oracle database and configure SQL*Plus is beyond the scope of this book. If you would like to learn more about it, check your Oracle documentation. If you do not have access to an Oracle server, you can download a free single-user version of the Oracle database by joining the Oracle Technology Network at http://otn.oracle.com.)

Assuming you have been given the necessary information and now have SQL*Plus showing an SQL> prompt, let's proceed.

Creating a Table

As you will recall from the first chapter, a table is constructed something like a spreadsheet: It is made up of columns, and you place rows of data into it. Before you can add the rows of data, you must define the columns that make up the table. You do this with the CREATE TABLE command. To see how this command works, enter the following code at the SQL> prompt:

```
CREATE TABLE plsql101_test_1 (
     first_name CHAR(15),
     last_name  CHAR(20)
     )
;
```

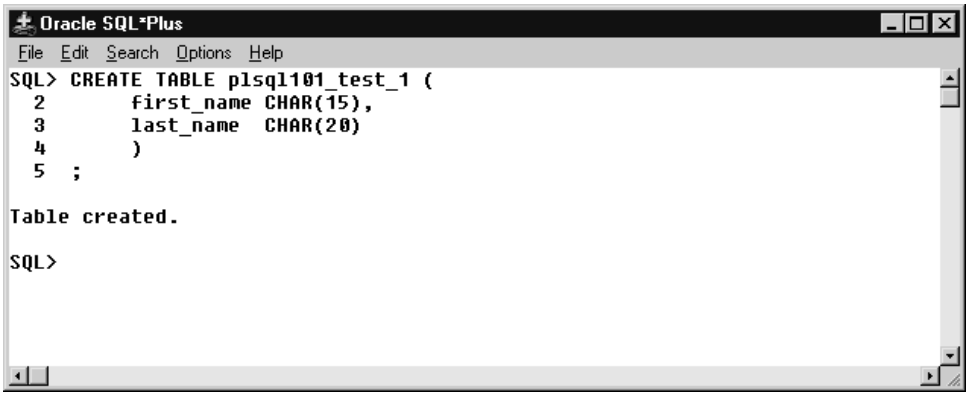


FIGURE 2-1. *Results of CREATE TABLE command*

After you have typed this command, press ENTER. Your screen should look like the one shown in Figure 2-1.

This is the SQL*Plus way of telling you that the command was successful. (If you see any other response, check the spelling in your command and try again.) You now have a table in Oracle! The structure of the command you used to create the table will be discussed in detail later in this chapter. For now, let's proceed directly to using the table by entering some records into it.

Inserting Records

To place records in a table, use the INSERT command. In SQL*Plus, type the following line at the SQL> prompt:

```
INSERT INTO plsql101_test_1 VALUES ('Jane', 'Smith');
```

After you have typed this command, press ENTER. You should see a response similar to the one shown in Figure 2-2.

Your table now contains its first record. To add a second record, type the following line into SQL*Plus and press ENTER:

```
INSERT INTO plsql101_test_1 VALUES ('Christopher', 'Allen');
```

Now your table contains two separate records. As you may have noticed, INSERT places records into a table one at a time. How do you see those records? Read on.

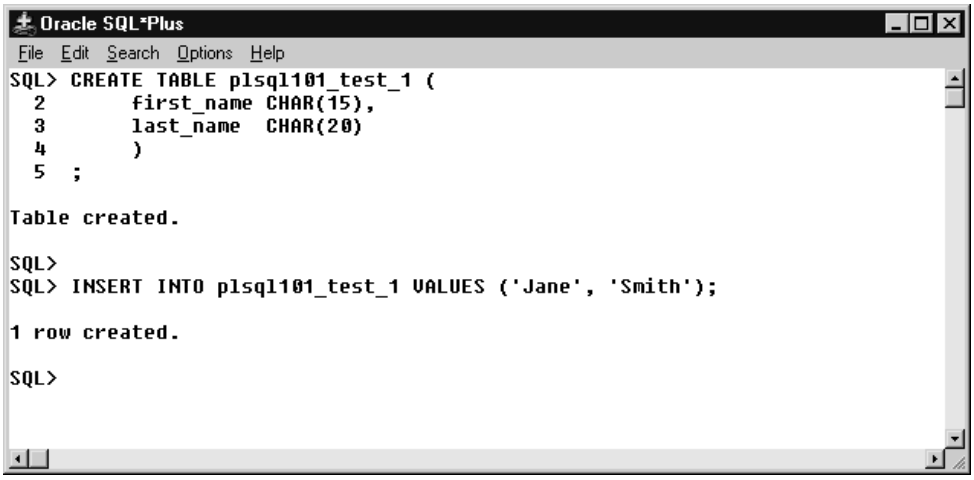


FIGURE 2-2. *Results of INSERT command*

NOTE
From this point on, the text will not tell you to press ENTER *after every command. It will simply instruct you to enter one or more lines of SQL commands. Press* ENTER *after every line in order for SQL*Plus to accept the commands.*

Selecting Records

To see the records you have inserted into your table, enter the following command:

```
SELECT * FROM plsql101_test_1;
```

In response, you should see the two records you entered, as shown in Figure 2-3.

Deleting a Table

To complete this first foray into the world of databases, you will delete the table you created.

NOTE
Deleting a table is a serious step! It is not reversible! Only use this command when you are absolutely certain you do not need the records the table contains.

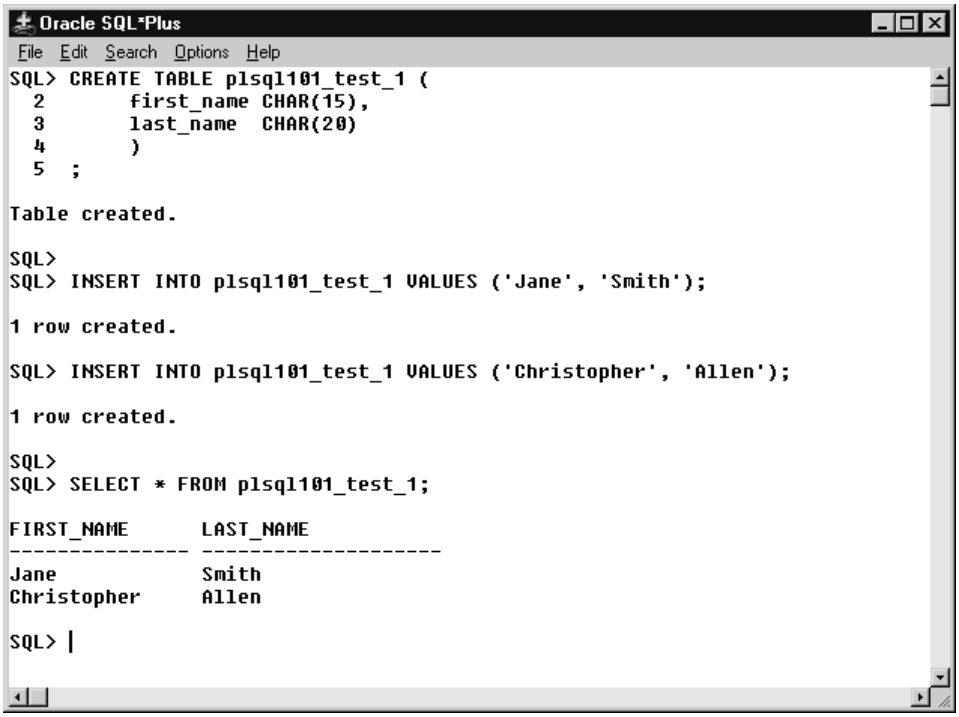


FIGURE 2-3. *Results of SELECT command*

To delete your table, enter the following command:

```
DROP TABLE plsql101_test_1;
```

Your screen should show the response depicted in Figure 2-4.

This response tells you that the command succeeded. You can double-check this by trying to select records from the table, using the command that follows:

```
SELECT * FROM plsql101_test_1;
```

You should see a display similar to the one shown in Figure 2-5. With this command, you are attempting to select records from a table that doesn't exist. In response, Oracle displays four lines of text. The first response line repeats the portion of your command where Oracle encountered a problem. (Since your command was only one line long, that is the line shown.) The second response line places an asterisk (*) beneath the spot in the command line where Oracle

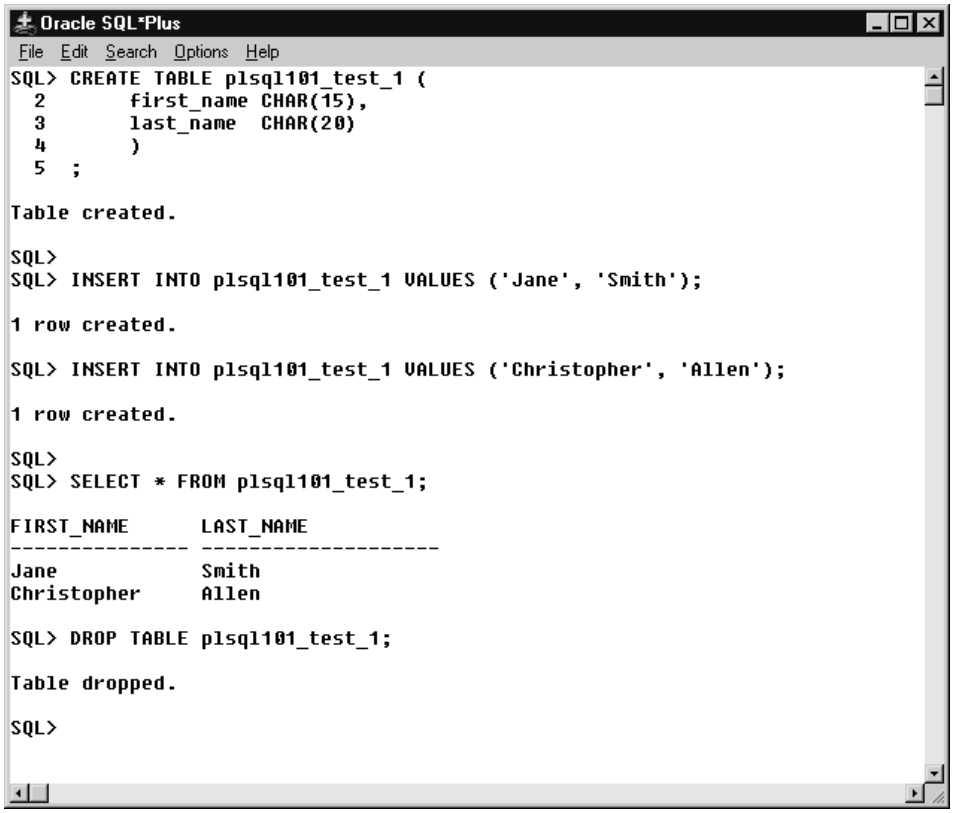


FIGURE 2-4. *Results of DROP TABLE command*

started getting confused. The third response line announces that there was an error, and the fourth response line tells you what that error is—in this case, that the table you have named (PLSQL101_TEST_1) doesn't exist.

The steps you just took demonstrated the most basic functions of a table: to receive, store, and supply information. Good job! You're done with the book now.

Okay, not really. The steps you have taken show just a tiny part of what you can do with a database. To learn more, read on.

Creating Tables

Databases are all about storing data, and data is stored in tables. To make a database useful, you need to know how to create tables that are somewhat more sophisticated

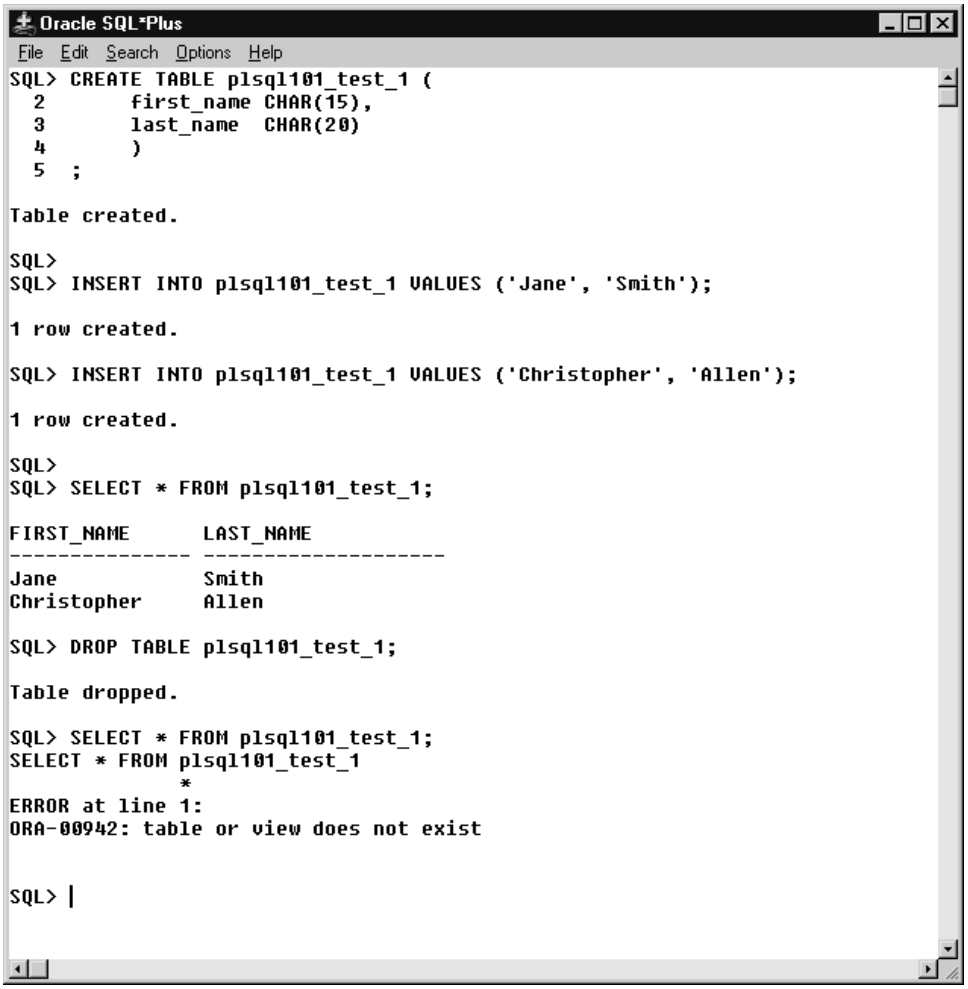


FIGURE 2-5. *Results when trying to select from a non-existent table*

than the one you created in the prior exercise. You need to know how to create tables that:

- Store various types of data, such as text, numbers, and dates
- Enforce length limits on the data entered
- Prohibit records from being entered if specific columns are empty

- Ensure that the values being entered in specific columns fall within a reasonable range
- Relate, in a sensible way, to data stored in other tables

In this section, you will learn how to create tables satisfying the first three of these points. The last two points will be covered in Chapter 7.

Guidelines for Naming Tables and Columns

There are certain guidelines you must follow regarding the names you give tables and columns. Some of them are hard-and-fast rules, while others are recommendations that will keep your tables from looking like they were created by a novice.

Rules

The following rules are true for any table or column. Do your best to memorize these *now* to save yourself some head-scratching later when you inadvertently try to specify a name that violates one or more of the rules. (It's a good idea to put a copy of these rules on a piece of paper that you can refer to while practicing your SQL commands.)

- The maximum length of a table or column name is 30 characters.
- Table or column names can include letters, numbers, and the underscore character (_). (There are a couple of other special characters that can be used if you employ an inconvenient workaround, but using them would be nothing but trouble, so you should stick with letters, numbers, and the underscore character.)
- Table or column names must start with an alphabetic character. A name can include numbers or underscores, but it must start with a letter.
- Uppercase and lowercase characters are treated the same in table and column names.
- A table or column name cannot contain spaces.
- Tables in Oracle are assigned to users; by default, they are assigned to whichever user created them. Every one of a user's tables must have a name that is different than all the other tables the user owns. In other words, a user cannot have two tables with the same name. (It is okay for different users to create tables with the same names, however.) Within a table, all of the columns must have unique names.
- Certain words represent commands and parameters to Oracle itself, and therefore cannot be used to name a table or column. You probably won't memorize all these "reserved" words, but it's good to get an idea of what they are. The restricted words are shown in Table 2-1.

TIP
Speaking just of table names, one way to ensure that a table name never matches an Oracle reserved word is to preface every table's name with an abbreviation denoting the system that the table is part of. For instance, in an Accounts Payable system, each table's name could begin with "AP_".

ACCESS	ADD	ALL	ALTER	AND
ANY	AS	ASC	AUDIT	BETWEEN
BY	CHAR	CHECK	CLUSTER	COLUMN
COMMENT	COMPRESS	CONNECT	CREATE	CURRENT
DATE	DECIMAL	DEFAULT	DELETE	DESC
DISTINCT	DROP	ELSE	EXCLUSIVE	EXISTS
FILE	FLOAT	FOR	FROM	GRANT
GROUP	HAVING	IDENTIFIED	IMMEDIATE	IN
INCREMENT	INDEX	INITIAL	INSERT	INTEGER
INTERSECT	INTO	IS	LEVEL	LIKE
LOCK	LONG	MAXEXTENTS	MINUS	MLSLABEL
MODE	MODIFY	NOAUDIT	NOCOMPRESS	NOT
NOWAIT	NULL	NUMBER	OF	OFFLINE
ON	ONLINE	OPTION	OR	ORDER
PCTFREE	PRIOR	PRIVILEGES	PUBLIC	RAW
RENAME	RESOURCE	REVOKE	ROW	ROWID
ROWNUM	ROWS	SELECT	SESSION	SET
SHARE	SIZE	SMALLINT	START	SUCCESSFUL
SYNONYM	SYSDATE	TABLE	THEN	TO
TRIGGER	UID	UNION	UNIQUE	UPDATE
USER	VALIDATE	VALUES	VARCHAR	VARCHAR2
VIEW	WHENEVER	WHERE	WITH	

TABLE 2-1. *Oracle Commands and Reserved Words that Cannot be Part of Table or Column Names*

Recommendations

The following items are good to keep in mind when designing your tables:

- Table names should be singular, not plural. I know the PRODUCT table is going to contain records for multiple products. So does everyone else, so you don't need to indicate that in the table's name. Keep the name singular so that when you look at a diagram showing the database's tables (discussed in Chapter 7), you can move from table to table saying things like "A PRODUCT is referenced by a PURCHASE ORDER…"
- Don't include the word TABLE or DATA in a table name. Experienced users understand that an object that stores information in a database is a table, and that tables store data. You don't need to remind them by putting TABLE or DATA in the tables' names.

Creating a More Involved Table

When creating a table, you have to tell Oracle the *datatype* and length for each column. Oracle tables can store all kinds of data, including text, numbers, dates, pictures, sound files, and other items. Oracle has specific features related to each kind of data. By far, the most common types of data in a table are text, numbers, and dates. What follows are examples of how to specify each of these common datatypes, along with explanations of the features that differentiate one datatype from another.

How Oracle Stores Text

As a basis for this topic, it's important to be clear about what a database considers to be text. It might seem obvious, but it isn't always, because some text columns are meant to store nothing but numbers.

A text column can store letters, numbers, spaces, and special characters—anything you can type on the keyboard. When a number is entered into a text column, it is still text; it's just text that happens to display as a number character. Numbers in text columns cannot be added, averaged, or subjected to any other mathematical operation. (However, there are functions enabling you to convert numbers in text columns to numbers for math purposes…but we'll save that for later.)

So why would you ever put a number in a text column, if you can't do math with it? Because there are situations where numbers are used for things other than math—telephone numbers, for instance. Consider this phone number:

(800) 555-1212

It consists of numbers and symbols that could be interpreted in a mathematical way—but doing so wouldn't make any sense. The same is true for ZIP codes (12345-6789) and Social Security numbers (123-45-6789). In each of these cases, the data is

comprised of numbers and math symbols, but is never intended to be added, subtracted, and so on. This type of data is best stored in a text column.

TIP
When you want to store numbers in a table, how can you decide whether to use a number or text column? Ask yourself whether you will ever be adding the numbers, averaging them, or performing any other mathematical operations on them. If so, use a number column. If not, it's probably better to use a text column.

Oracle offers a number of different ways to store text, and each way is appropriate for a different type of use. The most straightforward text datatype is the one you used when creating the table in the "Creating a Table" section; that datatype is called CHAR (short for "character"). When you define a CHAR column for a table, you also specify the maximum number of characters the column can hold. You accomplish this using a command constructed like the one that follows (don't enter this one yet—it is only an example):

```
CREATE TABLE table_name (column_name CHAR(n));
```

This simple example shows the language you would use to create a table with one CHAR column. Note that three locations in the example are italicized: the table name, the column name, and the number of characters the column can hold. When italics are used in an example command like this, they indicate locations where you would put in your own information, rather than typing exactly what is in the italicized text. In this case, the italics indicate where you would place your own table name, column name, and column length into the command. Examples like this, which show how a command is constructed, demonstrate the command's *syntax*.

The column's length is indicated with the character "n." In the world of databases, "n" is used to represent a location in which a number will be placed. You fill in the number that is appropriate for your application.

TIP
It is possible to define a CHAR column without specifying its length. If you do, a default length of 1 will be assigned. However, it is considered sloppy technique to define a column without specifying its length explicitly. Be sure to specify the column's length in all situations, even if that length is 1.The other column datatype for storing text is VARCHAR2 (short for "variable-length character"). Like CHAR, the VARCHAR2 datatype stores text, numbers, and special characters. So how is it different? When a CHAR column is designed to store, say, ten characters of text, it stores ten characters of text even if the data entered

doesn't consume all of those characters. A CHAR column will pad the end of the data with spaces until it is the full length of the column. So the name "George" entered into a CHAR(10) column would actually be stored as "George" with four spaces following it. Since there is no point in storing additional spaces in a column whose contents will vary in length, CHAR columns are best suited for columns where the length of the text is known to be fixed, such as abbreviations for states, countries, or gender.

In contrast, a VARCHAR2 stores only as many characters as are typed. A VARCHAR2(10) column storing "George" would only store six characters of data. The VARCHAR2 datatype is best suited for columns where the length of the text cannot be precisely predicted for each record, which describes most text columns stored in a database, such as names, descriptions, and so on.

NOTE
Why is it called VARCHAR2 instead of VARCHAR? Good question. There is a datatype named VARCHAR as well. In early versions of Oracle, the maximum length of a VARCHAR column was 1,000 characters, later expanded to 4,000 characters for the datatype VARCHAR2. In current versions of Oracle, both datatypes enjoy the 4,000-character limit. However, Oracle Corporation says they may change the behavior of a VARCHAR column in the future—and we have no way of knowing how the "changed" VARCHAR will behave—so you should always specify the full VARCHAR2 datatype name.

To try out these two text datatypes, enter the following code into SQL*Plus:

```
CREATE TABLE plsql101_test_2 (
     name   VARCHAR2(20),
     gender CHAR(1)
     )
;

INSERT INTO plsql101_test_2 VALUES ('George', 'M');
INSERT INTO plsql101_test_2 VALUES ('Jane', 'F');

SELECT * FROM plsql101_test_2;

DROP TABLE plsql101_test_2;
```

When you are done, your SQL*Plus screen should look similar to the one shown in Figure 2-6.

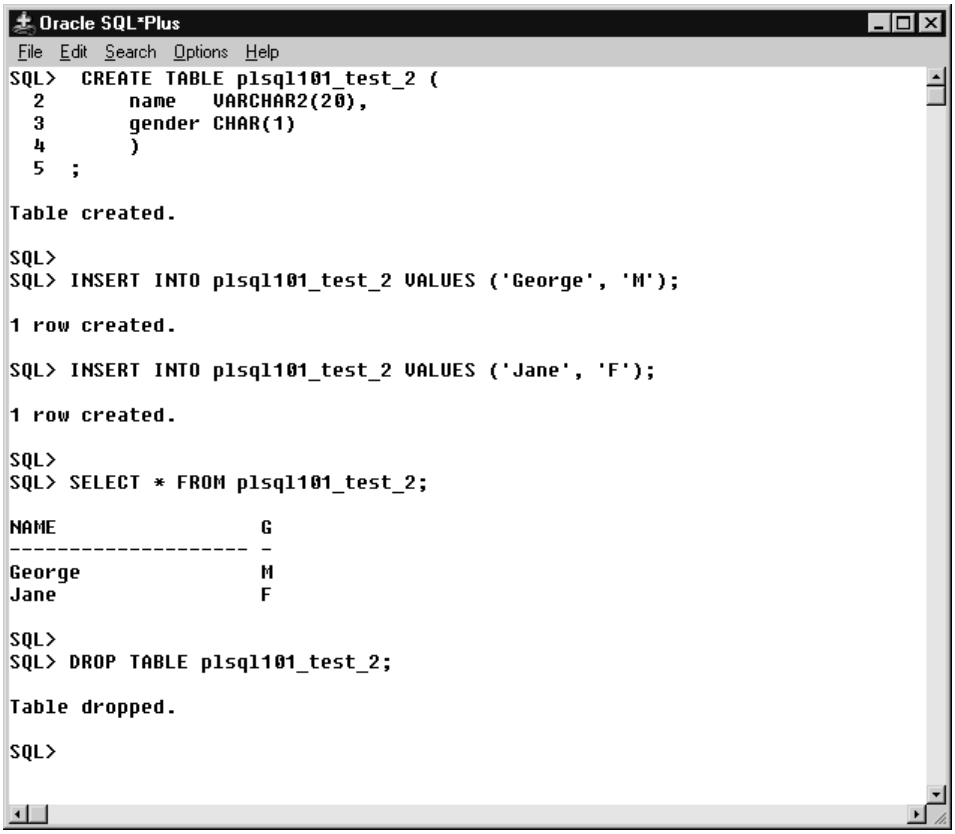


FIGURE 2-6. *Inserting records with CHAR and VARCHAR2 values*

TIP
You may have noticed that in an INSERT command, text is surrounded by single quotes. This holds true regardless of the type of SQL command you use. Text data is always surrounded by single quotes. Numbers are not.

There are also column datatypes designed to store very large amounts of text: LONG and CLOB. The LONG datatype can store up to 2,147,483,647 characters (two gigabytes) of text. The CLOB (which stands for Character Large OBject) datatype can store over 4 billion characters (four gigabytes) of text. This immense capacity comes at a price, however: these datatypes have restrictions on how they can be used. Using these datatypes is outside the scope of a "101" book, but if you need that type of storage, you can find out everything you need to know by checking Oracle's online documentation.

TIP

In the language of techies, a piece of text is called a string, which is a short way of saying "a string of characters." People who work with data a lot often use the terms "text" and "string" interchangeably. Another common term is ASCII, which stands for American Standard Code for Information Interchange. (It's pronounced "ask-ee".) ASCII is an agreed-upon standard for the computer values that represent text, numbers, the special characters on your keyboard, and a few special codes for controlling devices like printers. It's the "lowest common denominator" standard for transferring information between computers. In standard daily use, "ASCII" is used to indicate that a file essentially contains just text—no formatting, margins, boldface, or underlining. For instance, a Microsoft Word .doc file is not ASCII, but if you use the File | Save As command in Word to save the file with a type of Text Only, the resulting file will be ASCII. You can open ASCII files on any word processor or text editor.

How Oracle Stores Numbers

To define columns that will store numbers within a table, you use the NUMBER column datatype. When defining a NUMBER column, you also specify how many digits the column will need to store. This specification can be in two parts: the total number of digits the column can store, before a value's decimal point, and the number of digits it can store after the decimal point.

For instance, let's say you want to create a table that stores prices for products. All product prices are under one hundred dollars. Enter the following commands now to see how creating and using such a table would work:

```
CREATE TABLE plsql101_product (
     product_name  VARCHAR2(25),
     product_price NUMBER(4,2)
     )
;

INSERT INTO plsql101_product VALUES ('Product Name 1', 1);
INSERT INTO plsql101_product VALUES ('Product Name 2', 2.5);
INSERT INTO plsql101_product VALUES ('Product Name 3', 50.75);
INSERT INTO plsql101_product VALUES ('Product Name 4', 99.99);

SELECT * FROM plsql101_product;

DROP TABLE plsql101_product;
```

When you are through, your screen should look similar to Figure 2-7.

As you probably noticed, the syntax of the NUMBER datatype is as follows:

NUMBER(*total_number_of_digits, digits_after_a_decimal_point*)

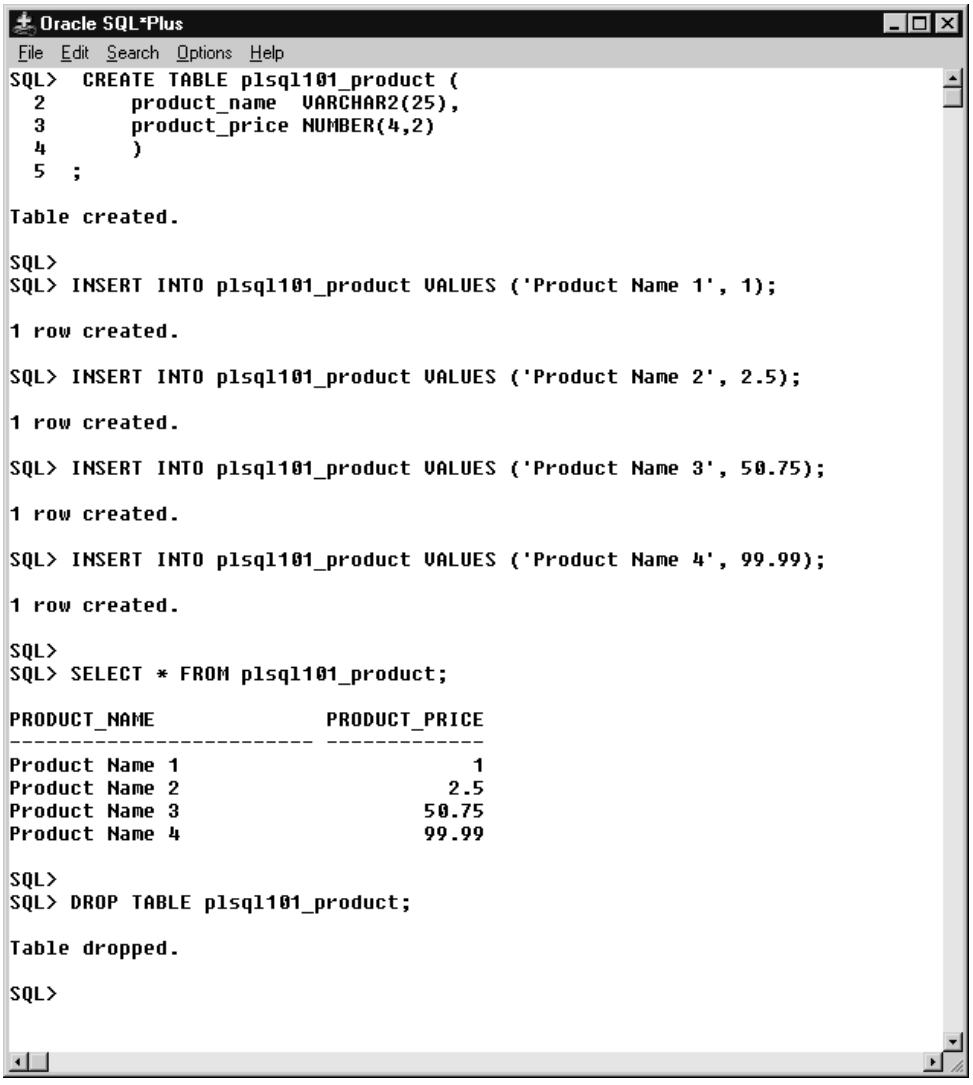


FIGURE 2-7. *Inserting records with NUMBER values*

The NUMBER datatype can store truly huge numbers. The largest value it can store is 999,999,999,999,999,999,999,999,999,999,999,990,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000. It can even store as many as 127 digits after a decimal place. This kind of industrial-strength capacity is one of the things that separates serious databases, like Oracle, from standard office productivity products, such as spreadsheets.

How Oracle Stores Dates

Dates present an interesting problem for computers. For instance, consider a list of dates like the ones that follow:

January 15, 2005
February 15, 2005
March 15, 2005

You could store this list in a text column, but the dates will not sort properly, because text columns sort from left to right, and the "F" that begins February falls before the "J" for January and the "M" for March. To get around this problem, you might use numbers to represent the months, instead of month names. This would result in the following list:

01-15-2005
02-15-2005
03-15-2005

This would sort the months properly. If the dates within each month were different, this approach would handle that too, since the day-of-the-month characters follow the month characters. However, if the years are different, this approach has a problem. Consider this variation on the list:

01-15-2010
02-15-2005
03-15-2000

If these are stored in a text column and then sorted, they will sort into exactly the order shown, because text columns sort from left to right. As soon as Oracle sees that the second record's first two characters are "02," it's going to put it after the record whose first two characters are "01," no matter what characters follow.

A workaround to this problem would be to put the year first. This approach would make the list look as follows:

2010-01-15
2005-02-15
2000-03-15

From the standpoint of sorting, this would work quite well. With the characters being read from left to right, a sorted version of the list would look like this:

2000-03-15
2005-02-15
2010-01-15

That's a very nice solution, as long as all you need to do with dates is sort them into the proper chronological order. However, lots of business situations require you to do more with dates than just sort them. Accounting departments want to know what receivables are due during the next 15 days, and who is more than 30 days late in paying their bill. Executives want to know how this period's sales compare with the same period last year. Managers want to know how long a project will take if all of the lead times double. This type of work requires the ability to compare two dates and count how many days (or weeks, months, or years) separate them. This is called *date arithmetic*.

You can't do date arithmetic with dates stored as text, because the text representations have no intrinsic value as dates. They're just strings of text characters that we, as humans, have agreed to interpret as dates. What's needed for date arithmetic is a means of converting dates into numbers. Since most date arithmetic involves counting days, the most useful approach would be one in which each day has a unique number, and tomorrow's number will be one higher than today's. That way, if you subtract an earlier date from a later one, the difference will be the number of days between the two.

With humans being clever and all, an approach to keeping track of days in this manner already exists: *Julian dates*. When a system uses Julian dates, it specifies a starting date as day 1; the next day is called day 2, and so on. Since each subsequent day increments the count by one, this type of calendar is ideally suited for date arithmetic. Oracle supports Julian dates, and its starting date is January 1, 4712 BC. Oracle automatically handles the conversion of dates between the visual format we can understand (for example, '08-MAY-2004') and the Julian date equivalent. We just insert dates using a familiar text representation, and Oracle converts them to their Julian equivalent behind the scenes. When we select those dates back out from the table, they appear in the familiar form of days, months, and years. We never have to look at dates in their Julian form.

To get a taste of how dates work in Oracle, enter the commands that follow:

```
CREATE TABLE plsql101_purchase (
     product_name  VARCHAR2(25),
     product_price NUMBER(4,2),
     purchase_date DATE
     )
;
```

```
INSERT INTO plsql101_purchase VALUES
     ('Product Name 1', 1, '5-NOV-03');
INSERT INTO plsql101_purchase VALUES
     ('Product Name 2', 2.5, '29-JUN-04');
INSERT INTO plsql101_purchase VALUES
     ('Product Name 3', 50.75, '10-DEC-05');
INSERT INTO plsql101_purchase VALUES
     ('Product Name 4', 99.99, '31-AUG-06');
```

After completing this exercise, your screen should look like the one shown in Figure 2-8.

TIP
Dates must be surrounded by single quotes in SQL statements, just like text strings.

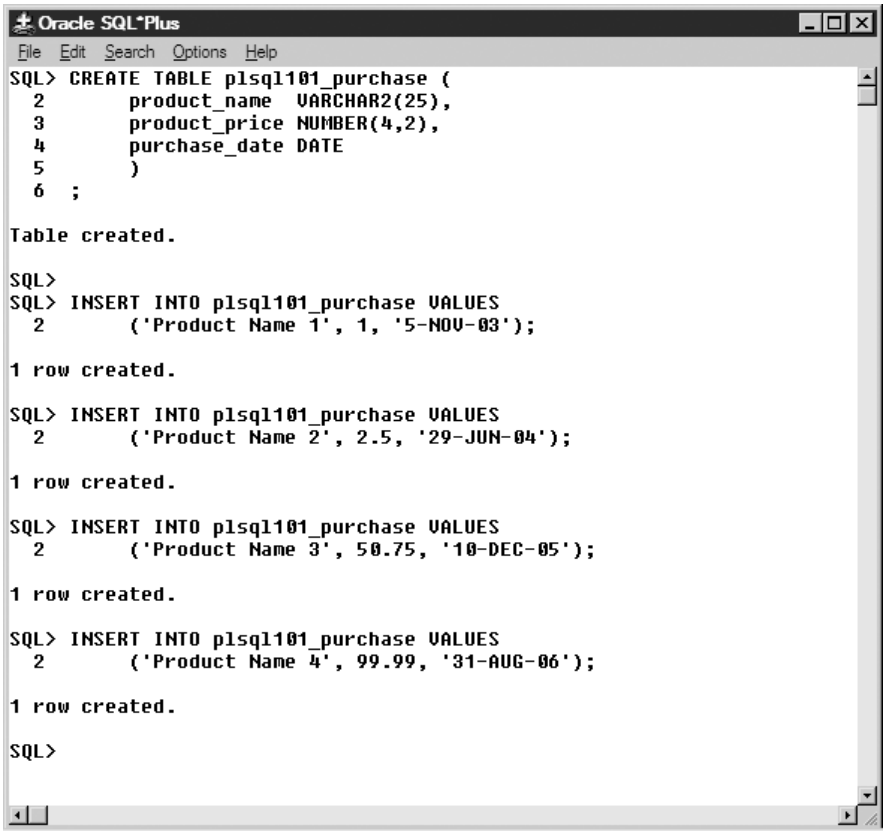


FIGURE 2-8. *Inserting records with DATE values*

Julian dates have other benefits in addition to accommodating date arithmetic. For instance, if someone tries to insert the date February 29, 2006 into an Oracle date column, Oracle will prevent the insertion from succeeding, because it recognizes that 2006 is not a leap year and therefore does not have a February 29. In addition, Julian dates can store time values. Time is stored as a decimal value following the integer that represents the date (or following 0 if the value is solely a time, with no date component). For instance, if a given day's Julian date value is 54321, then noon on that day would be stored as 54321.5 (the .5 shows that half of the day has gone by—the portion of the day necessary to reach noon). Oracle would store 6:00 A.M. on that same day as 54321.25, and 6:00 P.M. would be 54321.75. Other times would be stored as values that aren't nearly so tidy; for instance, 3:16 P.M. would add .636111111 to the day's Julian value. (You will have the opportunity to experiment with this feature in Chapter 6.)

Determining a Table's Structure

When you create your own table, you know what its structure is…for a while. Then other things take up that space in your memory and you forget. Moreover, if someone else created the table, you won't know what its structure is at all. What you need is a way to find out the structure of an existing table. You probably won't be surprised to learn that Oracle provides a command that does just that. The command is DESCRIBE, which can be shortened to DESC. Its syntax is as follows:

```
DESC table_name
```

This is one of the few commands that does not need to be ended with a semicolon. However, including it doesn't hurt anything, so you may want to include the semicolon just to reinforce the habit.

To see how the DESC command works, enter the following command:

```
DESC plsql101_purchase
```

The display you see in response should look like the one shown in Figure 2-9. The DESC command's output consists of three columns: Name, Null?, and Type. The Name column lists each of the table's columns by name, in the order that the columns appear in the table. The Null? column's purpose will be explained in the next paragraph, and the Type column shows the datatype and length for each of the table's columns.

NULL and NOT NULL Columns

When you design tables to store information for a particular purpose (let's use the word *application* in place of "purpose"), you have the ability to exercise quite a bit of control over what can and cannot go into those tables. Because you have

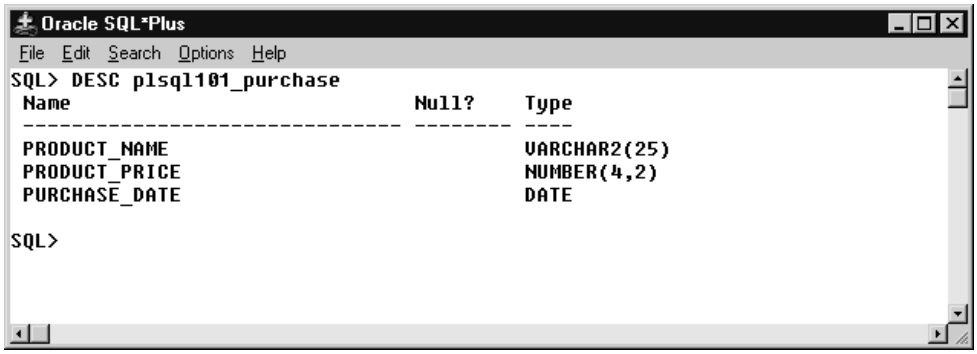


FIGURE 2-9. *Results of the DESCRIBE command*

the ability, you also have the responsibility to use this capability in a way that will ensure that the data that makes it into your tables is of the highest quality possible. One of the first things to decide is which columns in a record must contain data, and which columns can be blank.

By default, every column in a table is optional. That means you can enter records that have data in some, but not all, of the columns. The columns without data are considered *null*, meaning "empty." A zero is not null, and a space is not null; both are real values that may or may not have significance in a particular context. When a column is null, it truly contains no value whatsoever.

It might seem like it would be a good idea to make every one of a table's columns required for entry. That is sometimes a good approach, but usually not: Most tables contain columns that won't necessarily be filled in, or that may be filled in later, after the initial entry of the record. For instance, consider a table that will store information about people. Let's say the people are employees within a company. The information you want to store about each person might look like this:

First Name
Last Name
Hire Date
Job Title
Department
Supervisor
Salary
Birth Date
Insurance Plan
Phone Extension

TIP
Individual pieces of information like First Name and Salary are called attributes in database language. Attributes are directly related to columns in a table. The column is the means of physical storage; the attribute is the content being stored in each column for each row.

Does every one of these attributes need to be filled in (or *populated*) in order for an employee's record to be acceptable? Not really. When a new person is hired, the company can't know what insurance plan the employee will choose. In addition, it's possible that the employee's birth date and phone extension will not be immediately known. Requiring that these columns contain data in order for a record to be accepted would make the table unusable for its intended purpose.

On the other hand, it would be a very good idea to require data in some of the other columns. For instance, a record without a first name, last name, hire date, and salary is not likely to be usable, so those columns should be required.

You can specify which columns are required when you issue a CREATE TABLE command. (You can also change an existing table; that will be covered in Chapter 3.) Within the command, you identify a column as required by placing the words NOT NULL after the column's name and datatype. To see this in action, enter the following commands into SQL*Plus:


```
DROP TABLE plsql101_purchase;

CREATE TABLE plsql101_purchase (
     product_name  VARCHAR2(25) NOT NULL,
     product_price NUMBER(4,2)  NOT NULL,
     purchase_date DATE
     )
;
```

When you are done, your screen should look similar to Figure 2-10. To test the results of defining a column as NOT NULL, you need to know how to insert a record that does not contain data for every column in the table. That is the first topic in the following section.

Inserting Data—Additional Techniques

If you have done the exercises up to this point, you have already practiced the basics of inserting data into a table. Now it is time to learn some more advanced techniques.

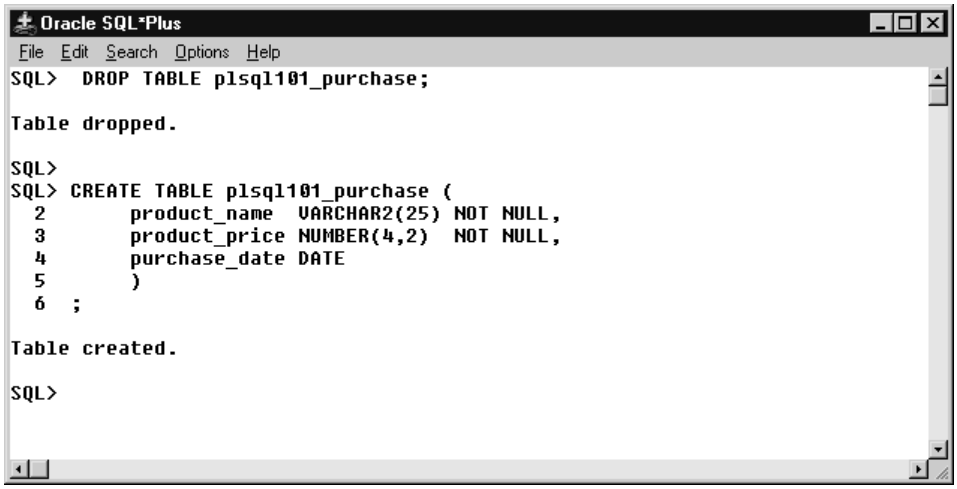


FIGURE 2-10. *Creating a table with NOT NULL columns*

In this section, you will learn how to insert records containing data in some, but not all, columns, as well as how to insert data containing apostrophes.

How to Insert Records Containing Null Values

Earlier in the chapter you learned that a null value is an empty attribute—for instance, a blank birth date in a personnel record. You will probably run into a variety of situations that call for inserting records with null values in certain columns. There are two ways to accomplish this.

The first technique is to just use the word "NULL" in the INSERT statement wherever you would have specified a value. For instance, in the most recent table you created (PLSQL101_PURCHASE), the product name and product price are required, but the purchase date is not. Therefore, you could insert a record that populates just the first two attributes by entering the following commands:

```
INSERT INTO plsql101_purchase VALUES ('Product Name 1', 1, NULL);

SELECT * FROM plsql101_purchase;
```

Your screen should now look similar to the one shown in Figure 2-11. Notice that when SQL*Plus displays your record in response to the SELECT command, the record's third column is blank.

Now that you know how to insert records with null values, it is time to check whether the NOT NULL settings you defined for the table's first two columns are working. How can you check this? By trying to insert a record that omits values in

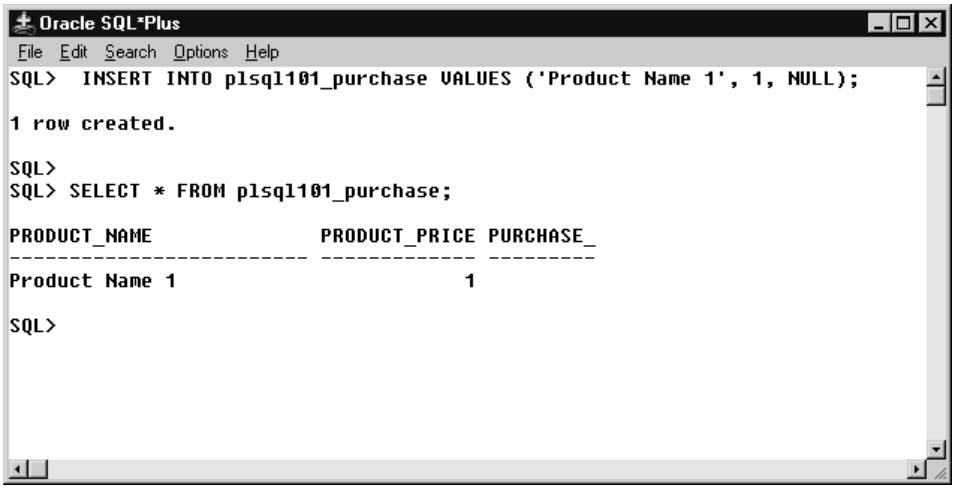


FIGURE 2-11. *Inserting records with null values—first technique*

either or both of the required columns. To be thorough, you should test all three variations: missing the product name, missing the product price, and missing both. Enter the following commands to perform these tests:

```
INSERT INTO plsql101_purchase VALUES
     (NULL, 2.5, '29-JUN-04');
INSERT INTO plsql101_purchase VALUES
     ('Product Name 3', null, '10-DEC-05');
INSERT INTO plsql101_purchase VALUES
     (NULL, NULL, '31-AUG-06');

SELECT * FROM plsql101_purchase;
```

The results of these commands should look similar to what you see in Figure 2-12. Each of the INSERT commands produced an Oracle error message reminding you in its friendly way that you can't insert null values into columns created as NOT NULL.

The second technique for inserting null values into a table produces exactly the same results as using NULL in your list of inserted values; it just achieves that result in a different way.

The technique uses a variation of the INSERT command syntax. In this variation, you explicitly name every column you are inserting data into. In all of your INSERT commands up to this point, you have not stated which columns you were inserting into; you just specified the values to be inserted. When you write INSERT commands in that way, Oracle makes two assumptions: You are inserting values into every column the table has, and the values you specify are in the same order as the columns in

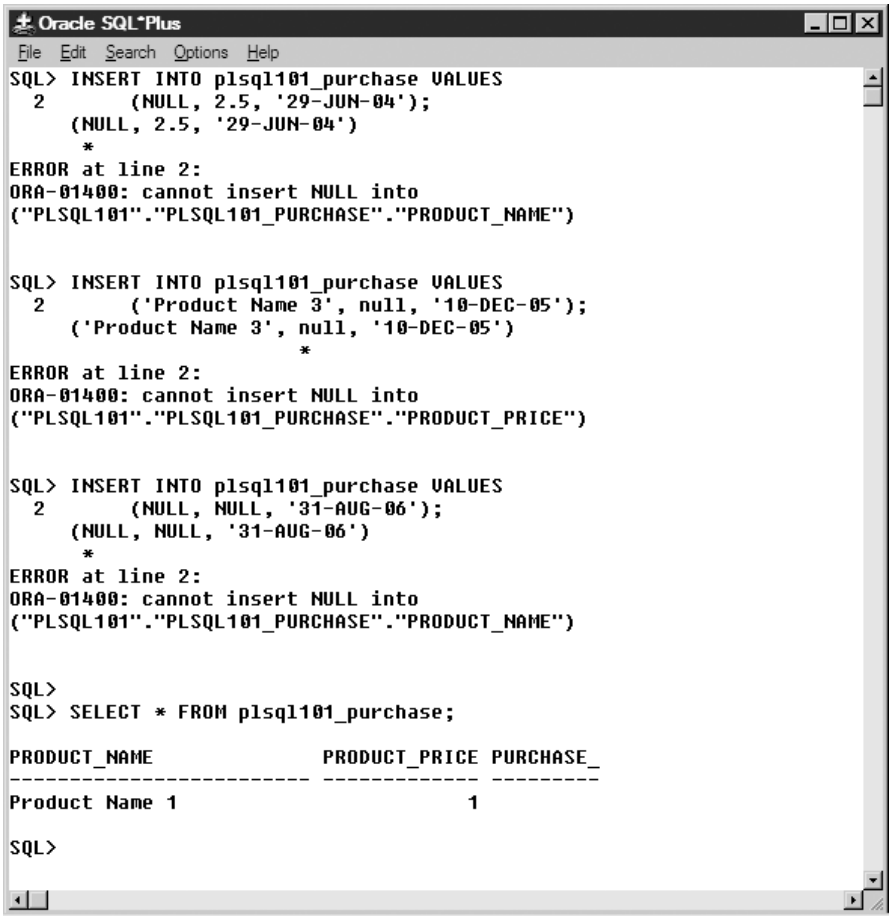


FIGURE 2-12. *Results of attempting to insert null values into NOT NULL columns*

the table. By explicitly stating which columns you are populating, and in what order, you override both of those assumptions, and give yourself the ability to skip columns altogether.

To see this in action, enter the following commands:

```
INSERT INTO plsql101_purchase (product_name, product_price)
     VALUES ('Product Name 2', 2.5);
INSERT INTO plsql101_purchase (product_name, product_price)
     VALUES ('Product Name 3', 50.75);
INSERT INTO plsql101_purchase (product_price, product_name)
     VALUES (99.99, 'Product Name 4');

SELECT * FROM plsql101_purchase;
```

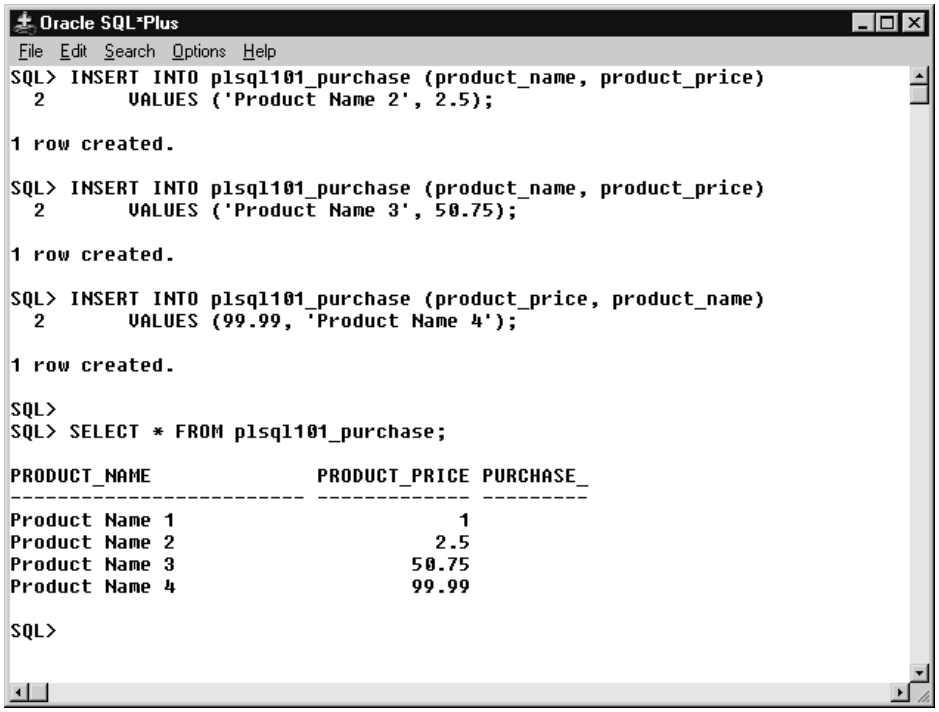


FIGURE 2-13. *Inserting records with null values—second technique*

The results you see should be similar to those shown in Figure 2-13.

Notice that in the last of the INSERT commands you just performed, the columns are named in reverse order. It doesn't matter what order you specify the columns in, as long as the values are provided in the same order as the columns are named. Generally, you will want to specify the columns in the order they occur in the table—but it's good to know how to change the INSERT command's column order if you need to.

How to Insert Data that Contains Apostrophes

At some time or another, you will probably need to insert records with text that contains apostrophes. This presents a bit of a problem, since Oracle interprets apostrophes as the beginning or end of a text string. If you try to just place an apostrophe in the middle of a piece of text and then insert it, Oracle will think that the text string ends when it reaches the apostrophe. When it discovers that more text follows the apostrophe, it will get thoroughly confused. If you would like to see this in action, enter the following command:

```
INSERT INTO plsql101_purchase VALUES
     ('Fifth Product's Name', 25, '05-MAY-06');
```

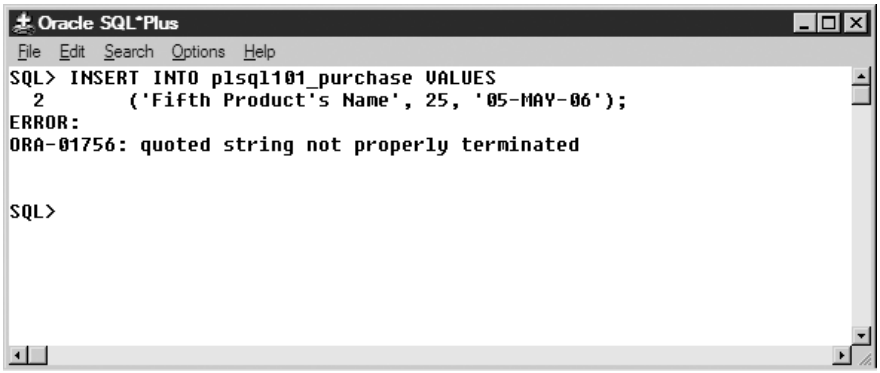


FIGURE 2-14. *Result of trying to insert a text string that contains an apostrophe*

In response, Oracle will display the error message shown in Figure 2-14.

Clearly, this approach does not work. To make it work, you have to do two things: execute a SET SCAN OFF command before the INSERT, and place two apostrophes in a row at the location in the text string where you want the single apostrophe to be inserted. The resulting commands look like this:

```
SET SCAN OFF

INSERT INTO plsql101_purchase VALUES
     ('Fifth Product''s Name', 25, '05-MAY-06');

SET SCAN ON
```

Enter those commands, and then check how well they worked by entering this one:

```
SELECT * FROM plsql101_purchase;
```

You should see your newly inserted record, as reflected in Figure 2-15.

Viewing Data—Additional Techniques

Now that you know how to do basic SELECT, it's time to learn some more sophisticated techniques for viewing data in a table. In this section, you will learn how to select specific columns out of a table, change the order in which selected columns are displayed, perform math using data in a table, connect text strings together, and change the names assigned to columns. Ready? Sure you are.

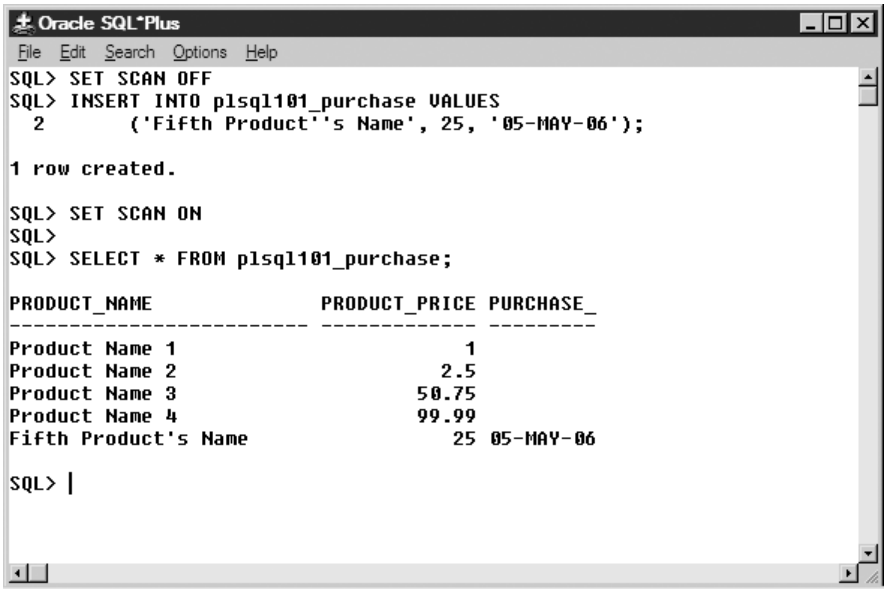


FIGURE 2-15. *Result of using correct technique to insert text containing an apostrophe*

Selecting Specific Columns

As your tables get larger, it's likely that sometime you will want to view some, but not all, of the columns in a table. It's easy to do; you just name the columns you want in your SELECT statement, rather than specifying all of them using the "*" character, as you have done up to this point. To try out this technique, enter the following command to select just the first column from the table you created earlier:

```
SELECT product_name FROM plsql101_purchase;
```

In response, you should see a display like the one shown in Figure 2-16. To practice this technique further, take a moment now to execute SELECT commands for each of the other columns in the table.

To choose more than one column, name each column you want, and place a comma between each name. For instance, to choose the first and third columns from your PLSQL101_PURCHASE table, enter the following command:

```
SELECT product_name, purchase_date FROM plsql101_purchase;
```

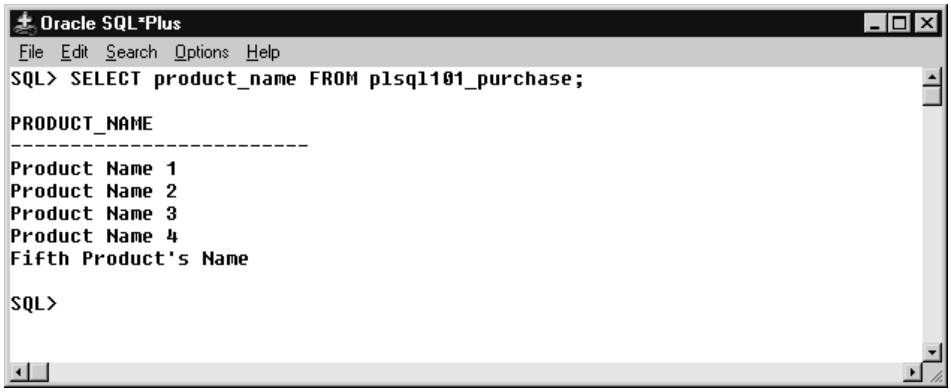


FIGURE 2-16. *Selecting specific columns*

Changing Column Order

Now that you know how to choose specific columns from a table, it's very easy to change the order in which those columns are shown. In your SELECT command, you just name the columns in the order you want them to appear.

For instance, to see the columns from the PLSQL101_PURCHASE table with the last column first and the first column last, enter this command:

```
SELECT purchase_date, product_price, product_name
FROM   plsql101_purchase;
```

In response, you should see output matching Figure 2-17. To help get familiar with this technique, take some time now to select records from your PLSQL101_PURCHASE table in varying column arrangements.

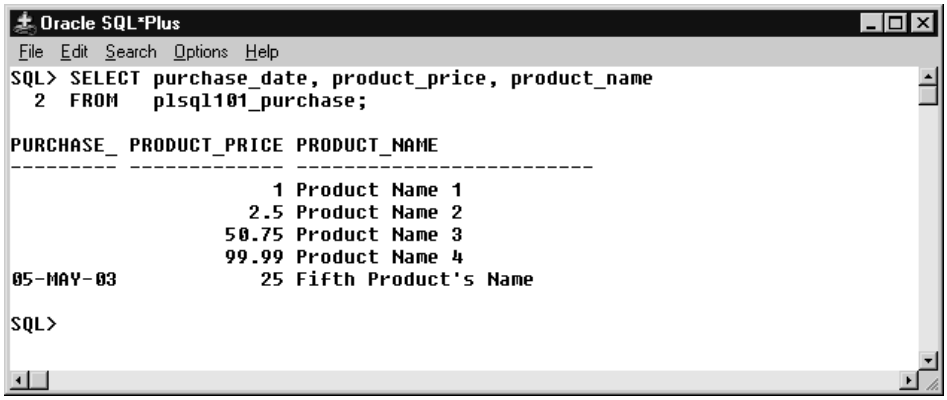


FIGURE 2-17. *Columns displayed in a custom arrangement*

Performing Math Using Data in a Table

There are many reasons why you might want to perform math operations using data stored in a table. For instance, you might want to see what the price of something would be if you increased it by 7 percent. Or you might want to calculate the amount an item costs including local tax, even if the tax isn't stored in the table. This is easy to do using SQL. You simply write SELECT statements that include the math operations.

For instance, let's say you wanted to see what the prices in the PLSQL101_PURCHASE table would look like if they were increased by 15 percent. Type in the following command to accomplish this:

```
SELECT product_name, product_price * 1.15 FROM plsql101_purchase;
```

The results you see from this command should match what is shown in Figure 2-18.

Math Operators

The techie name for math symbols is *operators*. The plus sign is an operator, for instance; so is the minus sign. Oracle supports standard four-function math: addition, subtraction, multiplication, and division. As you saw in the last example, multiplication is identified with the asterisk character (*). Division results from the / character, while addition and subtraction are produced by the + and – characters, respectively. To try each of these out in a way that is reasonably relevant to real-life work, we need to create a new table that has two number columns. The following set of commands will do this, as well as demonstrate the math operators.

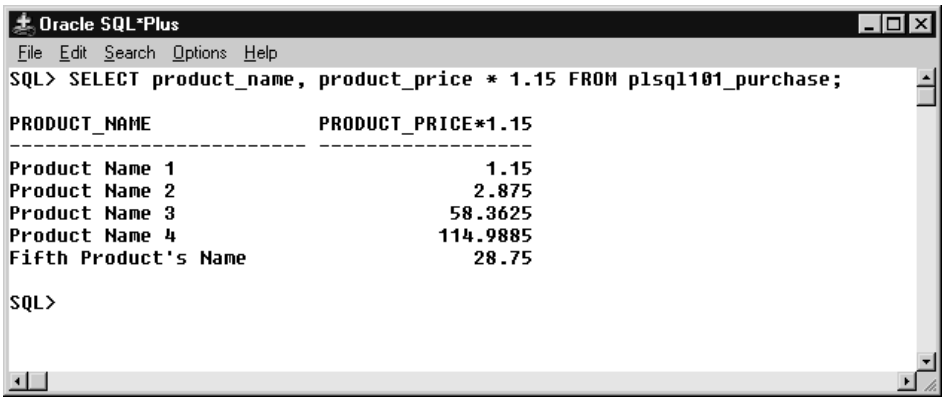


FIGURE 2-18. *Increasing a value by 15 percent*

```
DROP TABLE plsql101_purchase;

CREATE TABLE plsql101_purchase (
     product_name  VARCHAR2(25),
     product_price NUMBER(4,2),
     sales_tax     NUMBER(4,2),
     purchase_date DATE,
     salesperson   VARCHAR2(3)
     )
;

INSERT INTO plsql101_purchase VALUES
     ('Product Name 1', 1, .08, '5-NOV-04', 'AB');
INSERT INTO plsql101_purchase VALUES
     ('Product Name 2', 2.5, .21, '29-JUN-05', 'CD');
INSERT INTO plsql101_purchase VALUES
     ('Product Name 3', 50.75, 4.19, '10-DEC-06', 'EF');
INSERT INTO plsql101_purchase VALUES
     ('Product Name 4', 99.99, 8.25, '31-AUG-07', 'GH');

SELECT product_name, product_price + sales_tax FROM plsql101_purchase;
SELECT product_name, 100 - product_price FROM plsql101_purchase;
SELECT product_name, sales_tax / product_price FROM plsql101_purchase;
```

The results of the three SELECT commands should look similar to what is shown in Figure 2-19.

NOTE
This exercise demonstrates inserting dates with only two digits specifying the year. This is necessary in some versions of Oracle 7, which do not like to read a four-digit year under normal circumstances. If you are using Oracle 8 or later, it is always a good idea to specify the full four digits of a year in any SQL command.

What Is an Expression?

Within the world of Oracle, the term *expression* is used to denote a variety of things. For our purposes, it refers to the portion of a command that consists of one or more column names, NULL, a value you have entered yourself (like the ".08" in the preceding batch of commands, which would also be called a *constant* because its value is fixed), or a combination of any of those things connected by math operators. For instance, consider the following command:

```
SELECT product_name, product_price * 2 + 10 FROM plsql101_purchase;
```

In the preceding command, PRODUCT_NAME is an expression, and PRODUCT_PRICE * 2 + 10 is another expression.

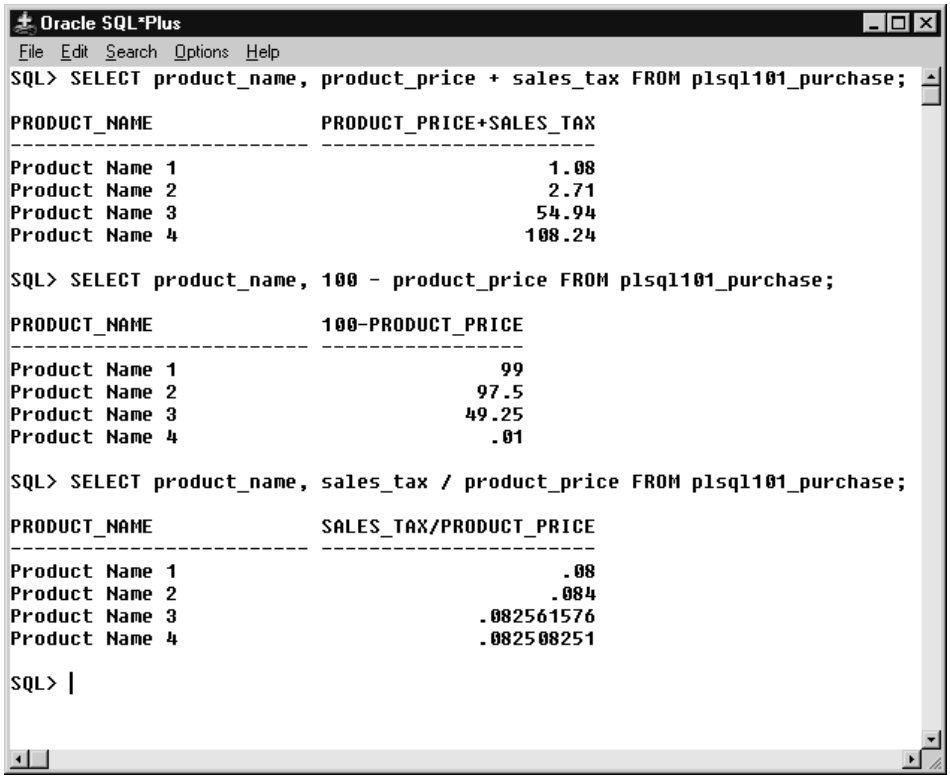


FIGURE 2-19. *SELECT commands using various math operators*

Looking at that example, you might wonder: "How does Oracle handle a situation where an expression contains more than one math operator?" That brings us to the topic of *operator precedence*.

Operator Precedence

When an expression contains more than one math operator, Oracle does have a method to decide the order in which to perform the operations. Multiplication and division are done before addition and subtraction, and from left to right. Once they are calculated, addition and subtraction are done next, also left to right.

However, many people forget which math operators are calculated first, if they ever knew at all. Because of this, it's a good idea to identify calculation precedence explicitly in your statements by using parentheses. Surround the portion of the expression you want executed first in a pair of parentheses, and there will never be any question how the expression will be calculated.

For instance, a clearer way to write the preceding example would be as follows:

```
SELECT product_name, (product_price * 2) + 10 FROM plsql101_purchase;
```

Connecting Two or More Pieces of Text Together

There are many, many situations in the world of databases where it is desirable to display the contents of two or more text columns together in one connected string of text, while continuing to store the text pieces in separate columns. For instance, a mailing label has a person's last name following their first name, and the city, state, and ZIP code (or equivalents for your country) all on the same line—but each are stored in separate columns in the table. Connecting two pieces of text is called *concatenation*.

In Oracle SELECT statements, you can indicate that two columns should be concatenated by putting two vertical bars (||) between the column names. For instance, the following command would concatenate the contents of the product name and salesperson columns:

```
SELECT product_name || salesperson
FROM plsql101_purchase;
```

However, this command's output would be hard to read because the product name would be followed immediately by the salesperson's initials; there would be no space between them. A more readable variation would be to insert between the columns a fixed string of text written to support and clarify the data that will be on either side. To separate the fixed text from the data that will surround it, it often makes sense to place a space before the fixed text, and another space after it. As is the case with other text in SQL commands, the fixed text string will be surrounded with single quotes. Type in the following command to see how this works:

```
SELECT product_name || ' was sold by ' || salesperson
FROM   plsql101_purchase;
```

The results of this command should match what you see in Figure 2-20.

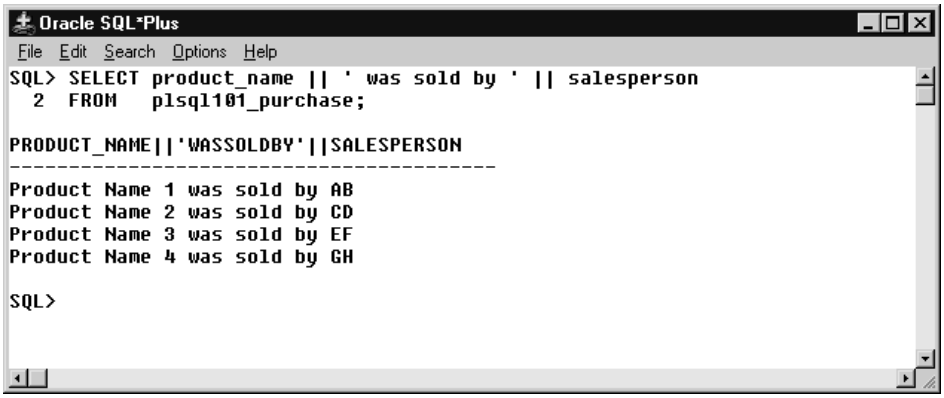


FIGURE 2-20. *Using string concatenation and literal text in a SELECT statement*

When you include fixed text in a command, the fixed text is called a *literal*. This means that it will be reproduced character for character, and not interpreted as the name of a table, column, or other object.

Assigning Aliases to Columns

You may have noticed in the last command that the column's header has gotten out of hand. By default, column headers are the column names. However, when you execute a SELECT statement that includes concatenated columns, the entire expression that generates the concatenated output is displayed as the column's header. This is usually unattractive and rarely helpful. SQL lets you define what will be placed at the top of a column in a SELECT statement. It's easy: After the column name (or expression), you just type the text you want displayed at the top of the output column.

To see this in action, enter the following variation on the previous SELECT command:

```
SELECT product_name || ' was sold by ' || salesperson SOLDBY
FROM   plsql101_purchase;
```

The surrogate name you specify for the column is called a *column alias*. This particular column alias, SOLDBY, gives a more readable column name, but it's still a little clumsy. If you surround the alias in double quotes, you can include spaces in it, and use lowercase letters, too. (You have to use double quotes here so Oracle will not try to interpret the column alias as a column name to select.) You can see this work by entering the following command:

```
SELECT product_name || ' was sold by ' || salesperson "Sold By"
FROM   plsql101_purchase;
```

Your display should look similar to the one shown in Figure 2-21.

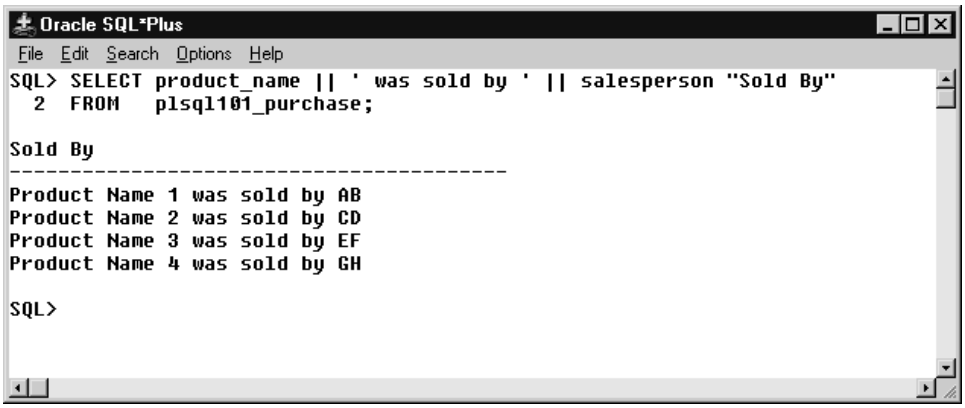


FIGURE 2-21. *Changing a column's header using a column alias*

Chapter Summary

This chapter has given you a good foundation in SQL basics. After doing a quick exercise demonstrating how a table is created, used, and dropped, you proceeded to learn and practice detailed techniques for each of these steps.

The name for a table or column can be up to 30 characters long. It must start with a letter, and can contain letters, numbers, and a small assortment of special characters, the most useful of which is the underscore (_), which you can use to visually separate words in the name. You cannot put a space in a table or column name. Oracle treats upper- and lowercase characters as identical values.

A number of words are reserved and cannot be used as table or column names; these include commands such as CREATE, as well as object names such as ROW. There are too many reserved words for most people to memorize; you will know if you accidentally use one of them because Oracle will display an error message stating "Invalid table name" or "Invalid column name" instead of completing the command. If you encounter this problem with a table name, add an abbreviation to the beginning of the name identifying what system the table is part of (for instance, AP_ADMIN instead of ADMIN). If you encounter the problem with a column name, add another word or two to the column name to more clearly describe what the column will contain.

Whenever you create a table, you are automatically assigned as the table's owner. The tables you own must all have unique names; you cannot own two tables that have the same name. (Two different Oracle users can have tables with the same name, however.) Within a table, each column must have a unique name. The same column name can be used in more than one table.

As a matter of general procedure, it is best to make table names singular, not plural: the employee table would be called EMPLOYEE, not EMPLOYEES. Also, there is no need to include the words TABLE and DATA in a table name, since both pieces of information are inferred by the fact that it is a table in the first place. When creating a table, you have to tell Oracle the datatype and length for each column. Oracle tables can store all kinds of data, including text, numbers, dates, pictures, sound files, and other items. Oracle has specific features related to each kind of data. By far, the most common types of data in a table are text, numbers, and dates.

Text columns can store letters, numbers, spaces, and special characters—anything you can type on the keyboard. When a number is entered into a text column, it is still text; it's just text that happens to display as a number character. Numbers in text columns cannot be added, averaged, or subjected to any other mathematical operation. It is common to put numbers in a text column when the numbers contain non-numeric characters, such as math symbols, alphabetic characters, or spaces. Data such as telephone numbers, Social Security numbers, and account numbers are familiar examples of text values that happen to contain a large percentage of numbers. If a numeric value is never going to be added, averaged, or in any other way involved in a mathematical operation, it is a good candidate for a text column.

There are two main types of text columns: fixed length and variable length. You can create a fixed-length column by specifying a CHAR datatype in your CREATE TABLE command. A CHAR column places spaces after any data entered, so the total length of the data (plus spaces) is always equal to the length of the column. This can be wasteful of storage space, so fixed-length CHAR columns are only appropriate for columns whose entries will always be the same length, for instance, gender or state codes.

Most text columns will contain data of varying lengths, so you will want to use the VARCHAR2 datatype when creating those columns. If the data you need to store in a text column is longer than the 2,000-character limit of a VARCHAR2 column, you can employ a LONG or CLOB datatype to store up to 4 billion characters per entry.

A text value is commonly referred to as a "string." When referring to strings in SQL commands, you must always surround the string in single quotes. Simple text containing just the characters you find on your keyboard—and no formatting characters such as the kind inserted by word processors and spreadsheets—is often called ASCII text (ASCII is the acronym for the American Standard Code for Information Interchange). ASCII is the "lowest common denominator" standard for transferring information between computers.

In contrast to text columns, Oracle offers one basic type of number column. Its datatype, appropriately enough, is NUMBER. When creating a number column, you simply specify the maximum number of digits it can hold, along with the number of decimal places its numbers will need. The largest number you can store is 999,999,999, 999,999,999,999,999,999,999,999,999,990,000,000,000,000,000,000,000,000,000, 000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000, 000,000.

Oracle provides a DATE datatype that stores both dates and times. To store dates, Oracle converts date values (which are also surrounded by single quotes) into Julian dates. Oracle automatically handles the conversion of dates between the visual format we can understand (for example, '22-FEB-2005') and the Julian date equivalent we cannot understand (for example, 32405). We insert dates using a familiar text representation, and Oracle converts them to their Julian equivalent behind the scenes. When we select those dates back out from the table, they appear in the familiar form of days, months, and years. We never have to look at dates in their Julian form.

The DATE datatype can be used to perform date arithmetic. For instance, to produce a date one week away from a known date, you simply add 7 to the known date. Oracle also performs validity checking on dates: For instance, if someone tries to insert the date February 29, 2006 into an Oracle date column, Oracle will prevent the insert from succeeding, because it recognizes that 2006 is not a leap year and therefore does not have a February 29.

The DATE datatype stores time values as decimal amounts representing how much of a day has passed at the time being stored. For instance, if a given day's Julian date value is 33333, then 6:00 P.M. on that day would be stored as 33333.75 (the .75 shows that 75 percent of the day has gone by at 6:00 P.M.).

After learning about the common datatypes in Oracle, you learned how to use the DESC command to see the structure of an existing table. You also learned that your CREATE TABLE commands could include NOT NULL specifications for any or all columns, causing Oracle to require inserted or updated records to contain values in those columns before the records will be accepted.

When adding or changing data in tables whose columns *do* accept nulls, you can bypass entering a value in a column by specifying NULL in that column's location in the SQL statement. You can also skip columns in INSERT commands by naming every column you care about in the command, and simply not naming the column you do not intend to insert data into. To insert data containing apostrophes using the SQL*Plus program, precede your INSERT command with a SET SCAN OFF command. Once you have finished inserting data containing apostrophes, issue a SET SCAN ON command to return things to normal.

Next, you learned some more sophisticated techniques for viewing data in a table. You can specify which of a table's columns you wish to view by naming the columns you want in your SELECT statement, rather than specifying all of them using the "*" character. If you would like to see columns in a different order, name them in the order you want them when writing your SELECT command.

To perform math, using data stored in a table, write the math operators into your SELECT statement, with the column name you care about included as a math variable. The resulting expression looks like a math formula and produces answers utilizing data in your table. When writing math formulas, you must pay attention to operator precedence, that is, the order in which Oracle performs operations if the formula contains more than one math operator. Multiplication, division, and any operations appearing in parentheses are done first and from left to right. Once they are done, addition and subtraction are done next, also left to right. The best way to handle operator precedence is to specify it explicitly in your statements by using parentheses; surround the portion of the expression you want executed first in a pair of parentheses, and there will never be any question of how the expression will be calculated.

When you want to add text instead of numbers—that is, concatenate text from two columns together—you can do so by placing two verticals bars (||) between the column names in your SELECT statement. If you wish to place a space between the two pieces of text, you can do so by using ||' '|| between the column names. Doing so will probably result in a column heading that is long and difficult to read, so you might want to assign an alias to the column by placing the alias name after the concatenated expression.

That's quite a bit of progress for one chapter. Read on to learn more!

Chapter Questions

1. **What is a datatype?**
   - **A.** Hard-coded information typed directly into a SQL command
   - **B.** The method Oracle uses to store dates

C. A declaration of whether a column will store text, numbers, dates, or other types of information

D. A type of computer terminal, used before personal computers, that relied on the presence of a mainframe computer

2. What is the correct syntax for creating a table containing two columns?

```
CREATE TABLE table_name
     column_name_1 datatype,
     column_name_2 datatype
;
CREATE TABLE table_name
     FROM column_name_1 datatype,
          column_name_2 datatype
;
CREATE TABLE table_name (
     column_name_1 datatype,
     column_name_2 datatype
     )
;
```

3. Which of the following is *not* a benefit of using Julian dates?

A. Date arithmetic

B. Validity checking

C. Proper sorting

D. Faster operation

E. Ability to store times

4. On which line will the following command fail?

```
SELECT first_name ||
       " " ||
       last_name
       "Full Name"
FROM   plsql101_person;
```

A. 1

B. 2

C. 3

D. 4

E. 5

F. The command will succeed.

5. **Which of the following are *not* operators you can use in a math formula within a SQL statement?**

   A. +

   B. (

   C.]

   D. *

   E. {

   F. /

6. **What is the proper syntax for assigning a column alias?**

   A. SELECT *column_name* ALIAS *alias_name*
   FROM *table_name*;

   B. SELECT *column_name alias_name*
   FROM *table_name*;

   C. SELECT *alias_name*
   FROM *table_name*;

   D. ASSIGN *alias_name* TO *column_name*;

Answers to Chapter Questions

1. C. A declaration of whether a column will store text, numbers, dates, or other types of information

Explanation A column's datatype defines the type—and often the length—of data that the column will store.

2. C.
```
CREATE TABLE table_name (
    column_name_1 datatype,
    column_name_2 datatype
     )
;
```

Explanation Please refer to the section titled "Creating a More Involved Table," and especially the code used in Figure 2-6, for a refresher on this subject.

3. D. Faster operation

Explanation Greater speed is not a reason to utilize Julian dates. They are used because they offer far greater functionality and versatility than any text-based alternative.

4. B. 2

Explanation The problem will be caused by the double quotes surrounding the space on line 2. The space is text, and text must be surrounded by single quotes, not double quotes. The sole exception to this is column aliases, which need to be surrounded by double quotes if they contain spaces or are mixed upper/lowercase. In this usage, the double quotes help Oracle separate the column alias from the names that make up the column's contents.

5. C, E. **], {**

Explanation Math operators include math symbols such as +, - ,*, /, and ().

6. B. SELECT *column_name alias_name*
FROM *table_name*;

Explanation To assign an alias to a selected column, simply place the alias after the column's name in the SELECT statement.

CHAPTER 3

Advanced Data Manipulation

In this chapter, you will explore more sophisticated ways to work with data. By "more sophisticated" I mean you will learn how to limit selected records to only those that satisfy the criteria you specify, how to sort records into whatever order you want, and how to make Oracle perform real-time calculations (like a calculator). In addition, you will learn how to change data already in a table, delete data from a table, select unique values from a table, and undo DML (Data Manipulation Language) operations such as INSERT, UPDATE, and DELETE. Sounds exciting, eh? You bet it is.

Limit Which Records You Select

One of the most common functions you will perform when selecting records is getting a specific subset of the records in a table. The subset you want will change constantly in order to answer questions like "What customers haven't heard from me for more than two weeks?" or "What products have sold more than 100 units in the last 30 days?" You can filter records in this fashion by adding a WHERE clause to your SELECT statement. You follow the WHERE clause with a statement of whatever *conditions* must be true about records in order for them to be shown. The syntax for this is as follows:

SELECT *columns* FROM *table_name* WHERE *condition(s)*;

As an example, a condition could be that a person's last contact date is more than two weeks ago. Or it could be that a product's sale date is 30 or fewer days before today, and that the total quantity sold is greater than 100. Let's go through some exercises to show how this is done. To give you something to work with, let's re-create the PLSQL101_PRODUCT table with a few more columns, and place records in it using the following commands:

```
DROP TABLE plsql101_product;

CREATE TABLE plsql101_product (
     product_name     VARCHAR2(25),
     product_price    NUMBER(4,2),
     quantity_on_hand NUMBER(5,0),
     last_stock_date  DATE
     )
;

INSERT INTO plsql101_product VALUES
     ('Small Widget', 99, 1, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Medium Wodget', 75, 1000, '15-JAN-05');
INSERT INTO plsql101_product VALUES
     ('Chrome Phoobar', 50, 100, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Round Chrome Snaphoo', 25, 10000, null);
```

Filter Records Based on Numbers

There are several ways you can filter records based on values in number columns. You can tell Oracle to show you only records that have a specific value in a column, to show records with values above or below an amount you specify, or to show records with values between a certain range.

Select Records Based on a Single Value

To select all the records from your test table that have a quantity of 1, enter the following command:

```
SELECT * FROM plsql101_product
WHERE  quantity_on_hand = 1;
```

The display you get in response should look like Figure 3-1. Take a moment now and practice this technique by selecting records whose price equals 25.

Next, select records containing values above or below a specific amount. For instance, to find products that may need to be restocked, you could enter the following command:

```
SELECT * FROM plsql101_product
WHERE  quantity_on_hand < 500;
```

Enter this command now, and compare your results with those shown in Figure 3-2.

The preceding command excludes records whose quantity on hand is exactly 500. If you want to select records that are less than or equal to a specific value,

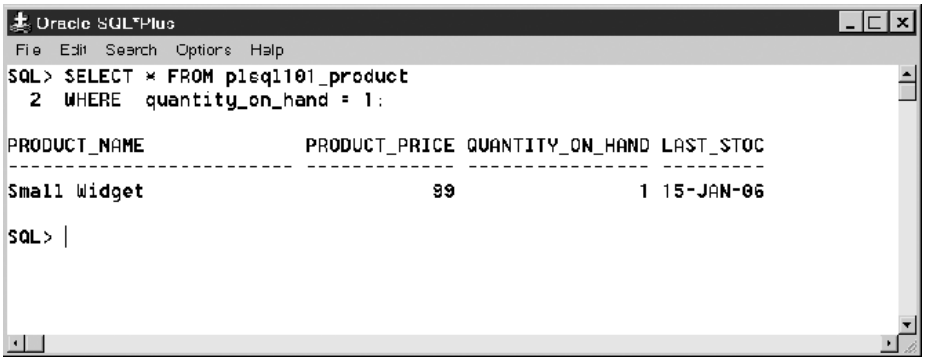


FIGURE 3-1. *Select records with values matching a specific number*

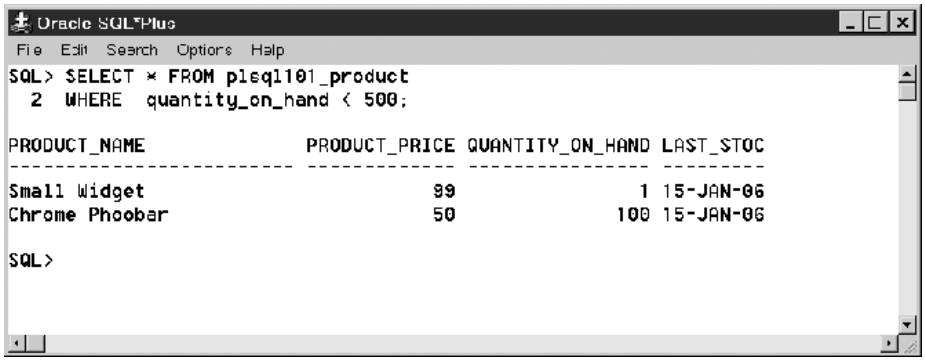


FIGURE 3-2. *Select records with values below a specific number*

you can do so by adding an equals sign (=) after the less-than sign (<). Try entering the following pair of commands to see the impact of this variation:

```
SELECT * FROM plsql101_product
WHERE  quantity_on_hand < 1000;

SELECT * FROM plsql101_product
WHERE  quantity_on_hand <= 1000;
```

The results from these two commands, shown in Figure 3-3, demonstrate the effect of adding the equals sign after the less-than sign. The first command, which states only that records with a quantity on hand less than 1,000, does not include the record for the Medium Wodget, because that record's quantity on hand is exactly 1,000, not less. The second command, by specifying that the values can be less than or equal to 1,000, causes the record for the Medium Wodget to be included.

Extend this technique a bit further and you can select records containing values above a specific amount by using the greater-than (>) sign instead of the less-than sign. Try the following pair of commands to see this in action:

```
SELECT * FROM plsql101_product
WHERE  quantity_on_hand > 1000;

SELECT * FROM plsql101_product
WHERE  quantity_on_hand >= 1000;
```

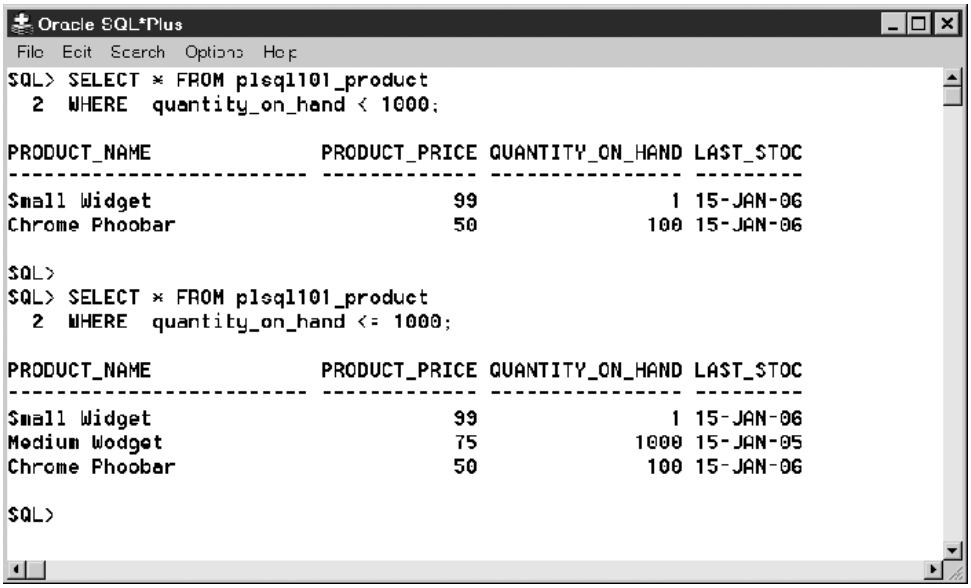


FIGURE 3-3. *Select records with values below or equal to a specific number*

Select Records Based on a Range of Values

To select records containing values that fall within a range, define the range by simply specifying a bottom limit and a top limit. To do this, you will learn a new technique: how to designate two separate conditions that must both be satisfied in order for a record to make it through the filter. It's easy, really: You just connect the two conditions with the word "AND." Try the following code to see how this works:

```
SELECT * FROM plsql101_product
WHERE  product_price >= 50
       AND
       product_price <= 100
;
```

Using AND between two criteria is the classic way to define a range of acceptable values. It will work with practically every database in existence. Oracle offers an alternate way to achieve the same result that is less traditional

but easier to read: the BETWEEN clause. Using BETWEEN, the preceding code could be rewritten as follows:

```
SELECT * FROM plsql101_product
WHERE  product_price BETWEEN 50 AND 100;
```

For practice purposes, create a series of SELECT statements now to determine whether the BETWEEN clause is exclusive or inclusive (that is, if the selected records include values that exactly match either of the numbers defined after the BETWEEN).

Exclude Records

What if you need to *exclude* a specific range from the selected records? No problem—just reverse the greater-than and less-than signs, and use OR instead of AND to connect the two conditions. This is shown in the following command:

```
SELECT * FROM plsql101_product
WHERE  product_price < 50
       OR
       product_price > 100
;
```

You can also use the BETWEEN clause to exclude a range of values; just precede it with the modifier "NOT." For example:

```
SELECT * FROM plsql101_product
WHERE  product_price NOT BETWEEN 50 AND 100;
```

The preceding example shows how to exclude a range of values from the records selected. If you just want to exclude one specific value, there is an easier way. By using the operators "<>" in your comparison, you state that records must be greater than or less than the value you specify, which is just another way of saying the records must be "not equal to" the value you define. To see how this approach works, enter the following command:

```
SELECT * FROM PLSQL101_PRODUCT
WHERE  PRODUCT_PRICE <> 99;
```

This traditional technique is understood by many different databases. Oracle also offers another way to produce the same result: using "!=" instead of "<>". Placing the exclamation point in front of the equals sign changes the meaning from "is equal to" to "is not equal to." To see how this works, enter the following commands:

```
SELECT * FROM PLSQL101_PRODUCT
WHERE  PRODUCT_PRICE = 99;2

SELECT * FROM PLSQL101_PRODUCT
WHERE  PRODUCT_PRICE != 99;
```

As the last few commands demonstrate, using "<>" or "!=" instead of "=" for individual values causes Oracle to display exactly the records it would filter out if a "=" was used instead. You might be surprised how often this is useful.

Select Records Based on a Group of Acceptable Values

There may be times when you want to select records containing any of a group of values—for instance, every product whose color is either red *or* green *or* white. You could get that result from a command like this (don't try to enter this one—it is for example purposes only):

```
SELECT * FROM product
WHERE  COLOR = 'Red'
   OR  COLOR = 'Green'
   OR  COLOR = 'White'
;
```

However, this approach will quickly get tedious if you have large number values that can be matched. Instead, you can get the same result more easily by using the IN operator, as demonstrated with this code (also an example only):

```
SELECT * FROM product
WHERE  COLOR IN ('Red', 'Green', 'White')
;
```

Note that the IN operator is followed by an opening parenthesis, a list of acceptable values separated by commas, and then a closing parenthesis. Now let's look at how to apply the IN operator to the PLSQL101_PRODUCT table you have built. Enter the following command to see how it works:

```
SELECT * FROM plsql101_product
WHERE  product_price IN (50, 99);
```

Filter Records Based on Text

Now that you know how to create WHERE clause expressions that evaluate numbers, it's easy to apply the same techniques to evaluate text columns. To find records containing values that match a specific text string, simply include a WHERE clause stating that the appropriate column equals the text string (which must be surrounded by single quotes, as all text is in SQL commands). Try the following command to see this in action:

```
SELECT * FROM plsql101_product
WHERE  product_name = 'Small Widget';
```

In response, you should get a display matching the one shown in Figure 3-4.

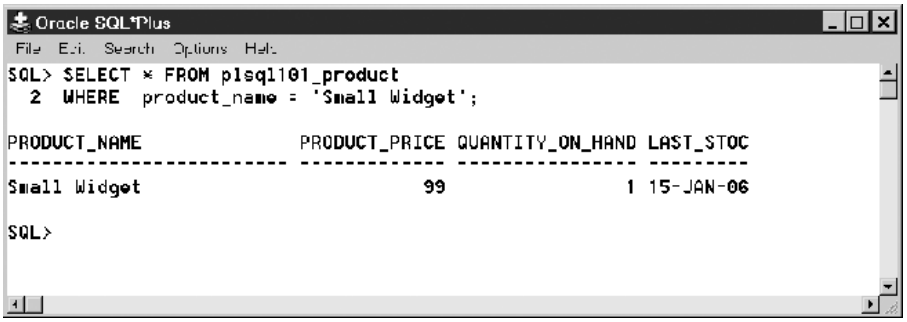


FIGURE 3-4. *Select records matching an explicit text string*

You can also specify a list of values to match by employing the IN operator. The following command demonstrates this technique:

```
SELECT * FROM plsql101_product
WHERE  product_name IN ('Small Widget', 'Round Chrome Snaphoo');
```

Use Wildcards

When searching text, it is often useful to be able to find a small bit of text anywhere within a column—for instance, to find all records that contain the word "Chrome" anywhere within the product name, such as "Chrome Phoobar" or "Round Chrome Snaphoo." You can accomplish this by using *wildcards* to represent the portion of text that varies. For instance, to find every record in your PLSQL101_PRODUCT table whose product name starts with "Chrome," use the following command:

```
SELECT * FROM plsql101_product
WHERE  product_name LIKE 'Chrome%';
```

Note that the word "Chrome" is followed by a percent sign (%). The percent sign is the wildcard character, and when it follows a text string, it means "anything can follow this text string, and it will still be a match."

You may have noticed, however, that the previous example did not return every record that has the word "Chrome" in its product name. That's because in the other record containing "Chrome" there is text before the word "Chrome" as well as after. To include both records in your results, place percent sign wildcards before *and* after the word "Chrome," as demonstrated in the following command:

```
SELECT * FROM plsql101_product
WHERE  product_name LIKE '%Chrome%';
```

The results of the previous two commands should look like Figure 3-5. One important fact to point out here is that while the Oracle commands themselves are

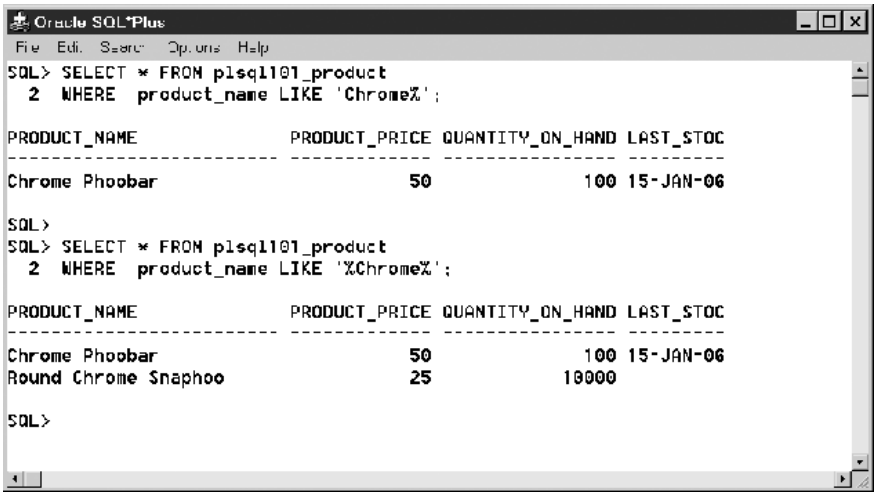


FIGURE 3-5. *Use wildcards to find text*

not case-sensitive—you will get the same result from SELECT, select, or SeLeCt—the text you put between single quotes for comparison purposes *is* case-sensitive. Searching for "Chrome" will not return records containing the word "chrome" or "CHROME." You will learn about a way around this in Chapter 5.

The % wildcard represents any amount of text—any number of characters can be replaced by a single % wildcard. There is also a wildcard that replaces just a single character: the underscore (_). To see this wildcard in action, enter the following command, which retrieves every record containing a product name that contains the letter "W" followed by any character and a "d":

```
SELECT * FROM plsql101_product
WHERE  product_name LIKE '%W_d%';
```

Filter Records Based on Dates

Selecting records based on the dates they contain works similar to selecting records based on numbers. Since the values you're comparing are dates, however, you will need to remember to surround any date you specify with single quotes, just like you did when you inserted them.

For example, to find every record in your PLSQL101_PRODUCT table whose stock date is January 15, 2006, enter the following command:

```
SELECT * FROM plsql101_product
WHERE  last_stock_date = '15-JAN-06';
```

Your results should match those shown in Figure 3-6.

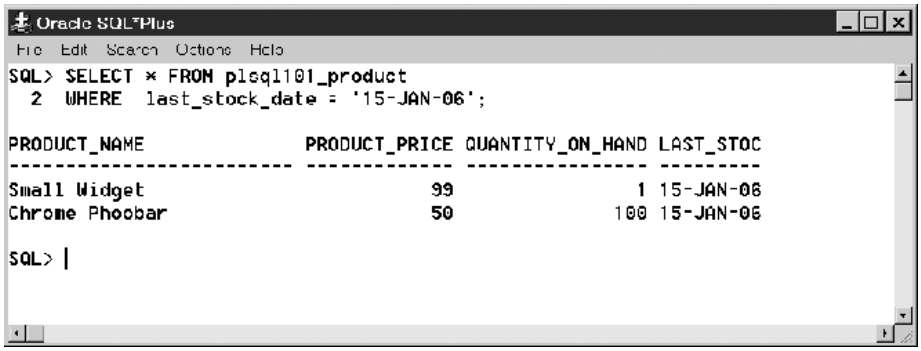


FIGURE 3-6. *Filtering records based on date*

In newer versions of Oracle, you can also specify years using four digits, as demonstrated in this command:

```
SELECT * FROM plsql101_product
WHERE  last_stock_date = '15-JAN-2006';
```

If you want to find records containing dates before or after a specific date, use the familiar greater-than and less-than signs, as demonstrated in this code:

```
SELECT * FROM plsql101_product
WHERE  last_stock_date > '31-DEC-05';
```

You can also use the BETWEEN clause to find dates that fall within a range, as shown in the following command:

```
SELECT * FROM plsql101_product
WHERE  last_stock_date BETWEEN '01-JAN-06' and '31-DEC-06';
```

By adding the NOT clause, you can identify a range to be excluded rather than included:

```
SELECT * FROM plsql101_product
WHERE  last_stock_date NOT BETWEEN '01-JAN-06' and '31-DEC-06';
```

Select Records Based on Null Values

You may have noticed that even though the last two commands contain exactly the opposite criteria of each other, their combined outputs do not show every record in

the database. How could there be a record that does not match either criterion, when one criterion is the opposite of the other? This situation arises when the database contains records with null values in a column named in the WHERE clause. A null value does not match any criterion, except one that checks for a null value. You can check for a null value by placing IS NULL in your WHERE clause, as shown in this command:

```
SELECT * FROM plsql101_product
WHERE  last_stock_date IS NULL;
```

To find records that contain data in a specific column, use IS NOT NULL, as shown in this code:

```
SELECT * FROM plsql101_product
WHERE  last_stock_date IS NOT NULL;
```

Try both of the previous commands and compare the output you get with that shown in Figure 3-7.

The parameters IS NULL and IS NOT NULL work in expressions evaluating numbers and text, too; in fact, they work for any type of column.

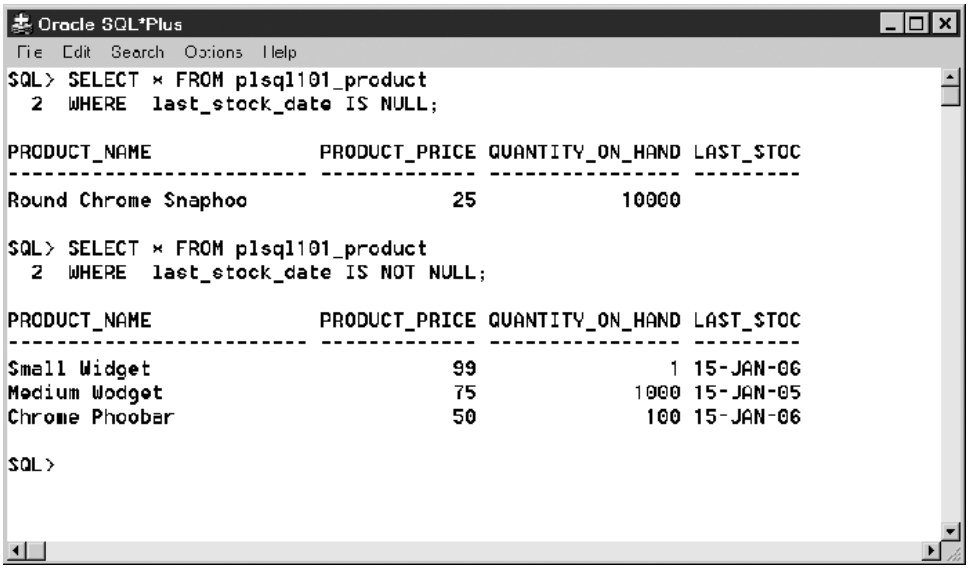


FIGURE 3-7. *Filtering for null values*

Change the Order of Records

Most of the time, the insertion order of data into a table bears little relevance to the order in which you want to view it. For instance, you insert purchases as they occur, but you may want to see them later in order by product or store. Similarly, you enter a company's employees into its employee table in the order the people are hired, but when you view a list of employees you will probably want to see them sorted by name and/or department. To get results like these, you need to know how to control the display order of the selected records.

Interestingly, you won't actually change the order of records within whatever table they're stored. At least not very often—doing so is a tedious, time-consuming task that few applications benefit from. Instead, you just change the order in which they're shown to you. Oracle fulfills this request by sorting a copy of the selected records before displaying them, and then displaying the sorted copy. This allows you (and thousands of other people connected to the database) to display records in any order you want without constantly rewriting tables with newly re-sorted versions.

Sort on Individual Columns

To change the display order of records, you just add an ORDER BY clause to your SELECT command. In the ORDER BY clause, you identify one or more columns that Oracle should sort the records by. The syntax of the ORDER BY clause is as follows:

SELECT * FROM *table_name* ORDER BY *column_to_sort_by*;

To see this in action, enter the following command:

```
SELECT * FROM plsql101_product
ORDER BY product_price;
```

In response, you should see a display similar to the one shown in Figure 3-8. Experiment with this technique further by writing a SELECT command that sorts records by their quantity on hand.

Sort on Multiple Columns

If you sort your PLSQL101_PRODUCT table by the LAST_STOCK_DATE column, you will see that a problem becomes evident: two of the table's records contain the same last stock date. How will Oracle know what order to place those records in? You can control this by specifying a second sort column in your SELECT command's ORDER BY clause.

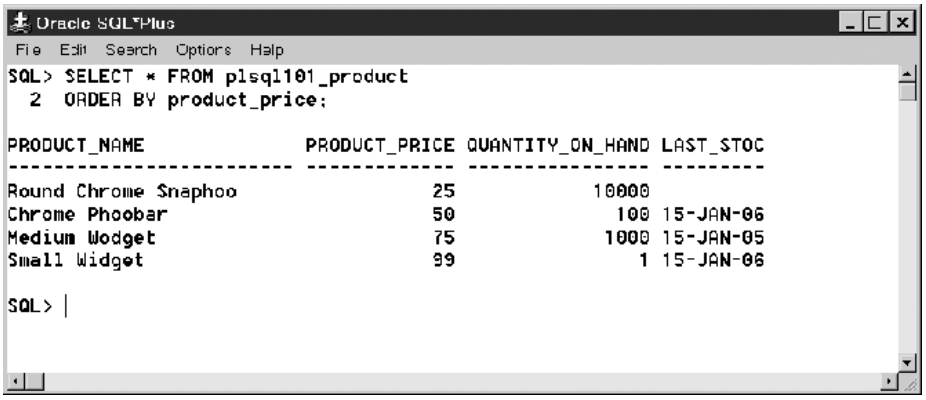


FIGURE 3-8. *Sort records by a single column*

TIP

When you specify two or more sort columns in an ORDER BY clause, the columns are not treated equally. The first column you name is the primary sort column, and it will determine all sorting until it reaches two or more records that have the same value in that column. Then the second sort column is applied to those records. If any of them have identical values in the second sort column, Oracle looks to see if you have defined a third sort column, and so on.

To see this in action, you will write a command that sorts product records by stock date, and within a given stock date, by product name. The command is as follows:

```
SELECT * FROM plsql101_product
ORDER BY last_stock_date, product_name;
```

The results from this command should match what is shown in Figure 3-9. Note that to define two sort columns, you simply separated the column names with a comma. This is the same method you used to separate column names when you wanted to select specific columns from a table.

In fact, let's combine the two techniques: selecting columns by name and sorting records by column. In the previous exercise, the records were sorted

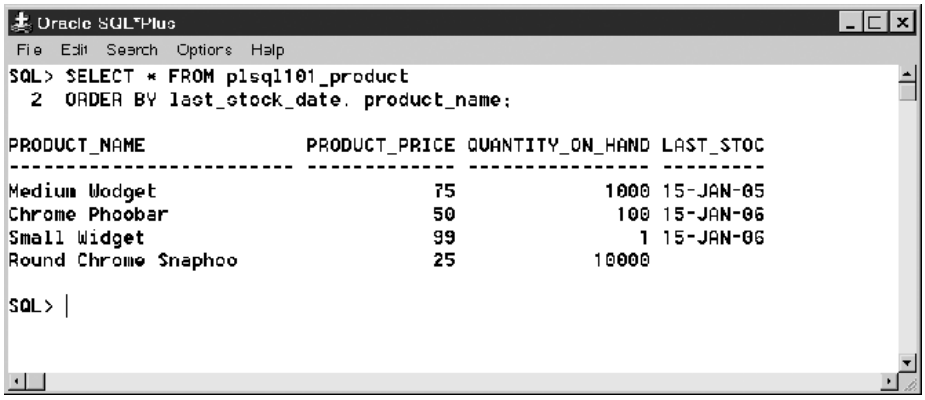


FIGURE 3-9. *Sort records by two columns*

based on the right-most column shown. That can easily confuse someone else looking at the data, because they will probably look at the first column, see that it isn't in order, and assume that the records are in no order whatsoever. Generally, you want the order of columns to reflect the order the records are sorted in: the left-most column is the primary sort *key,* the next column is the secondary sort key (if a secondary sort key is needed), and so on. You can easily make this happen with the PLSQL101_PRODUCT table. Try out the following command as an example:

```
SELECT   last_stock_date,
         product_name,
         product_price,
         quantity_on_hand
FROM     plsql101_product
ORDER BY last_stock_date,
         product_name
;
```

Your results should match those shown in Figure 3-10.

You can also sort columns in descending order, so that larger values are on top. While this is rarely useful for text columns, it is often handy for number or date columns. For instance, you could find the highest-priced products in your PLSQL101_PRODUCT table by entering the following command:

```
SELECT * FROM plsql101_product ORDER BY product_price DESC;
```

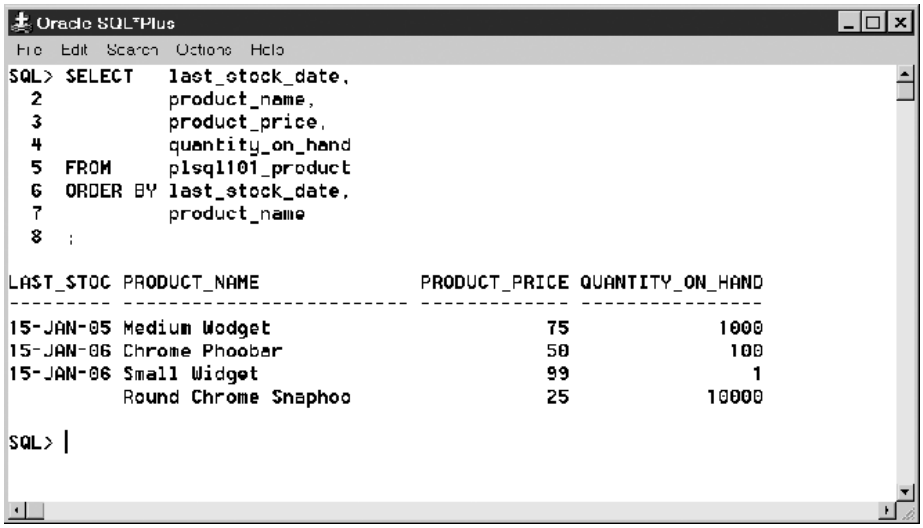


FIGURE 3-10. *Specify column order to reflect sort order*

You can even sort by a column that isn't being selected. For instance, try this command:

```
SELECT product_name FROM plsql101_product ORDER BY quantity_on_hand;
```

As a result, you see a list of product names. But without a column showing the quantity on hand, it's impossible to tell why the product names are sorted the way they are. This is why you will usually want to include the sort column in the columns displayed and, as mentioned earlier, put those columns in the same order as the sort order.

Show Only Unique Values

There will probably be times when you want to know what values a column contains, but you only want to see one instance of each value. For instance, if you need to know which salesperson sold products during a particular period of time, there would be no point in having the salesperson's ID shown repeatedly, once for every sale made. You just want to know who is in that group and who isn't. Therefore, you only need to see one row for every salesperson who has at least one sales record within the timeframe you have specified. This type of approach is useful for answering questions like "Who is scheduled to work next week?" and "What products sold this weekend?".

To see this technique in action, you're going to re-create a transaction table and populate it with records. Then you will see how to get unique values out of the table. To create and populate the table, enter the following commands:

```
DROP TABLE plsql101_purchase;

CREATE TABLE plsql101_purchase (
     product_name  VARCHAR2(25),
     salesperson   VARCHAR2(3),
     purchase_date DATE,
     quantity      NUMBER(4,2)
     )
;

INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'CA', '14-JUL-06', 1);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'BB', '14-JUL-06', 75);
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'GA', '14-JUL-06', 2);
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'GA', '15-JUL-06', 8);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'LB', '15-JUL-06', 20);
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'CA', '16-JUL-06', 2);
INSERT INTO plsql101_purchase VALUES
     ('Round Snaphoo', 'LB', '16-JUL-06', 25);
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'BB', '17-JUL-06', 2);
```

Selecting unique values from a table is similar to selecting a regular list of values; you just add the modifier DISTINCT to the SELECT command, as shown in the following pair of commands:

```
SELECT   product_name
FROM     plsql101_purchase
ORDER BY product_name;

SELECT DISTINCT product_name
FROM            plsql101_purchase
ORDER BY        product_name;
```

After you have entered both of these commands, compare the results you get with those shown in Figure 3-11.

You can also get the same results by using the modifier UNIQUE instead of DISTINCT, as shown in the following command:

```
SELECT UNIQUE product_name
FROM          plsql101_purchase
ORDER BY      product_name;
```

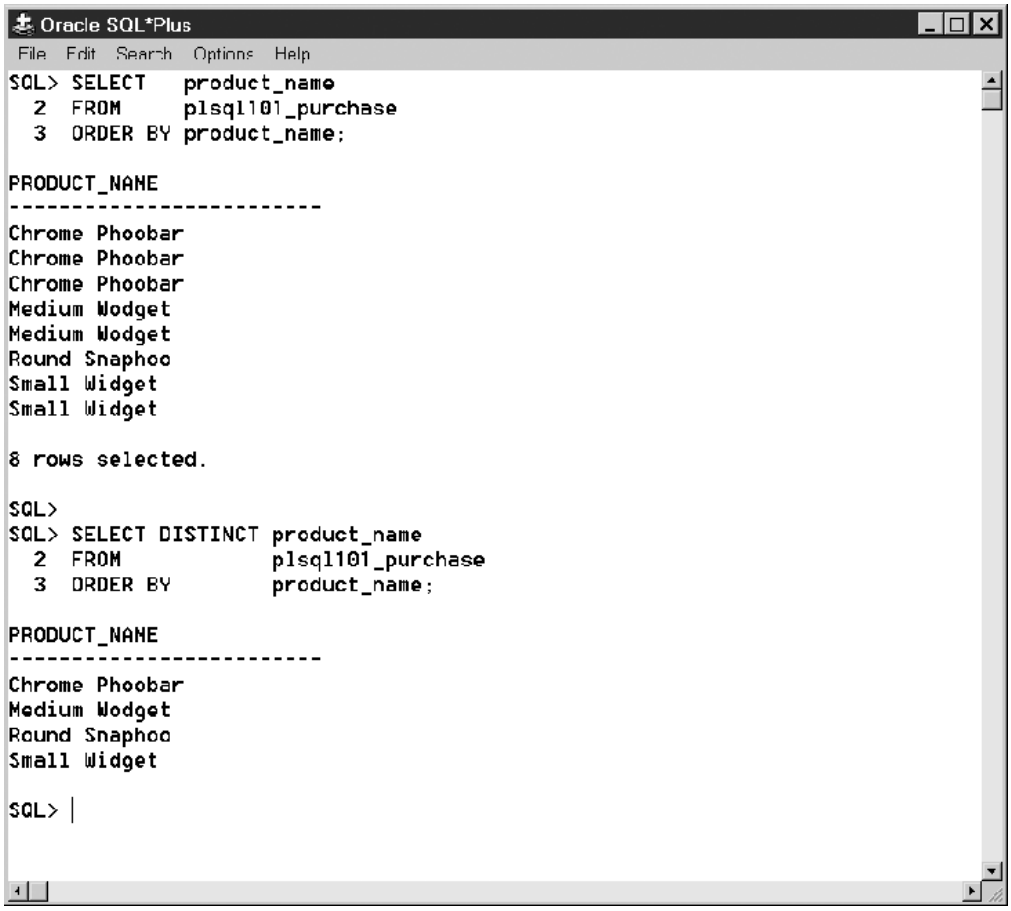


FIGURE 3-11. *Select unique values from a table*

The DISTINCT and UNIQUE modifiers produce identical results. Because DISTINCT tends to be more common, it will be used throughout this book.

Selecting unique values is especially useful when you limit the records to those matching a criterion that is important to you. For instance, to see who made sales during the first half of July, you could use the following command:

```
SELECT DISTINCT salesperson
FROM            plsql101_purchase
WHERE           purchase_date BETWEEN '01-JUL-06' AND '15-JUL-06'
ORDER BY        salesperson;
```

Select from DUAL

In Chapter 2, you saw that it was possible to perform math on values stored in a database, by defining the equation in your SELECT statement. The examples you tried in that chapter included the following (which will not work now, by the way, because the table they refer to no longer has a SALES_TAX column):

```
SELECT product_name, product_price + sales_tax FROM plsql101_purchase;
SELECT product_name, 100 - product_price FROM plsql101_purchase;
SELECT product_name, sales_tax / product_price FROM plsql101_purchase;
```

You can take this one step farther and have the SELECT statement specify all of the values that should be used in the calculation, meaning that no values are derived from the table at all. To see this in action, try the following command, which calculates the result of increasing the value 18 by 5 percent:

```
SELECT 18*1.05 FROM plsql101_purchase;
```

As your display will undoubtedly show, the answer is getting calculated, all right—calculated once for every record in the table. Wouldn't it be convenient if there was a table set up that you knew would always have just one record? Well, the bright folks who designed Oracle thought about that, too, and in response they designed Oracle's installation process to create a table called DUAL that is available to all users. To see how DUAL is constructed, enter the following commands:

```
DESC DUAL;
SELECT * FROM DUAL;
```

As you can see, the DUAL table contains one column (named DUMMY) and one row (whose value is simply X). The DUAL table's data is never meant to be used directly. Instead, the DUAL table is provided to support on-the-fly queries like the one you just did. Try it by entering the following command:

```
SELECT 18*1.05 FROM DUAL;
```

In response, just one instance of the answer of 18.9 displays, as shown in Figure 3-12.

You will have more opportunities to use the DUAL table in Chapter 5. Right now, it's time to move on, and learn how to change data already present in a table.

Modify Data In a Table

It's very easy to change data in an Oracle table. You can use the UPDATE command to perform this operation, and its syntax is as follows:

UPDATE *table_name* SET *column_name* = *new_value* WHERE *condition*;

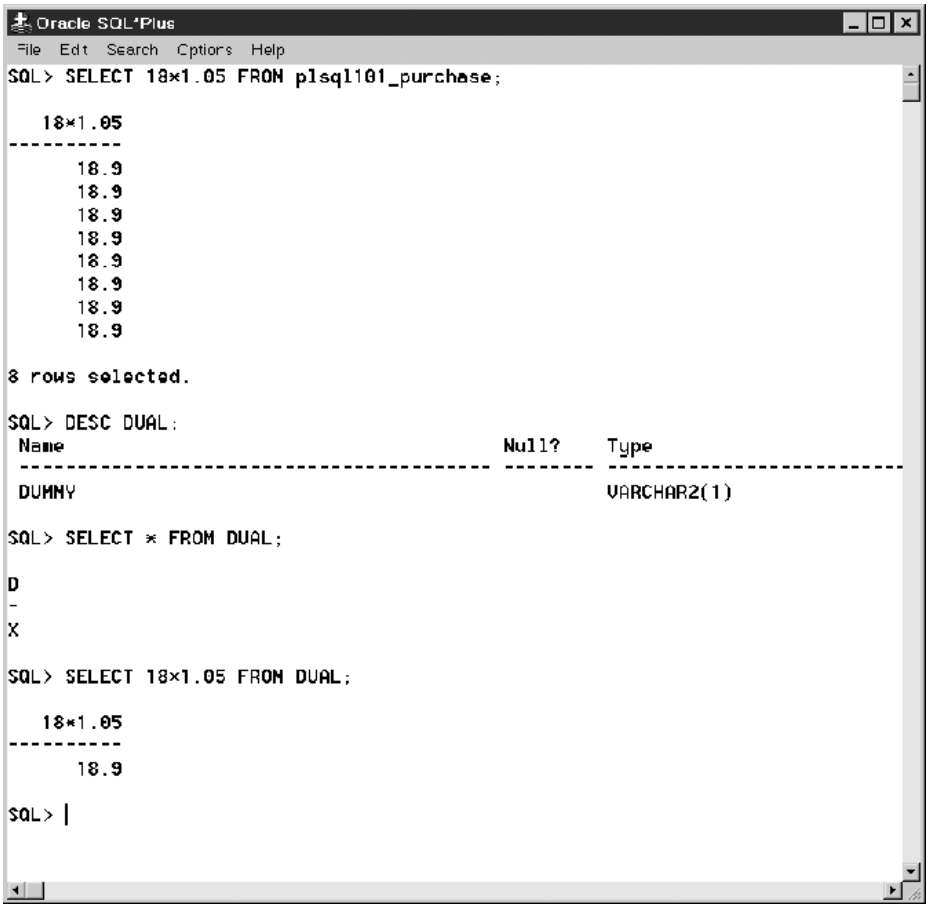


FIGURE 3-12. *Select values from DUAL*

For instance, to change all products named "Small Widget" to "Large Widget" in your PLSQL101_PURCHASE table, enter the following command:

```
SELECT * FROM plsql101_purchase;

UPDATE plsql101_purchase
SET    product_name = 'Large Widget'
WHERE  product_name = 'Small Widget';

SELECT * FROM plsql101_purchase;
```

Now select all the records in the PLSQL101_PURCHASE table. Your display should match Figure 3-13.

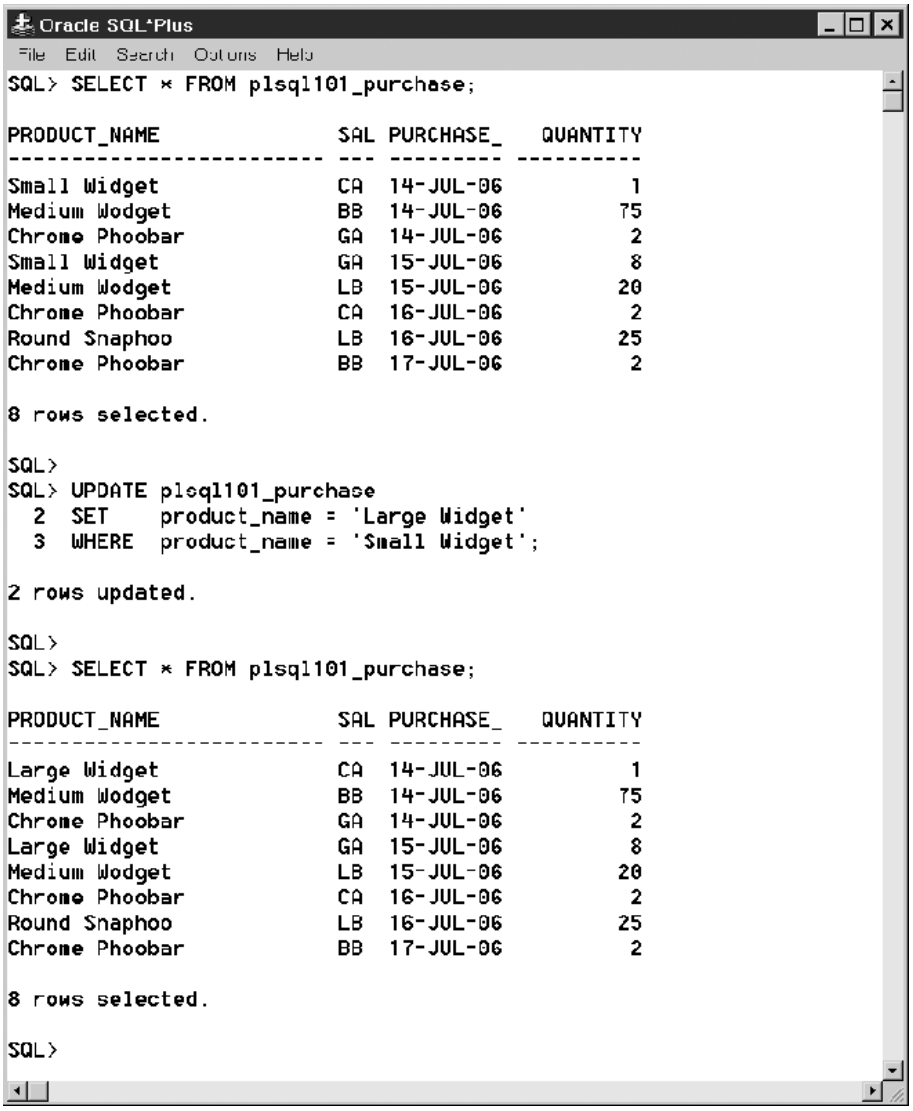


FIGURE 3-13. *Updating data in specific records*

NOTE
It is very important that you include a WHERE condition in your UPDATE command. If you do not include a WHERE condition, every record in the table will be updated!

Remove Records from a Table

The last of the fundamental skills you need while working with tables is the ability to delete records. The DELETE command uses the following syntax:

DELETE FROM *table_name* WHERE *condition*;

The DELETE command is easy to use—maybe too easy. Be sure you're thinking about the condition(s) you specify when using this command!

Delete Rows Matching Specific Criteria

Let's start our experimentation with this command by deleting the newest records in your PLSQL101_PURCHASE table. Enter the following command to remove all records whose purchase date is later than July 15, 2006:

```
SELECT * FROM plsql101_purchase;

DELETE FROM plsql101_purchase
WHERE purchase_date > '15-JUL-06';

SELECT * FROM plsql101_purchase;
```

Your results should match those shown in Figure 3-14.

You can delete records using any column or columns in your condition clause. For instance, try the following command to delete the "Large Widget" records:

```
DELETE FROM plsql101_purchase
WHERE product_name = 'Large Widget';
```

Select all the records once again, and you will see that the only remaining records are those in which wodgets or phoobars were purchased July 15 or earlier.

Delete All Rows

The final variation to delete records is deleting all rows from a table. There are two ways to do this: use the DELETE command without specifying a WHERE condition, and use an entirely new command—TRUNCATE.

Delete Records Without Specifying Criteria

The syntax for deleting all records in a table is as follows:

DELETE FROM *table_name*;

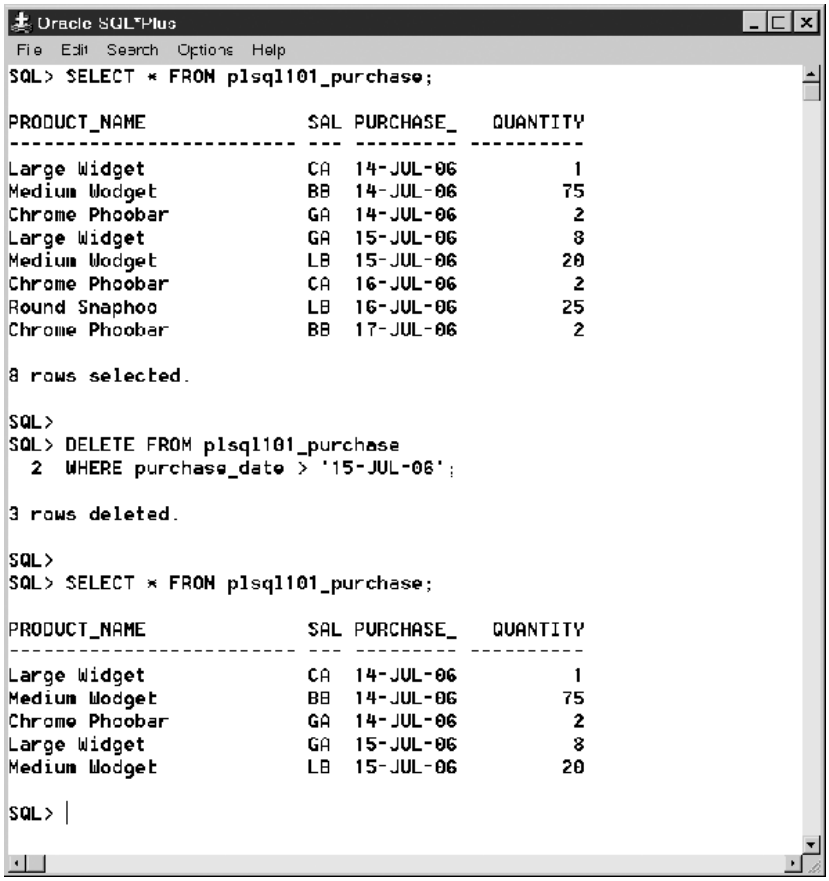


FIGURE 3-14. *Delete records based on date*

While this command is easy to read and understand, it has a major drawback: Even though it says that every record should be deleted, it still forces Oracle to read every row before deleting it, as it would if you had included a WHERE condition. This can be extremely time-consuming, wasting both your time and server resources. If you want to delete all records in a table, a more efficient method is to use the TRUNCATE command.

Truncate a Table

The advantage offered by the TRUNCATE command is speed. When Oracle executes this command, it does not evaluate the existing records within a table; it basically chops them off. In addition to speed, this command provides the added benefit of automatically freeing up the table space that the truncated records previously occupied.

The syntax of the TRUNCATE command is:

TRUNCATE TABLE *table_name*;

To see this in action, truncate your PLSQL101_PURCHASE table and then view its contents, using the commands that follow:

```
TRUNCATE TABLE plsql101_purchase;
SELECT * FROM plsql101_purchase;
```

NOTE
Unlike the DELETE command, the TRUNCATE command is not reversible! Use it only when you really mean it!

Transaction Control

So far in this chapter, you have created and dropped tables, inserted and deleted records, and generally done whatever you wanted, without having to think about how your actions may impact others. In real life you will be working with tables containing data that other people care about, and the changes you make will impact other users. To work responsibly, you need to understand how Oracle applies the changes you make. One of the immediate benefits of this is that you learn how to use Oracle's "undo" facility.

Undo DML Transactions

When you insert, update, or delete data in a table, Oracle does not actually apply those changes to the table immediately. It appears to you that the changes are applied right away; if you do a SELECT command, the changes you made are reflected in the output. But those changes are being held in temporary storage, and will only be applied to the actual table in response to one of several different catalysts. You'll see what those catalysts are soon; for now, let's see how things work *before* one of those catalysts has occurred.

Oracle's undo capability comes via the command ROLLBACK. When you roll back one or more transactions, you tell Oracle to not apply them to the database. To see this in action, enter the following commands:

```
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'CA', '14-JUL-06', 1);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'BB', '14-JUL-06', 75);

SELECT * FROM plsql101_purchase;

ROLLBACK;

SELECT * FROM plsql101_purchase;
```

Compare your results with those shown in Figure 3-15. The important part of this exercise is that your first SELECT returned records, while the second SELECT did not. The ROLLBACK command you issued removed the records from your local storage, and kept them from ever being written to the database table for permanent storage. The net result is that it is as if you never entered those two records.

The ability demonstrated by the ROLLBACK command is a useful undo mechanism, and it isn't limited to just one level of undo. By pairing ROLLBACK with another command, SAVEPOINT, you may specify any number of points to which a ROLLBACK command can return. The syntax of the SAVEPOINT command is as follows:

SAVEPOINT *savepoint_name*;

Why would you need multiple return points? Flexibility. If you have a large batch of commands to execute, you can put a savepoint after the end of each

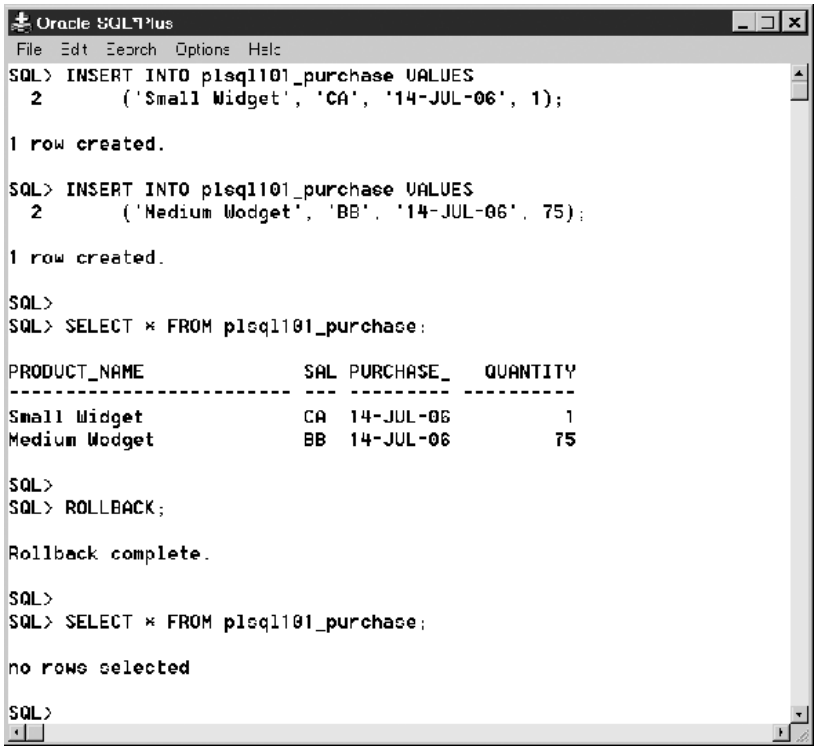


FIGURE 3-15. *Roll back data changes*

logical group of commands, and if the next group of commands is unsatisfactory for any reason, you can still roll back to the most recent savepoint and apply your changes up to that point in the database.

To see this in action, you'll enter a series of records and place a separate savepoint after each one. Then you will roll back to each savepoint, and see how that affects the records returned to you by SELECT statements. The commands to do this are as follows:

```
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'CA', '14-JUL-06', 1);
SAVEPOINT a;
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'BB', '14-JUL-06', 75);
SAVEPOINT sp_2;
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'GA', '14-JUL-06', 2);
SAVEPOINT third;
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'GA', '15-JUL-06', 8);
SAVEPOINT final_sp;
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'LB', '15-JUL-06', 20);
SELECT * FROM plsql101_purchase;
ROLLBACK TO final_sp;
SELECT * FROM plsql101_purchase;
ROLLBACK TO third;
SELECT * FROM plsql101_purchase;
ROLLBACK TO sp_2;
SELECT * FROM plsql101_purchase;
ROLLBACK TO a;
SELECT * FROM plsql101_purchase;
ROLLBACK;
SELECT * FROM plsql101_purchase;
```

Notice that the savepoint names in the preceding example don't really follow a methodical pattern. Actually, each name is an example of what could be a methodical pattern if it was applied to every savepoint name in the session. Savepoint names are just labels, so they can be anything you want. It is up to you to select savepoint names that make it obvious what data each savepoint covers. Savepoint names follow conventions similar to those for tables and columns: a maximum length of 30 characters, and the first character must be a letter.

Now that you know how to undo changes, you're ready to learn how to make changes permanent. To do this, use the COMMIT command. Because the COMMIT command causes Oracle to write your changes to the database table—which renders

rollbacks impossible—any savepoints present at the time of the commit are cleared. To see this in action, enter the following commands:

```
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'CA', '14-JUL-06', 1);
SAVEPOINT A;
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'BB', '14-JUL-06', 75);
SAVEPOINT B;
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'GA', '14-JUL-06', 2);
SAVEPOINT C;
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'GA', '15-JUL-06', 8);
SAVEPOINT D;
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'LB', '15-JUL-06', 20);

COMMIT;
ROLLBACK TO D;
SELECT * FROM plsql101_purchase;
```

Your results should match those shown in Figure 3-16. Notice that Oracle complains about the ROLLBACK command, telling you it's never heard of a savepoint named "D," even though you created one. Oracle has forgotten about your savepoint because they were all cleared when the data changes were committed to the table.

Make Data Available to Others

Because the COMMIT command causes your changes to be written to the database shared by all other users, committing your work affects the data other users see. When you issue the COMMIT command, it makes your changes visible to other users. The flip side of that fact is that the changes you make will not be visible to other users until you commit those changes—you could insert a thousand new records, change a thousand more, and then delete another thousand, and none of those changes would be reflected in other users' SELECT statements until you commit your work.

If you want to test this for yourself, open a second SQL*Plus window (using the same username and password you used for the first one), change some data in your first SQL*Plus® window, and look for the results of those changes in the second SQL*Plus® window. Go ahead and open a second SQL*Plus window now, and enter the commands following Figure 3-16 in each window:

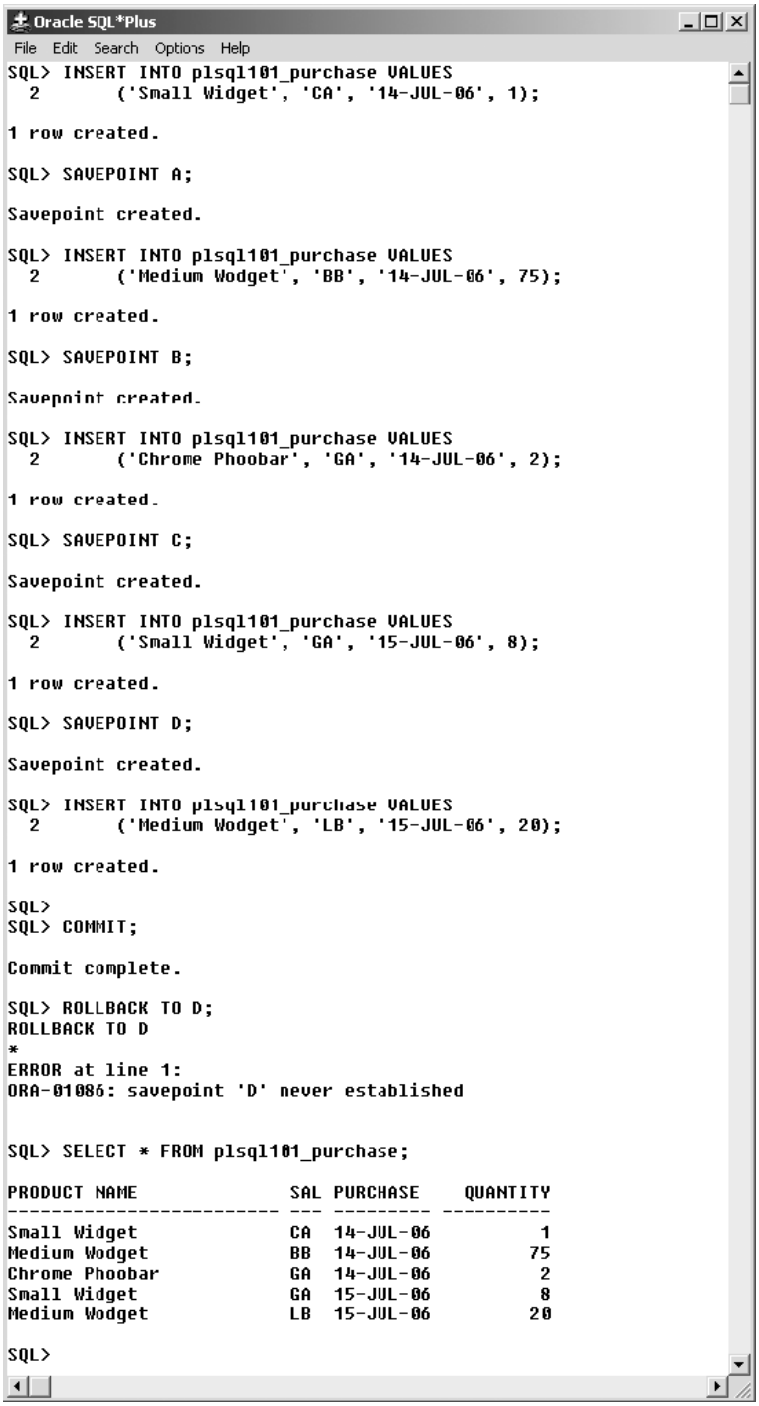


FIGURE 3-16. *Commit changes to a table*

Commands for First SQL*Plus Window	Commands for Second SQL*Plus Window
`SELECT * FROM plsql101_purchase;`	`SELECT * FROM plsql101_purchase;`
`INSERT INTO plsql101_purchase VALUES ( 'Round Snaphoo', 'CA', '16-JUL-06',5);`	`SELECT * FROM plsql101_purchase;`
`COMMIT;`	`SELECT * FROM plsql101_purchase;`

The results you see should be similar to those shown in Figure 3-17.

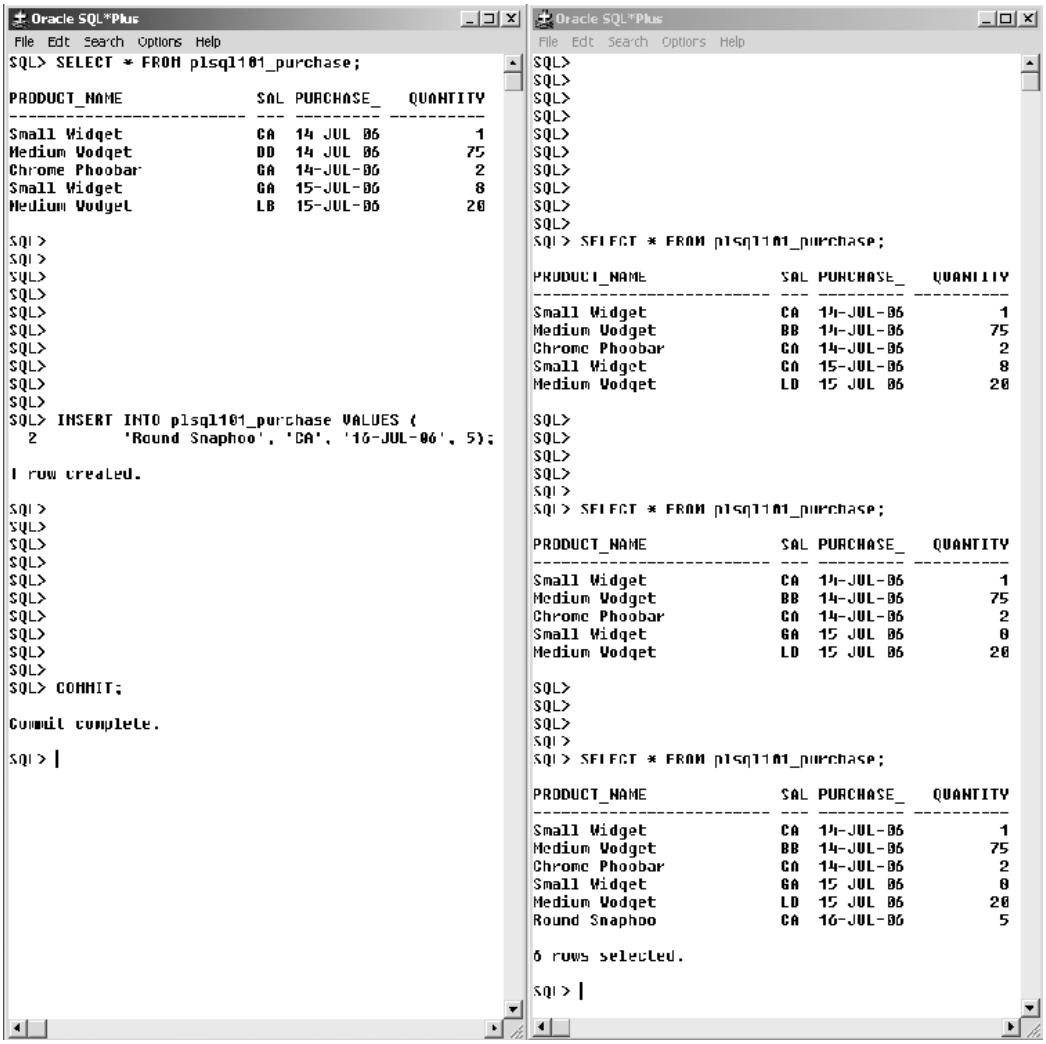


FIGURE 3-17. *Impact of the COMMIT command between different database sessions*

Implicit and Explicit COMMITs

By doing the exercises up to this point, you have performed several COMMIT commands. Entering the command explicitly, as you have, is one way to commit changes to the database—and there are other ways, too. Certain Oracle commands execute a COMMIT without waiting for you to tell them to—in other words, implicitly—before the new command is executed. To be specific, any DDL (Data Definition Language) command (such as CREATE TABLE or DROP TABLE) will implicitly commit any unsaved data before executing the command's stated function. In addition, logging out of Oracle (or simply closing SQL*Plus®) will automatically commit your changes.

Chapter Summary

You have covered a lot of ground in this chapter. You began by learning how to limit which records Oracle returns by including a WHERE clause in your SELECT statements. When filtering with a WHERE clause, you can use a variety of comparison operators in the filtering condition, including =, !=, >, <, <>, >=, <=, BETWEEN, and NOT. You can also create compound conditions by separating them with AND, or either/or conditions by separating them with OR. If you wish to select records whose values match any item within a group of satisfactory matching values, you can forego using multiple OR clauses by instead employing an IN operator.

When searching text, you can specify wildcards in your search string by using "_" to represent single characters, and "%" to represent multiple characters, along with the LIKE operator. With any datatype, you can find or avoid records with empty columns by using the IS NULL or IS NOT NULL operator in your WHERE clause.

Once you have your SELECT statement producing just the records you want, you can change the order in which they display by including an ORDER BY clause. In the clause you specify the column(s) by which the records should be sorted in the display. (Remember that ORDER BY only changes the order in which records are returned to you—it does not change their order in the actual table, because that would take much more time.) In general, you will want the left-most column displayed in your records to be the first sort column, and the next displayed column to be the next sort column, and so on; otherwise, it will be hard for people looking at the records to understand how they are sorted.

There may be times when you want to know what values a column contains, but you only want to see one instance of each value. To accomplish this, add the DISTINCT modifier right after the word SELECT in your query. To perform real-time calculations on data that isn't even in a table, select values from DUAL.

When the time comes to modify data in a table, you can employ the UPDATE command. When using this command, you identify the table to be updated, state what value should be assigned to what column, and then specify what condition a record must meet in order to receive the update. It is very important to include the WHERE clause, because if you don't, every record will be updated! The same is true when you remove records with the DELETE command: If you do not include a WHERE

clause, you will delete every record in the table. If that is your goal, a much faster approach is to use the TRUNCATE TABLE command, which doesn't bother reading every record in the table before deleting it.

Oracle offers "transaction control" commands that perform "undo" facilities. Most significant of these commands is ROLLBACK, which undoes any DML commands (INSERT, UPDATE, and DELETE) that have been performed since the last commit was performed. An explicit commit is performed whenever you issue the COMMIT command. An implicit commit occurs whenever you perform a DDL operation (including CREATE and DROP, among others), as well as when you exit from SQL*Plus.

Savepoints offer the ability to have a multilevel undo—that is, they let you decide just how far back in your DML commands you want to roll back. By issuing a SAVEPOINT command, you set a named marker that can later be rolled back to by using a ROLLBACK command along with the name of the desired savepoint. Savepoints remain active until the data is committed, after which they disappear. Once data changes are committed, the changed data is visible to other people and programs using the Oracle database. (Not understanding this can easily cause confusion if someone inserts/updates/changes some data and then doesn't understand why the changes aren't visible on a coworker's computer—usually it means the first person forgot to commit his or her changes.)

In Chapter 4, you will learn a suitcase full of techniques for controlling the SQL*Plus program. These techniques will help you get your work done more quickly, produce output that is more attractive, and automate so you can easily re-create an action without having to type its code again.

Chapter Questions

1. **What is the definition of a "savepoint"?**

   A. A place within a set of DML commands where you want Oracle to save data to the server so it is visible to other users.

   B. A place where Oracle should stop processing until you tell it to continue.

   C. A place within a set of DML commands to which Oracle can return, nullifying changes made beyond that point.

   D. A parameter used to indicate when Oracle needs to back up and restore its database.

2. **Which of the following is a valid condition?**

   A. WHERE 'Smith'

   B. WHERE 'Job_Description' = 'Manager'

C. WHERE SaLaRy = SYSDATE

D. WHERE LAST_NAME BETWEEN 'K' AND 9

E. WHERE HIREDATE BETWEEN '02-JAN-05' AND '01-JAN-04'

F. WHERE PRICE LIKE 10%

3. Which of the following are *not* reasonable series of transaction-control commands?

A. Insert some records, COMMIT, ROLLBACK

B. ROLLBACK, insert some records, COMMIT

C. SAVEPOINT, insert some records, ROLLBACK, ROLLBACK, COMMIT

D. ROLLBACK, insert some records, COMMIT, COMMIT

4. Which of the following shows the wildcards for a single character and multiple characters, respectively?

A. ?, *

B. _, %

C. ?, _

D. ?, %

E. %, _

F. *, _

G. *, ?

H. *, %

5. On which line would a command using the following syntax fail?

UPDATE *table_name*
WHERE *column_name = condition_to_be_met*
SET *column_name = new_value*
ORDER BY *column_name;*

A. 1

B. 2

C. 3

D. 4

E. The command would succeed.

Answers to Chapter Questions

1. C. A place within a set of DML commands to which Oracle can return, nullifying changes made beyond that point.

Explanation The SAVEPOINT command marks a place in a series of DML command that can be returned to later via a ROLLBACK command.

2. E. WHERE HIREDATE BETWEEN `'02-JAN-05' AND '01-JAN-04'`

Explanation Choice A does not compare anything with "Smith." Choice B has quotes around the column name. Choice C compares a column that obviously contains numbers (salary) with today's date, which makes no sense (the fact that "salary" has unusual case does not matter, because column names are not case-sensitive). Choice D tries to use a string and a number as the limiting ends of a BETWEEN operator, which does not make sense—the BETWEEN should be given with two values of the same datatype. Choice F uses the LIKE operator with a numeric column and numeric column value, but the LIKE operator only works with text.

3. A, C, D. Insert some records, COMMIT, ROLLBACK
SAVEPOINT, insert some records, ROLLBACK, ROLLBACK, COMMIT
ROLLBACK, insert some records, COMMIT, COMMIT

Explanation In Choice A, there is no reason to perform a ROLLBACK after a COMMIT, since there is no data to roll back to once the COMMIT has been done. In Choice C, there is no point in issuing a second ROLLBACK command. In Choice D, there is no point in performing a second COMMIT.

4. B. _, %

Explanation Please see the section titled "Use Wildcards" for a refresher on this topic.

5. B. 2

Explanation When issuing an UPDATE command, the SET clause must be included before the WHERE clause.

CHAPTER 4

Controlling SQL*Plus

his chapter presents a variety of useful techniques for getting the most out of the SQL*Plus program. You will learn how to save time and keystrokes by modifying and reusing old commands; get a "clean slate" in SQL*Plus by clearing the screen; customize the way SQL*Plus works and save those customizations so they are used automatically next time; improve the readability of data retrieved via SELECT commands; write selected data out to a disk file; and store commands in script files that can easily be rerun with very few keystrokes. Do less work and get more done! I think we can all agree that's worth learning about.

Edit Prior Commands

Up to this point, each time you have entered an SQL command into SQL*Plus you have had to type the command manually, even if it was similar to the prior command entered. SQL*Plus offers a variety of ways you can edit and reuse commands without having to completely retype them. We'll start with an approach that is likely to be very familiar, and then proceed to another approach that can be faster in certain situations.

Use a Text Editor

Even if you just started writing SQL commands when you began reading this book, I'll bet you have experienced a time when you wrote an SQL command that was a few lines long, entered it, and immediately discovered a minor mistake in the command. Wouldn't it be nice to be able to edit that command—like you edit text in a word processor—and have it automatically resubmitted for execution? You can. By typing the EDIT command (or its abbreviation, ED) at the next SQL> prompt, SQL*Plus will open your computer's default text-editing program and automatically place your last SQL command into it. You can edit the command, have it "saved" back into SQL*Plus, and then execute the edited version of the command.

I'm going to step you through an exercise that demonstrates how to do this. If you worked through the exercises in the last chapter, jump down to the "Use the EDIT Command" section. If you just started reading the book in this chapter—and therefore don't have the sample tables and data from the prior chapter created yet—enter the following SQL commands to create them before proceeding to the next section.

```
DROP TABLE plsql101_product;
CREATE TABLE plsql101_product (
     product_name     VARCHAR2(25),
     product_price    NUMBER(4,2),
```

```
     quantity_on_hand NUMBER(5,0),
     last_stock_date  DATE
     )
;

INSERT INTO plsql101_product VALUES
     ('Small Widget', 99, 1, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Medium Wodget', 75, 1000, '15-JAN-05');
INSERT INTO plsql101_product VALUES
     ('Chrome Phoobar', 50, 100, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Round Chrome Snaphoo', 25, 10000, null);

DROP TABLE plsql101_purchase;
CREATE TABLE plsql101_purchase (
     product_name  VARCHAR2(25),
     salesperson   VARCHAR2(3),
     purchase_date DATE,
     quantity      NUMBER(4,2)
     )
;

INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'CA', '14-JUL-06', 1);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'BB', '14-JUL-06', 75);
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'GA', '14-JUL-06', 2);
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'GA', '15-JUL-06', 8);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'LB', '15-JUL-06', 20);
INSERT INTO plsql101_purchase VALUES
     ('Round Snaphoo', 'CA', '16-JUL-06', 5);
```

Use the EDIT Command

To see how the EDIT command works, take the following steps:

1. Enter the following command. Note that it contains some misspellings.

```
SELECT   product_nmae
FROM     plsql101_produtc
WHERE    quantity_on_hand >= 100
         AND
         last_stock_date IS NOT NULL
ORDER BY product_name;
```

2. In response, SQL*Plus should display the message "ORA-00942: table or view does not exist." This is Oracle's way of telling you that the name of the table you're selecting from is misspelled. You could retype the command, but six lines is a lot of retyping to correct two misspellings, so…
3. Type **edit** and press ENTER. You should see an editor window like the one shown in Figure 4-1. (The actual program that opens to edit your text may vary from computer to computer. For instance, on Windows systems it will be Notepad by default, while on Unix systems it's likely to be ED or VI.) Your command will have been placed into a temporary file with a name like *afiedt.buf*. The name is irrelevant, because you aren't going to actually save your command to disk.
4. Correct the spelling of the column name on Line 1, and the spelling of the table name on Line 2.
5. Exit from the text-editing program (generally the File | Exit command will accomplish this). It will ask if you want to save your changes. Usually, a prompt like this means you are about to create (or update) a file on disk, but what's really going to happen is that the text-editing program will write your edited command back into SQL*Plus. Answer **Yes** to the prompt that asks about saving your changes.
6. You will see that your edited command has automatically been written into SQL*Plus. To execute the newly edited command, type one forward slash (/) and press ENTER.
7. You will see that your newly edited command executes as though you had typed it manually.

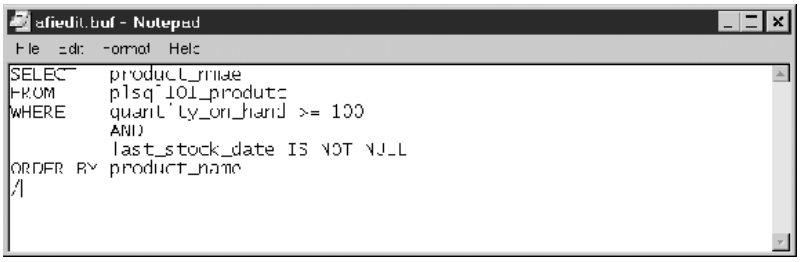


FIGURE 4-1. *Use the EDIT command to edit SQL commands*

Line-Level Editing

While it is very nice to be able to edit commands in a full-screen editor, sometimes the change you want to make is so small that you could retype the entire command in less time than it would take to open a text editor, make the change, and save it. In instances like these, you can employ an SQL*Plus feature allowing you to edit your previous command right in SQL*Plus. This approach doesn't offer the full features of a text editor, so it isn't well suited for multiline SQL commands, but it is the fastest way to make changes to short commands.

Use the CHANGE Command

The best way to understand this approach is to try it first, and afterward read an explanation of what you saw happen. Take the steps that follow to see how this approach to editing works:

1. Enter the following command. Notice that the column name is spelled incorrectly—be sure to type it that way.

   ```
   SELECT product_nmae FROM plsql101_product;
   ```

2. Notice that the error message displayed by SQL*Plus flags the column name PRODUCT_NMAE with an asterisk (*). This, of course, is because it is misspelled.

3. Type the following command:

   ```
   change/nmae/name
   ```

4. Press ENTER to execute the CHANGE command. Notice that SQL*Plus re-displays the command, this time with "NAME" replacing the old "NMAE" in the column name.

5. To execute the newly modified command, type a forward slash (**/**) and press ENTER.

6. Compare the results you got with those shown in Figure 4-2.

As you can see from the preceding example, the CHANGE command allows you to replace any text string in a command with any other. CHANGE is not an SQL command; it works only within the SQL*Plus program.

In the previous exercise, you started the command with "CHANGE." You can also abbreviate this to simply "C." The long and short versions of the command do the same thing; the "C" shortcut is simply a convenience.

The syntax of the CHANGE command is as follows:

C[HANGE] *separator_character old_text* [*separator_character new_text*]

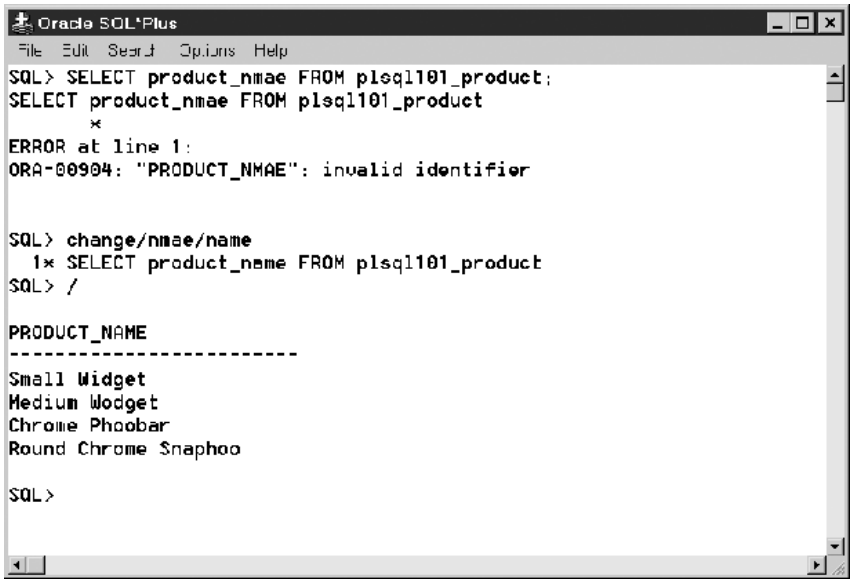


FIGURE 4-2. *Correct a command line using the CHANGE command*

The square brackets represent portions of the command that are optional. The separator character that follows can be any character that is not a letter or a number. (In the previous exercise, the separator character was the forward slash, and that is the most common character used as a separator.) After the separator character, you specify the old text that should be replaced. If you stop the command there and press ENTER, the old text will be removed and nothing will replace it. If you want to put something in place of the old text, just type the separator character again, followed by the new text to replace the old.

Take a moment now to experiment with this command. Enter a valid SQL statement, execute it, and then change it using the CHANGE command. Then enter an erroneous SQL statement and change it using the same technique.

Control Which Line Is Edited During Line-Level Editing

In the previous two examples, you used EDIT to modify multiple lines and CHANGE to modify single lines. The CHANGE command can also do multiline editing, but it works differently than EDIT. Instead of giving you a nice text-editing environment where you can move your cursor from line to line by just pressing arrow keys or

clicking with your mouse, the CHANGE command continues to let you edit just one line at a time. To correct multiline statements with the CHANGE command, you must specify which line you want to work on before making any actual changes. To do this, simply enter the number of the line you want to change before using the CHANGE command. Entering the line number causes SQL*Plus to make that line current.

This may all seem a little abstract, because very few programs in the consumer world work this way. The best way to learn it, as usual, is to try it for yourself. Enter the following commands to accomplish this:

```
SELECT   product_nmae
FROM     plsql101_produtc
WHERE    quantity_on_hand >= 100
         AND
         last_stock_date IS NOT NULL
ORDER BY product_name;

1
c/ma/am
2
c/tc/ct
/
```

Compare your results now with those shown in Figure 4-3. As you can see, each time you enter a number, SQL*Plus makes that line number from the prior SQL command current and allows you to modify the line using the CHANGE command.

Copy and Paste

It's common to need to repeat an SQL command that you executed two, three, or even more commands ago. In these instances, the CHANGE and EDIT commands won't help you, because the command you want is no longer in the SQL*Plus command buffer. You can, however, leverage your prior typing in a different way. You can copy commands from the SQL*Plus display screen and reuse them by pasting them back in at the SQL> prompt. To see this in action, start by entering the following commands:

```
SELECT * FROM plsql101_product;

UPDATE plsql101_product
SET    product_name = 'Large Widget'
WHERE  product_name = 'Small Widget';
```

To check the results of your UPDATE command, you don't need to retype the SELECT statement. You can just copy it. Move your computer's mouse so that it is

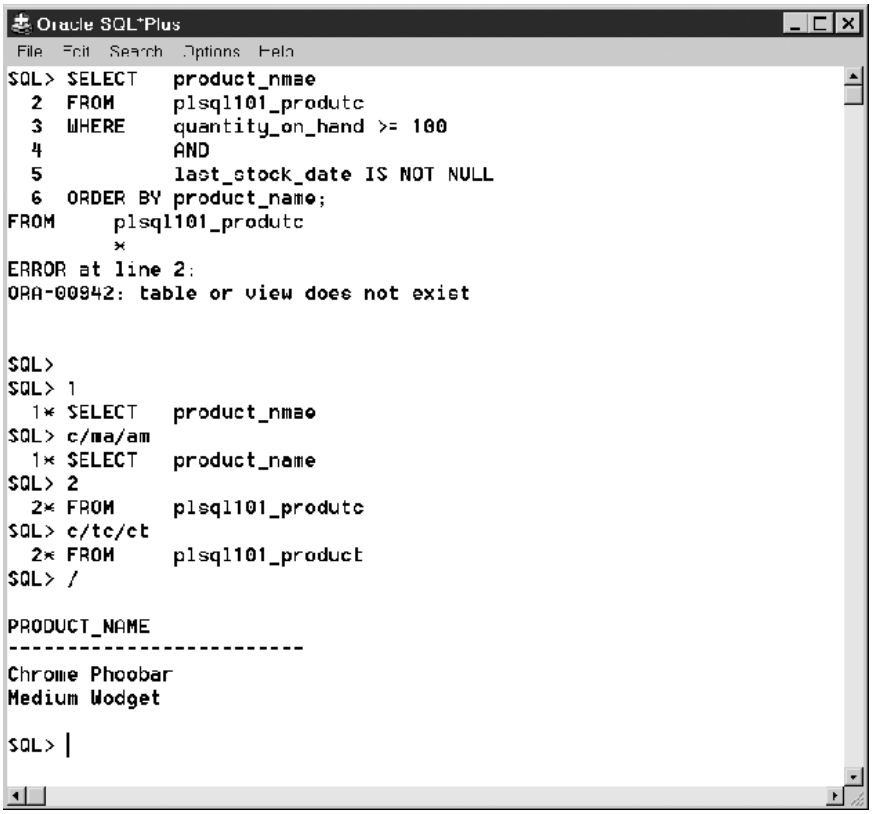


FIGURE 4-3. *Use the CHANGE command for multiline editing*

just before the "S" of "SELECT." Hold down the left mouse button and drag the mouse along the entire length of the command, like you would if you wanted to copy it within a word processor. When the entire command is highlighted, let go of the mouse button and open the SQL*Plus Edit menu. Select the Copy command to place a duplicate of the command into the Windows copy buffer. Then execute the menu command Edit | Paste to paste the command back into SQL*Plus. Press ENTER to cause the command to execute. Your screen should now look similar to Figure 4-4.

You can also use your operating system's standard keyboard shortcuts for the Copy and Paste commands used in this approach. For instance, if you are running SQL*Plus in a Windows environment, you can hold down the CTRL key and tap the letter "C" to copy the selected command, then use CTRL-V to paste it.

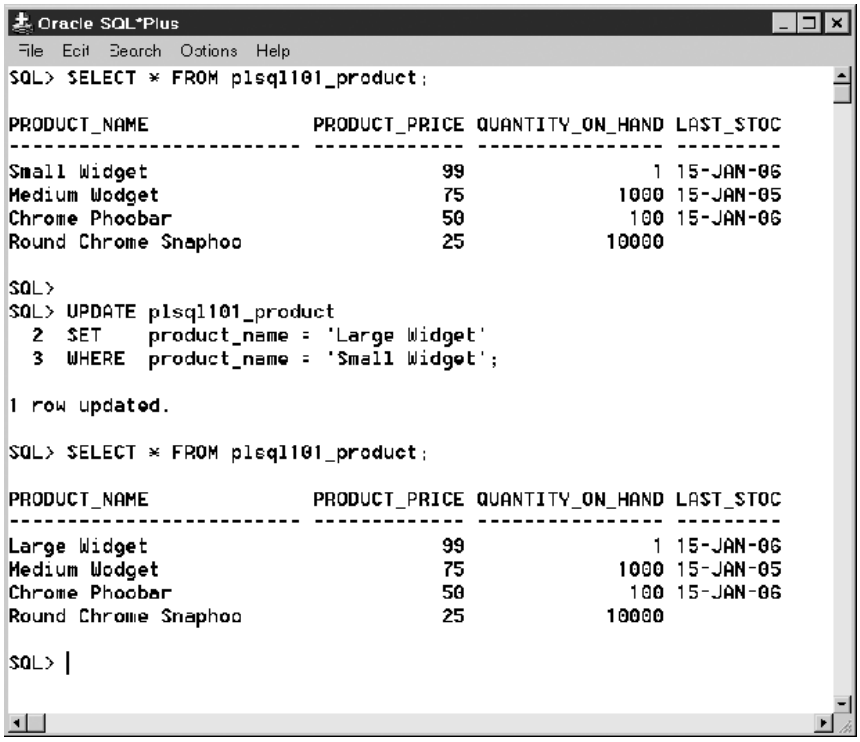


FIGURE 4-4. *Results of copying and pasting an SQL command*

There's an even quicker way, too. Let's try it out by making a copy of your last UPDATE command to change the product name back to its original value. Take the following steps:

1. Move your mouse pointer so it is just to the left of the "U" for "UPDATE" in the first line of the UPDATE command.
2. Hold down your left mouse button.
3. Drag the mouse over the entire first line of the original UPDATE command.
4. While still holding down the left mouse button, click the right mouse button once. You will see the text you selected automatically copied to the SQL> prompt.
5. Press ENTER to start a new line at the SQL> prompt (its prompt will be "2").

6. Move your mouse pointer so it is just to the left of the "S" for "SET" in the second line of the original UPDATE command.
7. Hold down your left mouse button.
8. Drag the mouse over the second line up until it reaches the "L" of "Large." You want to include the single quote just before "Large," but not the "L."
9. While still holding down the left mouse button, click the right mouse button once. You will see the partial command you selected automatically copied to the SQL> prompt.
10. Type the word **Small** followed by a space.
11. Select the rest of the original UPDATE command's second line and copy it using the same double-mouse-button technique you have used twice already.
12. Press ENTER to start a new line at the SQL> prompt.
13. Perform a similar treatment on the original UPDATE command's third line, changing "Small" to "Large."
14. Press ENTER to run the command.

This technique works for commands that have scrolled off the top of your SQL*Plus window, too. You can scroll up to find a command, use this technique, and the command will be pasted next to your current SQL> prompt.

Clear the SQL*Plus Screen

By now you have executed dozens or perhaps hundreds of SQL commands while practicing the things you've learned in this book. At any point have you wished you could clear up the SQL*Plus screen—return it to a blank slate, to reduce the clutter? You can, and it's easy to do. Just press SHIFT- DELETE. You will see the dialog box shown in Figure 4-5. Click the OK button, and your SQL*Plus screen will clear to show just an SQL> prompt.

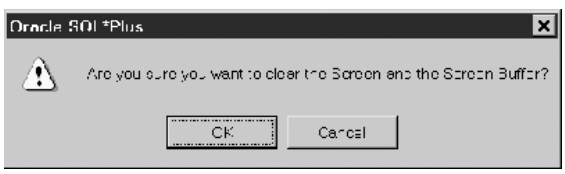


FIGURE 4-5. *SQL*Plus dialog box for clearing the screen*

Customize the SQL*Plus Environment

Many facets of SQL*Plus behavior can be modified. You won't get much benefit from changing most of the facets, but a handful is very handy. We'll see how to change them using the SQL*Plus menu, and then see how to change a few using commands at the SQL*Plus prompt.

Customize Using the SQL*Plus Menu

Within SQL*Plus, execute the Options | Environment menu command. This will cause a dialog box to appear that looks like the one shown in Figure 4-6. The left half of the Environment dialog box contains a scrolling list of options, while the right half contains two settings that control how much data SQL*Plus keeps in its scroll-back buffer. By default, SQL*Plus remembers up to 100 characters of each line you type, and up to 1,000 such lines. Using the Environment dialog box, however, you can tell SQL*Plus to store up to 3,392 characters per line (occasionally useful) and up to 2,000 lines (often useful, since the lines of data that display in response to your commands are counted too). By changing these values, you can maximize the number of prior commands and results SQL*Plus stores, making it easier to go back and find commands to copy or results to compare.

To change the buffer width and length, type **200** into the Buffer Width field and **2000** into the Buffer Length field.

On the left side of the Environment dialog box, two of the options in the Set Options list are useful at this time: *linesize* and *pagesize*. Linesize sets the maximum width SQL*Plus will provide for each line before wrapping. When the linesize is too small, the data you select may be wider than SQL*Plus can display on one line, in which case SQL*Plus will wrap columns to make them fit. It does make them fit, but

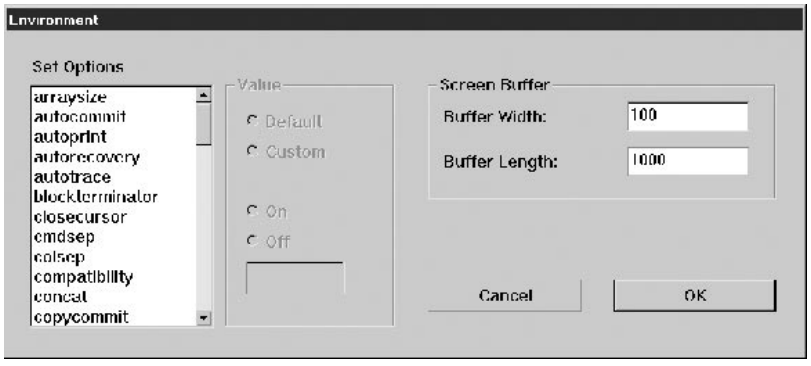


FIGURE 4-6. *SQL*Plus Environment dialog box*

it also makes them very difficult to read. Figure 4-7 shows an example of this problem. By setting a linesize large enough to accommodate the width of the data being displayed, you can make your listings more readable…to a point. The trade-off is that SQL*Plus doesn't scroll to the right, so any data not shown on your screen won't be viewable at all.

The linesize value is independent of the Buffer Width parameter modified earlier. Linesize controls how wide the lines can be, while Buffer Width determines how many characters of each line will be stored in memory for later retrieval. It makes sense for the two values to be the same, so that all the data you see is being stored in the memory buffer.

To set the linesize value so it matches the Buffer Width, scroll down the Set Options list until you see the linesize option. Select it, and in the dialog box's Value box, click the Current radio button. This will enable the value field at the bottom of the dialog box's Value box. Enter **200** into that field. Then click the OK button to close the Environment dialog box. Making this change will help ensure that the results you get look less like Figure 4-7 and more like Figure 4-8.

Another useful option is pagesize, which controls how many lines of data SQL*Plus will display in response to a SELECT command before it repeats the

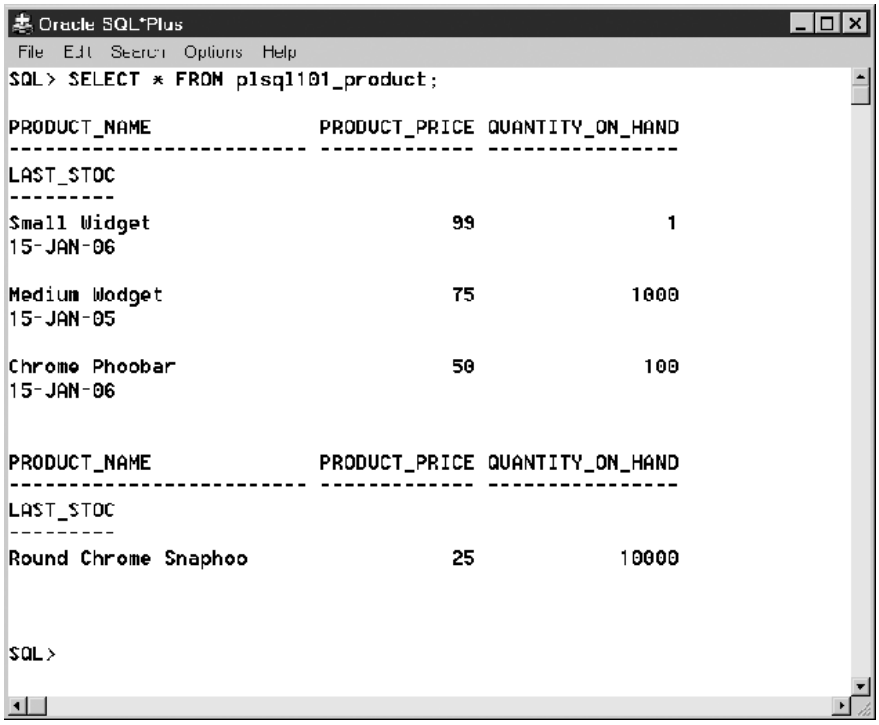


FIGURE 4-7. *Results of having data wider than the linesize setting*

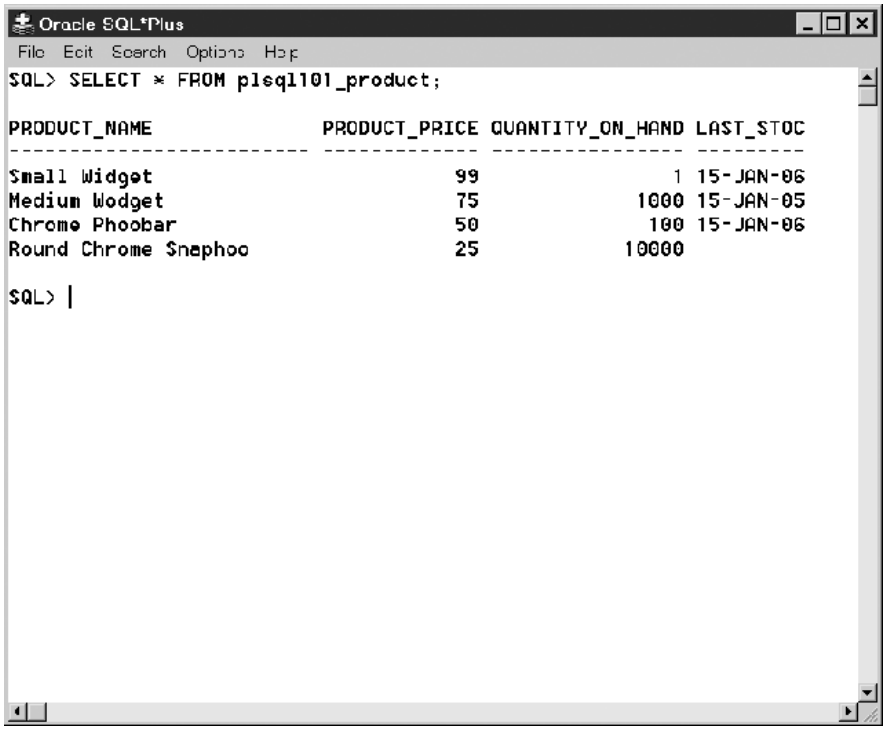


FIGURE 4-8. *Results of setting a more accommodating linesize*

column headings. The default value is quite low, causing SQL*Plus to show numerous sets of headings per screen when running on a modern high-resolution display. I like changing the pagesize to 2000, so that only the longest lists of data contain more than one set of headers. You can try this setting by entering **2000** into the pagesize option's value field.

Once you are done changing values in the Environment dialog box, click the OK button to close it.

Customize Using Commands

All of the options shown in the Environment dialog box's Set Options list can be changed from SQL*Plus. To see this in action, enter the following commands at the SQL> prompt:

```
SET LINESIZE 200
SET PAGESIZE 2000
```

Produce More Readable Output

You may have noticed by now that SQL*Plus does very little to beautify the records it displays. It doesn't align decimal places in numbers; it cuts off column headings as it sees fit; and it insists on showing the entire contents of a large text column in a single row, regardless of how wide the column must become in order to do so. With a few simple commands you can dramatically improve the appearance of SQL*Plus output.

The trick to doing all of this is the COLUMN command. Like STORE, the COLUMN command does not get sent to the Oracle database. Its only job is to affect the way your own copy of SQL*Plus displays information. As such, COLUMN commands do not need to end with a semicolon like standard SQL commands do. In addition, they stay active only as long as your SQL*Plus session lasts—if you exit SQL*Plus and then restart it, the effect is gone until you issue the COLUMN commands again.

Before you start experimenting with the COLUMN command, it would be good to add a record that needs a lot of formatting to your PL/SQL 101 sample tables. Enter the following code to add such a record:

```
INSERT INTO plsql101_product VALUES (
     'Extra Huge Mega Phoobar +',
     9.95,
     1234,
     '15-JAN-07')
;
```

Format Numbers in SQL*Plus

There are three things that commonly need to be done to numbers:

- Align their decimals
- Place a separator between hundreds, thousands, and so on
- Place a currency symbol with them

We'll look at each need individually and then combine them.

Align Decimals

The syntax of the COLUMN command to align decimals is as follows:

COLUMN *column_name* FORMAT *format_code*

You replace the *column_name* argument with the name of the column you wish to format. Note that there is no mention of which table the column is in! The

COLUMN command affects all columns with the name you specify, regardless of the tables in which the columns reside. Fortunately, if two columns have the same name they probably contain similar data, so the formatting you apply to one generally makes sense for the other as well.

You replace the *format_code* argument with a representation of how the numbers should look. The representation consists of one "9" for every digit your numbers will require, along with a "." for the decimal place. (If your country's standard format uses a different character than "." to denote decimals, use "D" in the COLUMN command's *format_code* argument instead of ".", and the decimal indicator from your database's national configuration will be used.)

To see the COLUMN command in action, enter the following commands:

```
SELECT * FROM plsql101_product;

COLUMN product_price FORMAT 9999.99

SELECT * FROM plsql101_product;
```

Your screen should now look similar to the one shown in Figure 4-9. Notice how the values in the PRODUCT_PRICE column started out unaligned, and then became aligned after you issued the COLUMN command.

Add a Group Separator

A *group separator* is a character that separates hundreds, thousands, and so on, within a number. Your PLSQL101_PRODUCT table has values in its QUANTITY_ON_HAND column that could benefit from having a comma separate the hundreds from the thousands. You can achieve this result with the same COLUMN syntax you used to get decimal alignment; you just need to change the format code. Try entering the following commands to see how it works:

```
COLUMN quantity_on_hand FORMAT 99,999

SELECT * FROM plsql101_product;
```

In response, you can see that the QUANTITY_ON_HAND column now includes commas when appropriate.

Include a Currency Symbol

As you might suspect, this too is simply a variation on the format code. Try the following code to place a dollar sign ($) before each PRODUCT_PRICE value:

```
COLUMN product_price FORMAT $99.99

SELECT * FROM plsql101_product;
```

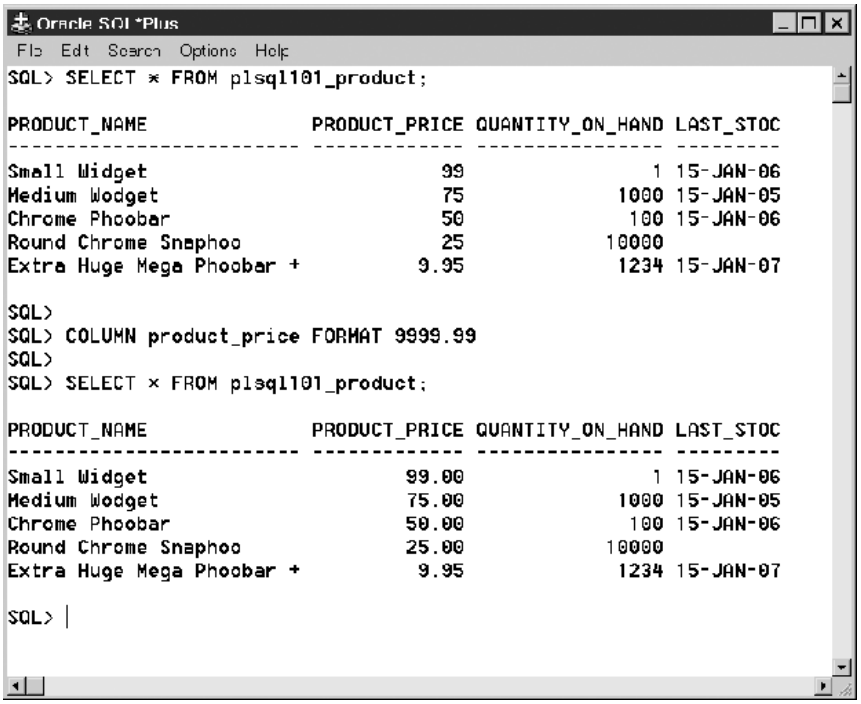


FIGURE 4-9. *Use the COLUMN command to align decimals*

Other Useful Number Format Codes

Table 4-1 contains a list of the most important format codes you can use with numbers. Take a moment now and try out each one of these codes, so you can see firsthand what they do. Be sure to try the RN code for a little bit of fun.

Format Text in SQL*Plus

One of the most common things I hear people complaining about with SQL*Plus is that it doesn't wrap the contents of large text columns. This is a valid complaint, because it diminishes the program's usefulness. However, there is a simple way to make SQL*Plus wrap large text columns. It uses a variation on the COLUMN command. The syntax is as follows:

COLUMN *column_name* FORMAT A*nn* WORD_WRAP

You've probably figured out that you replace *column_name* with the name of the column you want to wrap. The other argument is *nn*, which is where you place a number representing how many characters wide the wrapped column should be. (The "A" preceding the number stands for "alphanumeric.")

Element	Example	Description
9	9999	Specifies number of digits to return
0	0999	Displays one or more leading zeros
0	9990	Causes empty values to display as zeros
$	$9999	Places a dollar sign before the value
, (comma)	9,999	Places a comma in the position indicated
. (period)	99.99	Places a decimal point in the position indicated
MI	9999MI	Causes a minus sign (–) to be displayed after any negative value
S	S9999	Places a plus sign (+) for positive values and a minus sign (–) for negative values in the position indicated
PR	9999PR	Causes negative values to be surrounded by angle brackets (<>)
D	99D99	Displays your country's decimal character in the position indicated
G	9G999	Displays your country's group separator in the position indicated
C	C999	Displays the ISO currency symbol in the position indicated
L	L999	Displays the local currency symbol in the position indicated
U	U999	Displays the dual currency symbol (such as Euro) in the position indicated
RN or rn	RN	Causes numbers to display as upper- or lowercase Roman numerals (limited to integers between 1 and 3,999)

TABLE 4-1. *Number Format Codes*

Try the following commands to see how this works. Compare your results with those shown in Figure 4-10.

```
SELECT * FROM plsql101_product;

COLUMN product_name FORMAT A10 WORD_WRAP

SELECT * FROM plsql101_product;
```

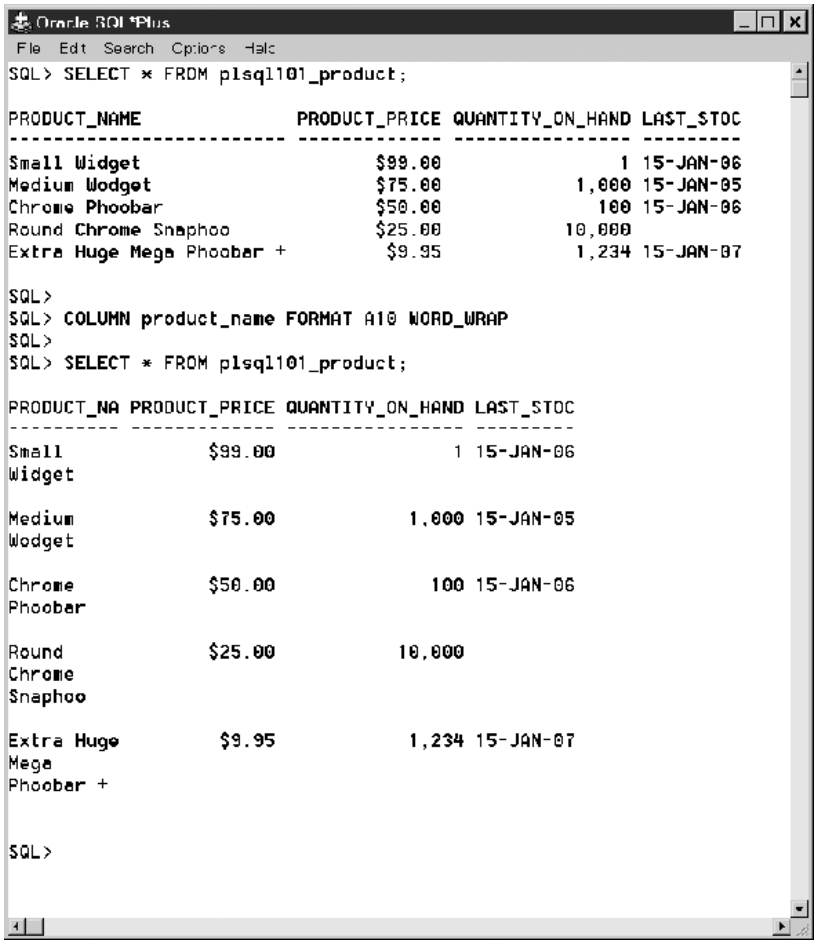


FIGURE 4-10. *Change a column's displayed width in SQL*Plus*

As you can see, the product names now fit easily into a narrow space. You might be thinking, "They fit before, too." That's true. This technique works best with columns that are wider: 30, 40, 50, 100, or even several hundred characters wide. So why didn't I create an exercise showing how it works with text that long?

Do *you* want to type in a bunch of hundred-character-long product names?

I didn't think so. Remember this technique, and when a situation arises where a wide column doesn't fit within the SQL*Plus screen, you'll know what to do.

Format Column Headings in SQL*Plus

While the techniques you've learned so far give you the ability to polish up the appearance of the displayed records, the column headings above those records are still a mess. Besides being comprised entirely of capital letters, the column names are too long to fit within the width of some of the columns—so some of the names are cut off. A variation of the COLUMN command will take care of that. The new syntax is:

COLUMN *column_name* HEADING '*heading_text*' JUSTIFY LEFT

…or…

COLUMN *column_name* HEADING '*heading_text*' JUSTIFY CENTER

…or…

COLUMN *column_name* HEADING '*heading_text*' JUSTIFY RIGHT

In addition to letting you control what headings display above columns, this technique offers a couple of other nice benefits: you can use a mixture of upper- and lowercase characters, and you can break the headings into multiple lines. Within the *heading_text* argument, a vertical bar (|) represents a line break. You can even specify whether the headings should be justified to the column's left margin, to its center, or to its right margin.

To see this in action, try the following commands:

```
SELECT * FROM plsql101_product;

COLUMN product_name HEADING 'Product|Name' JUSTIFY CENTER

SELECT * FROM plsql101_product;
```

You can put all of these COLUMN command options together and use them at the same time. Try the following commands and compare your results with those shown in Figure 4-11:

```
SELECT * FROM plsql101_product;

COLUMN product_name FORMAT A10 WORD_WRAP HEADING 'Name' JUSTIFY CENTER
COLUMN product_price FORMAT $99.99 HEADING 'Price' JUSTIFY RIGHT
COLUMN quantity_on_hand FORMAT 99,999 HEADING 'On|Hand' JUSTIFY RIGHT
COLUMN last_stock_date HEADING 'Last|Stock|Date' JUSTIFY RIGHT

SELECT * FROM plsql101_product;
```

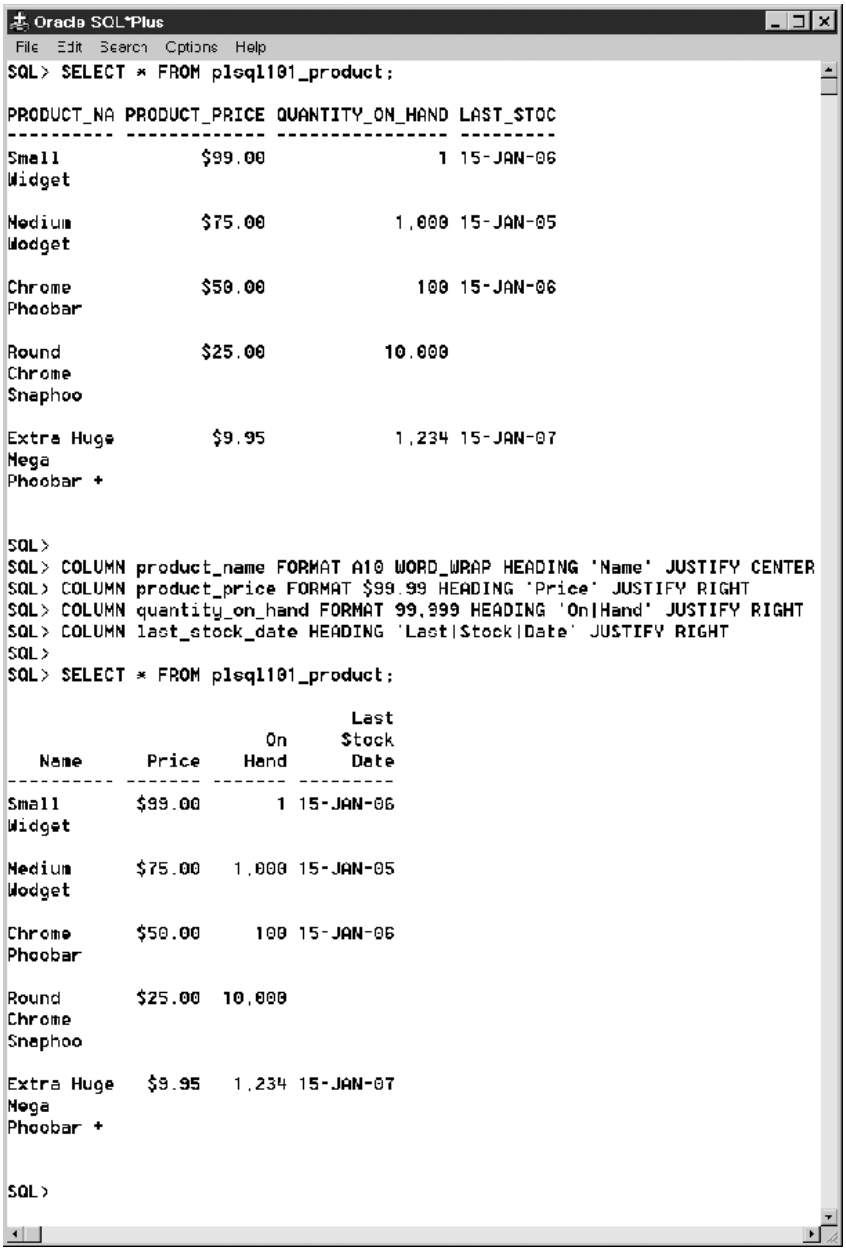


FIGURE 4-11. *Format text with a variety of COLUMN commands*

To turn off the formatting from the COLUMN command, you can use this syntax:

COLUMN *column_name* OFF

For instance, to make the columns in your PLSQL101_PRODUCT table display like they did before you applied any formatting, enter the following commands:

```
COLUMN product_name OFF
COLUMN product_price OFF
COLUMN quantity_on_hand OFF
COLUMN last_stock_date OFF

SELECT * FROM plsql101_product;
```

Spool Output to Disk

Spooling is the process of writing information out to a file on a disk. There are times when it's handy to do this from within SQL*Plus, either to make a record of a series of commands and their results, or to store voluminous output from a single command. (If the output fits within a single SQL*Plus screen, you can simply use the mouse to select the information you want, copy it, and paste it into whatever program you want. Once the information is pasted into the destination program, you may need to apply a fixed-space font such as Courier New to it in order for its lines to align properly.)

The syntax of the SPOOL command is as follows:

SPOOL *spool_file_name*

The spool file name can include a file extension if you wish (such as .sql or .prn). If you do not specify one, the extension .lst will be appended to the end of the name you specify. Also, you can include a *path* as part of the spool file name; the path is the name of the disk drive and directory in which the spool file should be stored. If you do not include a path, the spool file will be stored in the BIN directory beneath your Oracle home directory.

To try the SPOOL command, enter the following commands. Note that because SPOOL controls behavior within SQL*Plus—and does not affect the Oracle server—you do not need to place a semicolon at the end of each SPOOL command.

```
SPOOL c:\plsql101_test.prn
SELECT * FROM plsql101_product;
SELECT * FROM plsql101_purchase;
SPOOL OFF
```

TIP
*For those of you running SQL*Plus on Unix, the path for the spool file will have a structure more like this:*

```
/u01/user/plsql101_test.prn
```

(Remember that path and file names in Unix are case-sensitive.)

After executing these commands, use Windows Explorer or the File Manager to navigate to the location where you stored your plsql101_test.prn file. Open the file and you will see a complete record of everything that crossed your SQL*Plus screen.

SQL Script Files

By this time, you have learned quite a few different SQL commands, and you have typed in many lines as you experimented with those commands. In a business environment, it's common to have certain operations that get performed in exactly the same way—or almost exactly the same way—many times. Retyping the same commands over and over can get tedious quickly. Instead, you can store the commands needed to accomplish a specific task in a disk file. This has three major benefits: it saves you time by eliminating the need to retype repetitive commands; it makes the procedure finish more quickly because commands are read from the disk file much more quickly than you could type them; and it ensures that the commands are executed in exactly the same way, with perfect syntax, each time.

Create a Script File

A script file is just a plain text file. You can create one using any text editor or word processor. (If you use a word processor, be sure to use the Save As command to save the file in a "text only" format, so it will not contain any of the word processor's formatting codes.) You can even use the SQL*Plus EDIT command to start your system's default text editor to create a new script file. To see how this works, take the following steps:

1. In SQL*Plus, enter this command:

```
EDIT c:\plsql101_test.sql
```

NOTE
Unix users should modify the file path to a location of your choosing. The same guideline will apply to subsequent exercises that involve file paths.

2. Within the text editor, enter the following commands into your plsql101_test.sql file:

```
CREATE TABLE plsql101_temp (
     first_name VARCHAR2(15),
     last_name  VARCHAR2(25)
     )
;

INSERT INTO plsql101_temp VALUES ('Joe', 'Smith');
INSERT INTO plsql101_temp VALUES ('Jane', 'Miller');

SELECT * FROM plsql101_temp;

DROP TABLE plsql101_temp;
```

3. Exit from the text editor. When asked if you want to save the file you just created, answer Yes.

That's it! You now have a script file containing SQL commands. This particular script file contains commands that create a table, populate it with data, select data out of it, and then drop it. You would never create a script with these commands in real life, because the script is self-nullifying. However, it serves as an excellent example of the kinds of commands you can include in a script file to automate common actions.

Run a Script File

Running a script file in SQL*Plus is very easy. You simply precede the name of the file with the "at" sign (@). Enter the following command at the SQL> prompt to see this in action:

```
@c:\plsql101_test
```

In response, you should see a screen similar to the one shown in Figure 4-12. Notice that you did not need to include the .sql file extension in the command. If you do not specify a file extension in the @ command, the extension of .sql is assumed.

Use Variables In Script Files

Sometimes it is handy to be able to write a script file that can work in a variety of situations, changing what it does in each situation. You can accomplish this by using *variables* in your script files. A variable takes the place of a portion of your command, allowing you to "fill in" that portion when the script runs—thereby changing what the script does. (The opposite of this is information typed explicitly

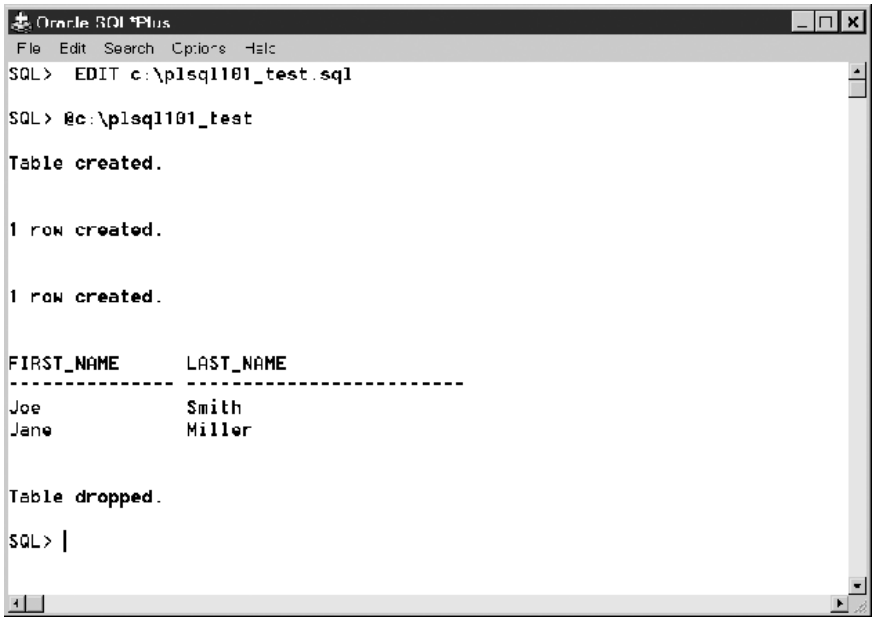


FIGURE 4-12. *Run an SQL script file*

into the script file. This type of information is called *hard coded* because it cannot be changed when the script runs.) You can build variables into your SQL scripts in two different ways: using substitution variables, and using the ACCEPT command.

Substitution Variables

Using a *substitution variable* is the simplest way to build a variable into your script. To see how this works, create a script file named plsql101_test2.sql and place within it the following commands (note the ampersand character on Line 5):

```
SET VERIFY OFF

SELECT product_name, quantity, purchase_date
FROM   plsql101_purchase
WHERE  quantity >= &minimum_quantity_sold
;

SET VERIFY ON
```

Save and run the script. You will see a brand-new prompt asking you to "Enter value for minimum_quantity_sold." The number that you type in will be placed into the script's WHERE clause as if it had been hard-coded into the script. Enter a value of **20** and see how the script performs. Then run it again [to do this just type a forward slash (**/**) and press ENTER] and respond to the prompt with a value of **5**, to see how the script's behavior changes.

The SET VERIFY OFF and SET VERIFY ON commands in the script help improve its appearance when the script runs. Without them, SQL*Plus would insist on showing old and new values for the substitution variable before executing your SELECT command, which will confuse anyone running the script other than its creator—and will eventually annoy even its creator.

Substitution variables work just as well for text and dates, too. You must remember, though, that SQL requires text and dates to be surrounded by single quotes. Since it is unlikely that other people using your script will remember this, the best practice is to place the single quotes into the script itself. Consider the following code for an example:

```
SET VERIFY OFF

SELECT product_name, quantity, purchase_date
FROM   plsql101_purchase
WHERE  purchase_date = '&date_you_want_to_select'
;

SET VERIFY ON
```

Notice that the substitution variable in this example is surrounded by single quotes. Those quotes will surround whatever date the user types in, thereby making a properly formatted date.

Place this code in a script file named plsql101_test3.sql, and then run it to see how it works. (The table currently contains records whose dates are 14-JUL-06, 15-JUL-06, and 16-JUL-06.)

To sharpen your skills at this technique, create a script file that allows the user to specify two dates between which records will be selected. This will involve using the BETWEEN clause and two separate substitution variables.

The ACCEPT Command

You may have noticed that the prompt SQL*Plus displays to users when it encounters a substitution variable isn't exactly attractive. An alternative is the ACCEPT command, which allows you to define any prompt you want. The ACCEPT command's syntax is as follows:

accept *variable_name* prompt '*prompt text*'

To see how it works, create a script named plsql101_test4.sql and place the following commands within it:

```
SET VERIFY OFF
SET ECHO OFF

ACCEPT v_earliest_date PROMPT 'Earliest date? (dd-mmm-yy): '
ACCEPT v_latest_date PROMPT 'Thank you. Latest date? (dd-mmm-yy): '
SELECT product_name, quantity, purchase_date
FROM   plsql101_purchase
WHERE  purchase_date BETWEEN '&v_earliest_date' AND '&v_latest_date'
ORDER BY product_name, quantity
;

SET VERIFY ON
SET ECHO ON
```

This script employs one more pair of new commands: SET ECHO OFF and SET ECHO ON. The SET ECHO commands control whether commands in the script file are shown to the user. In this case, they ensure that the user only sees the prompts from the ACCEPT commands and does not see the commands themselves.

Chapter Summary

This chapter presented a variety of useful techniques for getting the most out of the SQL*Plus program. You began by learning how to edit and reuse commands. There are two ways to do this: using the ED command to invoke your system's default text editor, or using the CHANGE command to perform line-level editing. If the command you want to reuse doesn't need to be changed, you can simply copy it from the SQL*Plus screen and paste it back in at the cursor position to use it again.

After learning how to reuse prior commands, you saw that you can clear the SQL*Plus screen by using the SHIFT-DELETE key sequence. Then you learned how to customize numerous facets of the SQL*Plus environment using both the Options | Environment menu command and a variety of commands you enter directly at the SQL prompt. To ensure that your changes will be active in future sessions, you can use the STORE command to save them.

To make selected data easier to read, you can employ the COLUMN command to format the display of numbers, dates, and text, as well as the wording and justification of column headings. You can also use the SPOOL command to create a disk file containing everything you see go across your SQL*Plus screen.

Speaking of disk files, one of your most powerful tools for making your SQL work more efficiently is storing often-used groups of commands in text files using

the .sql extension. You can make SQL*Plus run these script files simply by typing an @ character at the SQL prompt, followed by the path and name of the file that contains the commands you want to run. To make the script files more versatile, you can include substitution variables and the ACCEPT command so you can enter criteria (or any other information) when the script runs.

Way to go! Now let's move on to the really hard stuff.

OK, I'm just kidding. The next chapter isn't hard at all. In fact, it contains some very cool functions that are easy to use and that dramatically increase what you can do with SQL. It just gets more and more interesting…

Chapter Questions

1. **What editor starts when you execute the ED command from SQL*Plus?**

   A. Oracle's internal editor

   B. Your system's default editor

   C. The EDIT program

   D. The VI program

2. **Which of the following commands will *not* alter the way data displays on your screen?**

   A. COLUMN

   B. SET LINESIZE

   C. SPOOL

   D. SET PAGESIZE

3. **On which line will the following command fail?**

```
SELECT product_name, quantity, purchase_date
FROM   plsql101_purchase
WHERE  quantity <= &maximum_quantity_sold;
```

   A. 1

   B. 2

   C. 3

   D. The command will succeed.

4. On which line will the following script encounter a problem?

```
SET VERIFY OFF
SET ECHO OFF
ACCEPT v_earliest_date PROMPT 'Earliest date? (dd-mmm-yy): '
ACCEPT v_latest_date   PROMPT 'Latest date? (dd-mmm-yy): '
SELECT product_name, quantity, purch_date
FROM   plsql101_purchase
WHERE  purch_date BETWEEN '&earliest_date' AND '&latest_date'
ORDER BY product_name, quantity;
SET VERIFY ON
SET ECHO ON
```

A. 1

B. 3

C. 5

D. 7

E. 9

Answers to Chapter Questions

1. B. Your system's default editor

Explanation Oracle does not have an editor of its own. The ED command will start whatever editing program your system is configured to use by default.

2. C. SPOOL

Explanation The SPOOL command simply controls whether the data displayed on your SQL*Plus screen is also written out to a disk file. It does not alter the displayed data in any way.

3. D. The command will succeed

Explanation The only thing unusual about this SELECT command is its use of the & character on the third line. This character marks the name that follows (maximum_quantity_sold) as a substitution variable, which will cause a prompt to be displayed to the user when the command runs. This syntax is perfectly acceptable.

4. D. 7

Explanation The names used in the substitution variables do not match those created by the ACCEPT commands.

PART II

Advanced SQL

CHAPTER 5

SQL Functions

his unit contains a wealth of advanced techniques you can use to make your Oracle applications easier to use, more powerful, and more efficient. Following this chapter, you will learn about Oracle indexes, constraints, and relationships in Chapter 6, and learn a variety of powerful real-life techniques in Chapter 7 to help you perform day-to-day database tasks in the most efficient way.

Before all that good stuff, though, is this chapter, which focuses on the fascinating world of SQL functions. A *function* is like a mini-command you can place within a larger SQL statement. Data goes into a function looking one way, and comes out looking another way, based on the purpose the function is designed to fulfill. For instance, functions can change the way data appears (like turning a date value into the related day of the week), subtotal the data in a way you specify, or alter the content of the data (like taking one set of codes and translating them into a different set of codes). By learning to use functions, you take a major step ahead of those who have merely been exposed to SQL, and move toward the group of people who really understand how to make SQL dance for them.

The functions will be presented in two groups: single-row functions and group functions. Single-row functions perform operations that could affect the display of every row in a table. In contrast, group functions are designed to give you information about subsets of your data, with the groupings defined in any way you please.

If you just started reading in this chapter and have not done any of the exercises in the preceding chapters, you will need to create the sample tables built in prior chapters before you can do the exercises in this chapter. To accomplish this, enter the following SQL commands:

```
DROP TABLE plsql101_product;
CREATE TABLE plsql101_product (
     product_name     VARCHAR2(25),
     product_price    NUMBER(4,2),
     quantity_on_hand NUMBER(5,0),
     last_stock_date  DATE
     )
;

INSERT INTO plsql101_product VALUES
     ('Small Widget', 99, 1, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Medium Wodget', 75, 1000, '15-JAN-05');
INSERT INTO plsql101_product VALUES
     ('Chrome Phoobar', 50, 100, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Round Chrome Snaphoo', 25, 10000, null);
INSERT INTO plsql101_product VALUES
```

```
     ('Extra Huge Mega Phoobar +',9.95,1234,'15-JAN-07');

DROP TABLE plsql101_purchase;
CREATE TABLE plsql101_purchase (
     product_name  VARCHAR2(25),
     salesperson   VARCHAR2(3),
     purchase_date DATE,
     quantity      NUMBER(4,2)
     )
;

INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'CA', '14-JUL-06',1);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'BB', '14-JUL-06',75);
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'GA', '14-JUL-06',2);
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'GA', '15-JUL-06',8);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'LB', '15-JUL-06',20);
INSERT INTO plsql101_purchase VALUES
     ('Round Snaphoo', 'CA', '16-JUL-06',5);
```

Commonly Used Single-Row Functions

This section introduces you to single-row functions. These functions give you row-by-row control over how the data in your database is entered and presented. The functions fall into the following categories:

- System variables
- Number
- Character (text)
- Date
- Datatype conversion
- Other functions

System Variables

System variables are maintained by Oracle to provide you with information about the environment in which the database is running. The three system variables presented here allow you to determine the system date and time, the ID of the user

executing an SQL statement, and the name of the computer from which a user is executing commands. These functions can be very useful in a variety of ways, as you will see.

SYSDATE

The SYSDATE function returns the current date and time. To see this function in action, enter the following command:

```
SELECT SYSDATE FROM DUAL;
```

In response, you will see the current date appear on your screen. A more interesting way to use this command is in DML statements. For instance, you can cause the current date to be inserted into any date field by specifying SYSDATE in the INSERT statement. Try the following command to see how this works:

```
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'SH', sysdate,10);
```

After you have entered this command, use a SELECT statement to see all the records in your PLSQL101_PURCHASE table, and you will see that your new record has been added with today's date in the PURCHASE_DATE column. (Actually, the value entered in that column contains both the date and the time—you will see how to display the time component of the value later in this chapter.)

Let's extend this idea a bit further by using some date math in the INSERT statement. Enter the following commands:

```
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'SH', sysdate-14,15);
INSERT INTO plsql101_purchase VALUES
     ('Round Snaphoo', 'SH', sysdate-7,25);
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'SH', sysdate+7,10);
```

With these commands, you can see that today's date can be manipulated simply by adding and subtracting days. For instance, by subtracting 7 from today's SYSDATE value, you get the date value for exactly a week ago.

SYSDATE is also useful when you want to view records containing dates that have a certain relationship to today. For instance, to see all the sales that occurred in the last 30 days, you could use a command like the one that follows.

```
SELECT * FROM plsql101_purchase
WHERE  purchase_date BETWEEN (SYSDATE-30) AND SYSDATE;
```

The results you get from this command should be similar to those you see in Figure 5-1.

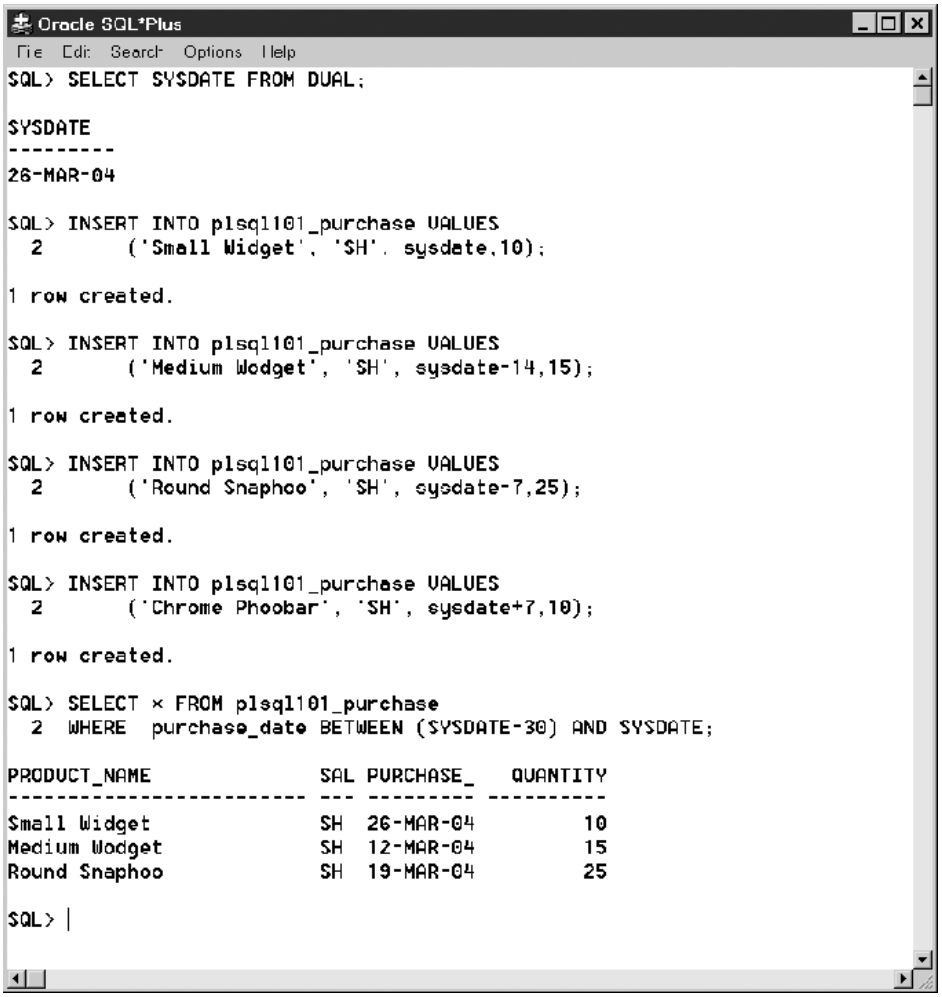


FIGURE 5-1. *Select records using SYSDATE in the WHERE clause*

Take a few moments now to experiment with SYSDATE. For instance, try selecting all the records that have been entered in the last two weeks, the last six months, and the last year. When you are done, delete the records used for this SYSDATE section by issuing the following command:

```
DELETE FROM plsql101_purchase
WHERE  SALESPERSON = 'SH';
```

SYSTIMESTAMP

SYSTIMESTAMP returns the *database server's* current date, time (including fractions of seconds), and time zone. Enter the following to see an example:

```
SELECT SYSTIMESTAMP FROM DUAL;
```

CURRENT_DATE

CURRENT_DATE returns your *local* computer's current date and time, in a date format.

CURRENT_TIMESTAMP

CURRENT_TIMESTAMP returns your *local* computer's current date, time (including fractions of seconds), and time zone. Enter the following to see an example:

```
SELECT CURRENT_TIMESTAMP FROM DUAL;
```

USER

Before explaining what the USER function does, I want to tell you that I won't be able to demonstrate a good use for this function until later in the book. The same is true for the USERENV function that follows. These functions are both useful when you want to audit activity on a table—that is, keep track of who is inserting, updating, and deleting records. Doing that is a relatively sophisticated operation, and you will learn how to do it in Chapter 9. To keep all the functions in one chapter, though, I'm presenting these two functions now. I recommend that you treat them as interesting novelties for the time being. When you encounter them again later in the book, they'll be familiar.

That having been said, let's learn about the USER function. It returns the Oracle user ID of the person who issues the command containing a USER function. Try the following command to see what I mean:

```
SELECT USER FROM DUAL;
```

In response, you will see the name you logged in as when you started SQL*Plus. As I said earlier, this is nothing more than an interesting novelty at the moment, but later on it will be useful when you want Oracle to store the user ID of a person making changes to the database.

USERENV

The USERENV function can return a variety of different facts about the computer environment of the person who issued the command containing the USERENV

function. The most useful of these facts is the name of the computer the person is working on. Enter the following command to see what I mean:

```
SELECT USERENV('TERMINAL') FROM DUAL;
```

In response, you will see your computer's name. This function, combined with the USER function you just learned, enables you to determine who took an action and from what computer. Add a SYSDATE function to the mix, and you have the beginning of a detailed audit record. You'll learn how to put these to use in this capacity in Chapter 9.

Number Functions

Number functions manipulate numeric values, changing them to suit your needs. The functions presented here provide common mathematical features. If the data you work with is mostly text-oriented, you might not see a need to know these functions. I recommend that you learn them anyway. A big part of growing more valuable as a technical person is being familiar with what a system *can* do, so that when a new need arises, you know what tools are available for taking care of that need.

ROUND

The ROUND function rounds numbers to whatever degree of precision you specify. Its syntax is as follows:

ROUND(*input_value, decimal_places_of_precision*)

To use the ROUND function—and every other function that modifies a value—you "wrap" it around the value you want to modify. Since this is usually done in a SELECT statement, you accomplish this by wrapping the function around the column name that contains the values to be modified.

Let's look at an example. The PLSQL101_PRODUCT table contains prices for the products. Some of those prices are integers with no decimal values—but not all. Try this pair of commands to see the ROUND function in action:

```
SELECT product_name, product_price
FROM   plsql101_product;

SELECT product_name, ROUND(product_price, 0)
FROM   plsql101_product;
```

The results you get should look similar to those shown in Figure 5-2.

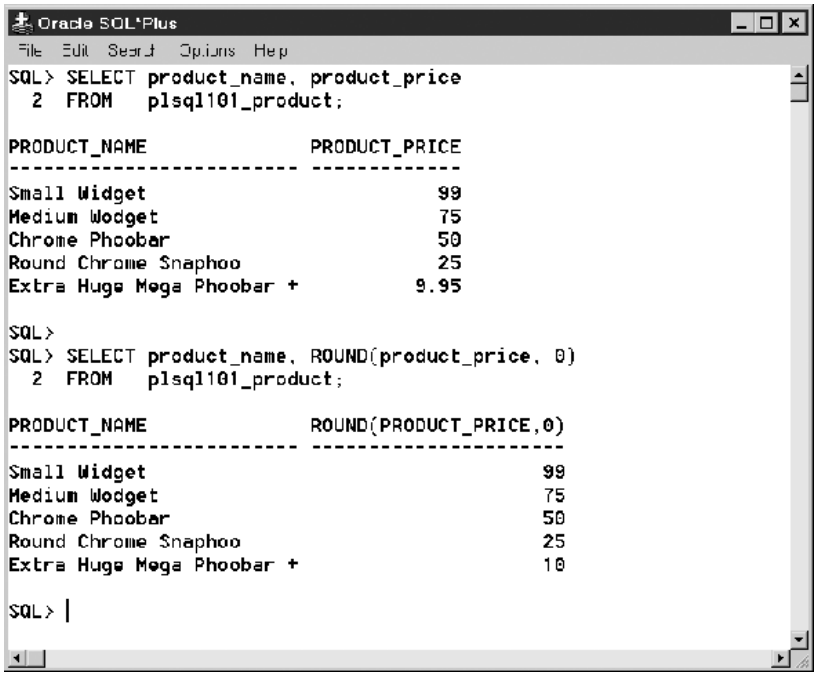


FIGURE 5-2. *The ROUND function*

This example shows one of the most common uses for the ROUND function. Another example would be rounding detailed values that contain a lot of decimal places down to dollars and cents; that would require specifying a decimal precision value of 2. You can specify any number of decimals of precision you want, but certain values make more sense than others. If you specify a negative number, the ROUND function starts rounding *before* the decimal point, resulting in numbers that are rounded to the nearest 10, 100, 1000, and so on.

The best way to see the relationship between the ROUND function's decimal places of precision and the change the function makes in the value it processes is to use it on numbers containing many decimal places. Since your test tables don't contain any records whose values have many decimal places—and it wouldn't make sense to create product records with prices like that—we'll use DUAL to demonstrate what ROUND does with such numbers. Enter the following commands to see the relationship between the ROUND function's decimal places of precision and the way the function rounds the number it is given. The results are summarized in Table 5-1.

```
SELECT ROUND(1234.5678, 4) FROM DUAL;
SELECT ROUND(1234.5678, 3) FROM DUAL;
SELECT ROUND(1234.5678, 2) FROM DUAL;
SELECT ROUND(1234.5678, 1) FROM DUAL;
SELECT ROUND(1234.5678, 0) FROM DUAL;
SELECT ROUND(1234.5678, -1) FROM DUAL;
SELECT ROUND(1234.5678, -2) FROM DUAL;
SELECT ROUND(1234.5678, -3) FROM DUAL;
```

TRUNC

The TRUNC function truncates precision from a number. The difference between this and rounding becomes apparent when a number contains decimal values of .5 or higher. Rounding the number would cause it to move up to the next higher number, while truncating it does not. Enter the following series of commands to see how this works. The results are summarized in Table 5-2.

```
SELECT TRUNC(1234.5678, 4) FROM DUAL;
SELECT TRUNC(1234.5678, 3) FROM DUAL;
SELECT TRUNC(1234.5678, 2) FROM DUAL;
SELECT TRUNC(1234.5678, 1) FROM DUAL;
SELECT TRUNC(1234.5678, 0) FROM DUAL;
SELECT TRUNC(1234.5678, -1) FROM DUAL;
SELECT TRUNC(1234.5678, -2) FROM DUAL;
SELECT TRUNC(1234.5678, -3) FROM DUAL;
```

ROUND Function	Resulting Number
ROUND(1234.5678, 4)	1234.5678
ROUND(1234.5678, 3)	1234.568
ROUND(1234.5678, 2)	1234.57
ROUND(1234.5678, 1)	1234.6
ROUND(1234.5678, 0)	1235
ROUND(1234.5678, -1)	1230
ROUND(1234.5678, -2)	1200
ROUND(1234.5678, -3)	1000

TABLE 5-1. *ROUND function precision results*

TRUNC Function	Resulting Number
TRUNC(1234.5678, 4)	1234.5678
TRUNC(1234.5678, 3)	1234.567
TRUNC(1234.5678, 2)	1234.56
TRUNC(1234.5678, 1)	1234.5
TRUNC(1234.5678, 0)	1234
TRUNC(1234.5678, -1)	1230
TRUNC(1234.5678, -2)	1200
TRUNC(1234.5678, -3)	1000

TABLE 5-2. *TRUNC function precision results*

Text Functions

Text functions, referred to in Oracle as *character functions*, manipulate text strings. The most common things to do with text strings are changing their case (between uppercase, lowercase, and mixed case); separating a long string into a number of shorter substrings; and cleaning up text coming in from an external source that is padded with extra spaces. By learning the character functions that follow, you will learn how to do each of those things.

UPPER, LOWER, and INITCAP

These three functions change the case of the text you give them. Since their functions are reasonably self-explanatory, I'll let them do the talking:

```
SELECT UPPER(product_name) FROM plsql101_product;
SELECT LOWER(product_name) FROM plsql101_product;
SELECT INITCAP(product_name) FROM plsql101_product;
```

The results you get from these commands should match what you see in Figure 5-3.

SELECT INITCAP('this TEXT hAd UNpredictABLE caSE') FROM DUAL;

Of the three case-changing character functions, you will probably use UPPER the most. One very handy use for it is in SELECT statements, when you are not sure what case your desired text will be in. For those instances, you just wrap an UPPER function around the name of the column you're searching, and then specify the text you want to match in uppercase letters. To demonstrate this technique, you need to

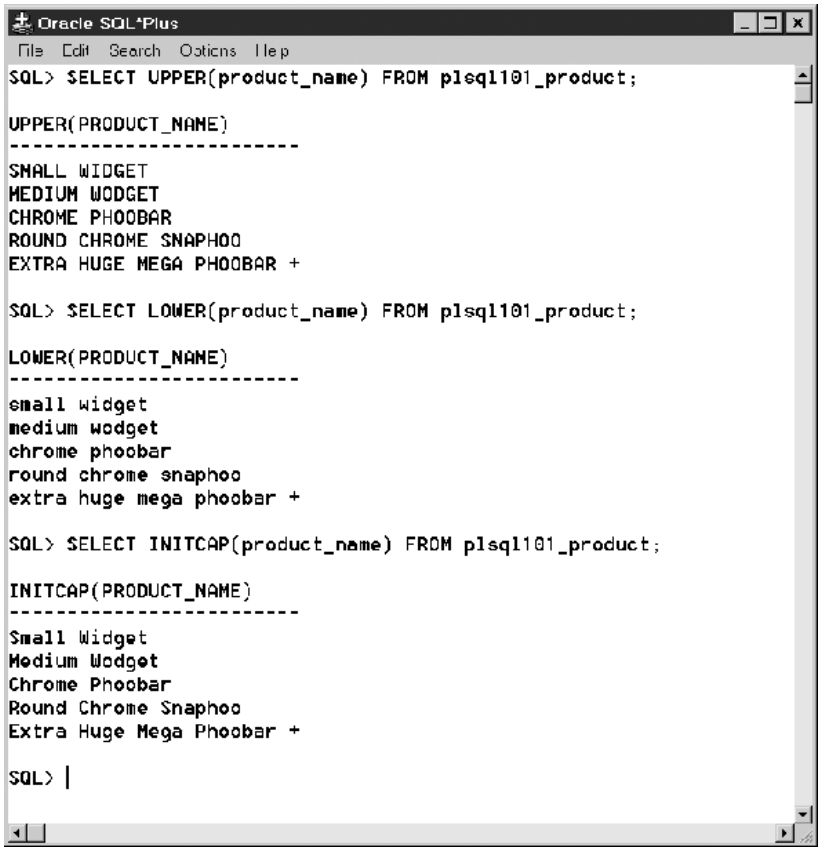


FIGURE 5-3. *Results of the UPPER, LOWER, and INITCAP functions*

change your test records a little, so there are records containing the same word but with different case. The following code makes this change, demonstrates how to use the UPPER function to overcome the difference in case, and then changes the data back so the case is once again the same. Enter the commands and compare the results of your SELECT command with those shown in Figure 5-4.

```
UPDATE plsql101_product
SET    product_name = 'chrome phoobar'
WHERE  product_name = 'Chrome Phoobar';

SELECT * FROM plsql101_product
WHERE  UPPER(product_name) LIKE '%PHOOBAR%';
```

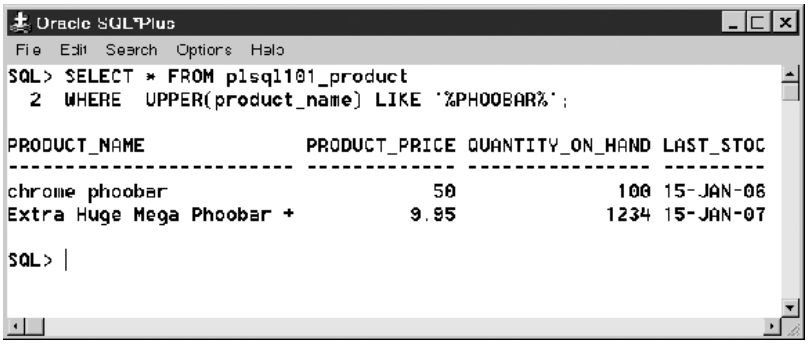


FIGURE 5-4. *Use the UPPER function to simplify text searches*

Using the UPPER function in this way can make it a lot easier to find the text you want when you don't know the case in which it was originally entered. However, as you can see in Figure 5-4, the data displayed as a result is still inconsistent in its use of upper- and lowercase characters. The solution is to wrap an INITCAP function around the PRODUCT_NAME column to clean it up. Enter the following code to see how this works:

```
SELECT INITCAP(product_name),
       product_price,
       quantity_on_hand,
       last_stock_date
FROM   plsql101_product
WHERE  UPPER(product_name) LIKE '%PHOOBAR%';
```

After you have compared the results you got with those shown in Figure 5-5, enter the following code to return your product names to the state they were in before this exercise:

```
UPDATE plsql101_product
SET    product_name = 'Chrome Phoobar'
WHERE  product_name = 'chrome phoobar';
```

LENGTH

There are times when it is useful to determine the lengths of data stored in a database column. The LENGTH function provides this capability. Imagine, for

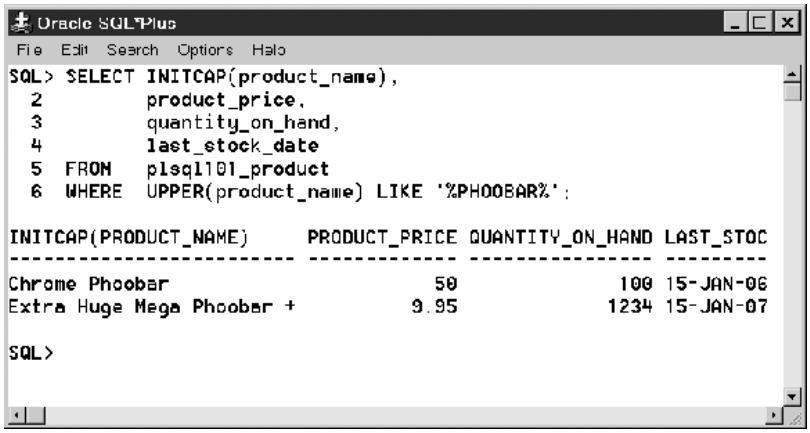


FIGURE 5-5. *Use the INITCAP function to clean up mixed-case data*

example, that you are using a table similar to the PLSQL101_PRODUCT table in your business, and the table feeds product names into the catalog department. They are considering using a smaller page size for the catalog, and the new page size requires them to reduce the length of product names from 25 characters to 15 characters. To help in their decision, they would like to know how many product names they would need to change. You can produce a list of the names that would need to be changed by employing a command such as this:

```
SELECT   product_name, LENGTH(product_name) NAME_LENGTH
FROM     plsql101_product
WHERE    LENGTH(product_name) >15
ORDER BY product_name;
```

NOTE
This example applies the alias NAME_LENGTH to the column containing product-name lengths, in order to make the column headings more readable.

The LENGTH function is also useful for determining the size of the largest entry in a column, as well as the size of the average entry in a column. You will see how to do both of these things a bit later in this section.

SUBSTR

There will be times in your Oracle career when you encounter data with a column containing multiple bits of data that you need to separate in discrete segments. In plain language, you will need to turn a column like this:

```
ITEM_ID
LA-101
LA-102
LA-103
LA-104
NY-101
NY-102
NY-103
NY-104
```

into multiple columns like this:

```
MANUFACTURER LOCATION          MANUFACTURER ITEM NUMBER
LA                             101
LA                             102
LA                             103
LA                             104
NY                             101
NY                             102
NY                             103
NY                             104
```

Since text is referred to as a *string* in the computer world, a smaller portion of text derived from a larger piece of text is called a *substring*. In the example just shown, the strings in the ITEM_ID column were broken out into two substrings each. This process is called *parsing* strings.

Oracle provides a function named SUBSTR to do this. Whenever you want to cut strings up into substrings, you need to specify the point at which the substring should start, as well as the length that the substring should be. For instance, in the preceding example, the first substring was the manufacturer's location. Its values

start at the first character position in the ITEM_ID column, and extend for two characters. The next substring was the manufacturer's item number, whose values start at the fourth character position within the ITEM_ID and extend for three characters.

None of your current sample tables from this book contain data that calls for parsing. I'm sure you know what that means: That's right, you get to practice your CREATE TABLE command. Enter the following commands to create an appropriate table and records:

```
CREATE TABLE plsql101_old_item (
     item_id   CHAR(20),
     item_desc CHAR(25)
     )
;

INSERT INTO plsql101_old_item VALUES
     ('LA-101', 'Can, Small');
INSERT INTO plsql101_old_item VALUES
     ('LA-102', 'Can, Large');
INSERT INTO plsql101_old_item VALUES
     ('LA-103', 'Bottle, Small');
INSERT INTO plsql101_old_item VALUES
     ('LA-104', 'Bottle, Large');
INSERT INTO plsql101_old_item VALUES
     ('NY-101', 'Box, Small');
INSERT INTO plsql101_old_item VALUES
     ('NY-102', 'Box, Large');
INSERT INTO plsql101_old_item VALUES
     ('NY-103', 'Shipping Carton, Small');
INSERT INTO plsql101_old_item VALUES
     ('NY-104', 'Shipping Carton, Large');
```

Now that you have data that can use parsing, it's time to learn the syntax of the SUBSTR command. It is:

SUBSTR(*source_text*, *starting_character_position*, *number_of_characters*)

The *source_text* value will usually be the name of the column that needs to be parsed. The *starting_character_position* is the first character in the column to include, and the *number_of_characters* is the number of characters to get. To parse the item ID into a manufacturer location and item number, enter the following command:

```
SELECT SUBSTR(item_id, 1, 2) MFGR_LOCATION,
       SUBSTR(item_id, 4, 3) ITEM_NUMBER,
```

```
       item_desc
FROM   plsql101_old_item
;
```

After you have entered this command, compare the results you get with those shown in Figure 5-6.

Parsing strings is a very common part of transferring data from one application to another, because the two applications never store data in exactly the same way. Later in this chapter you will become familiar with this process by learning how to copy records from one table to another, and part of the process will include parsing the data along the way.

INSTR

Using SUBSTR, as shown in the previous exercise, works great when you know exactly how long each substring will be. Often, however, you will be called upon to parse strings like those in the ITEM_DESC column of your PLSQL101_OLD_ITEM table—strings whose substrings vary in length. This means that not only is the length of the first substring unknown, but the starting position of the second substring can also vary. The only way to parse a string like this is to find out the location of the character (or characters) separating the items you want to parse. Oracle provides a function named INSTR that does just that.

INSTR searches for the text you specify and returns a number identifying the starting position of that text within a string. By using the number returned by INSTR

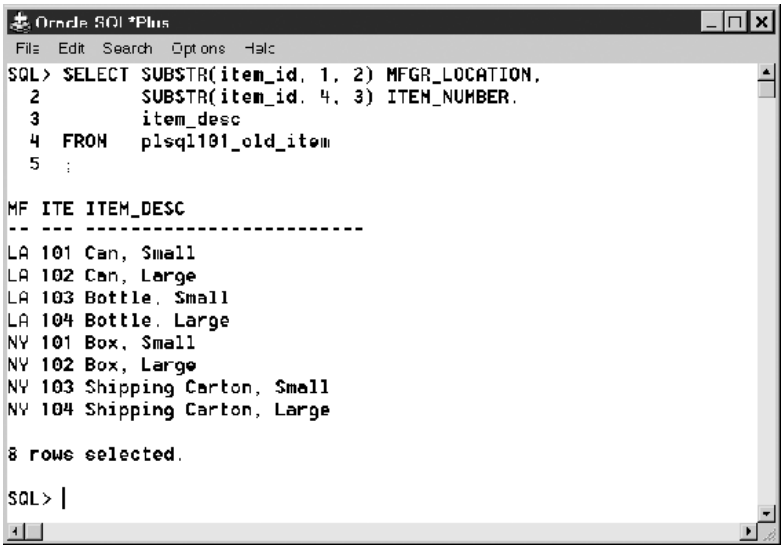


FIGURE 5-6. *Parse data using the SUBSTR function*

to control the length of your first SUBSTR function, as well as the starting position of the next substring, you can reliably slice and dice long strings no matter how they are divided.

The INSTR function's syntax is as follows:

INSTR(*source_text*, *text_to_locate*, *starting_character_position*)

The *source_text* is generally the name of the column containing the long string you want to parse. The *text_to_locate* is the text you want to find, and the *starting_character_position* specifies the character number in the source text at which you want to start searching (to start at the beginning of the text, use a *starting_character_position* value of 1).

The INSTR function can help us separate the PLSQL101_OLD_ITEM table's ITEM_DESC column into two pieces. All we have to do is tell it to locate the comma that separates the item category from the item size. By using the number it returns, we can specify the proper size for the item category, as well as the starting point for the item size.

If we're going to have the INSTR function help us separate the PLSQL101_OLD_ITEM table's ITEM_DESC column into two pieces, we need to understand what information the function provides for each record. Enter the following command to see the INSTR function in action:

```
SELECT item_desc,
       INSTR(item_desc,
             ',',
             1
             )
FROM   plsql101_old_item;
```

As Figure 5-7 shows, the INSTR function returns a number identifying the location of the comma in each record's item description. We could use that number as the length of our SUBSTR function to get the item category, but if we did, the category would include the comma. Therefore, we will want to subtract 1 from the INSTR function's value. The following code demonstrates how to do this:

```
SELECT item_desc,
       SUBSTR(item_desc,
              1,
              INSTR(item_desc,
                    ',',
                    1
                    ) -1
              )
FROM   plsql101_old_item;
```

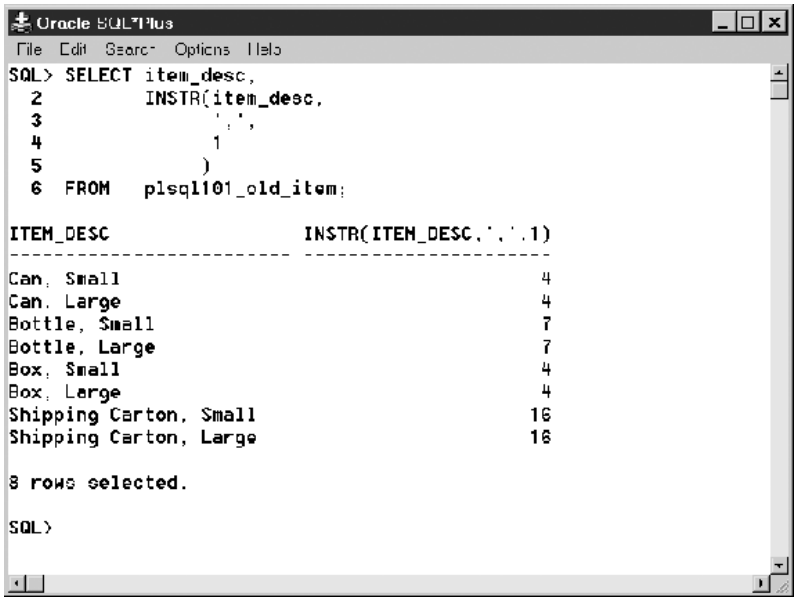


FIGURE 5-7. *Results of the INSTR function*

Enter the code and compare your results with those shown in Figure 5-8. As you can see, you now have a means to get a clean item category from each item record.

You have just had your first experience using one function within another one. This is called *nesting functions*. In a nested function, the inner function returns a value that is then used by the outer function. This is a powerful capability.

Getting back to the subject at hand, you still need to extract the item size from the ITEM_DESC column. The tricky part of this is the starting position for the size's SUBSTR function. Once again the INSTR function provides the solution by identifying the location of the comma preceding the size. However, that comma is located two characters before the actual start of the size, so you will want to add 2 to the value returned by the INSTR function. Enter the code that follows to get a nice clean list of each item's size:

```
SELECT item_desc,
       SUBSTR(item_desc,
              INSTR(item_desc,
                    ',',
                    1
                    ) +2,
              99
              )
FROM   plsql101_old_item;
```

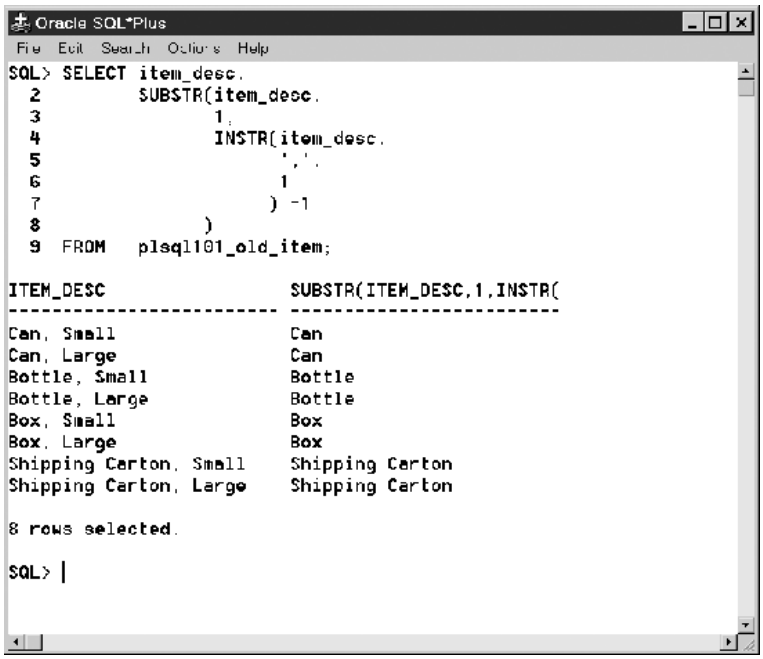


FIGURE 5-8. *Parse a variable-length substring*

In this case, the length of the substring is not a concern, because you are extracting the last portion of text in the overall string. To signify this, I specified a length of 99, which can help serve as a reminder that the SUBSTR function is pulling out the last text in the overall string.

Now that you have seen how to parse each item's category and size, it's time to do both in one command. The code that follows will include two SUBSTR functions: one for category, and the other for size. To help keep things clear, I'm placing a column alias after each SUBSTR function identifying which attribute it is producing.

```
SELECT item_desc,
       SUBSTR(item_desc,
              1,
              INSTR(item_desc,
                    ',',
                    1
                    ) -1
              ) CATEGORY,
       SUBSTR(item_desc,
              INSTR(item_desc,
```

```
                    ',',
                    1
                    ) +2,
               99
               ) ITEM_SIZE
FROM   plsql101_old_item;
```

The results you get from this command should match those shown in Figure 5-9.

The formatting used in the previous code uses indenting to help clarify how the portions of each function and nested function are grouped together. It's useful to do this when you are learning about functions, because it helps you keep clear about what part of which function you are dealing with at any given location in the command. Oracle doesn't care how the command is formatted, and will produce

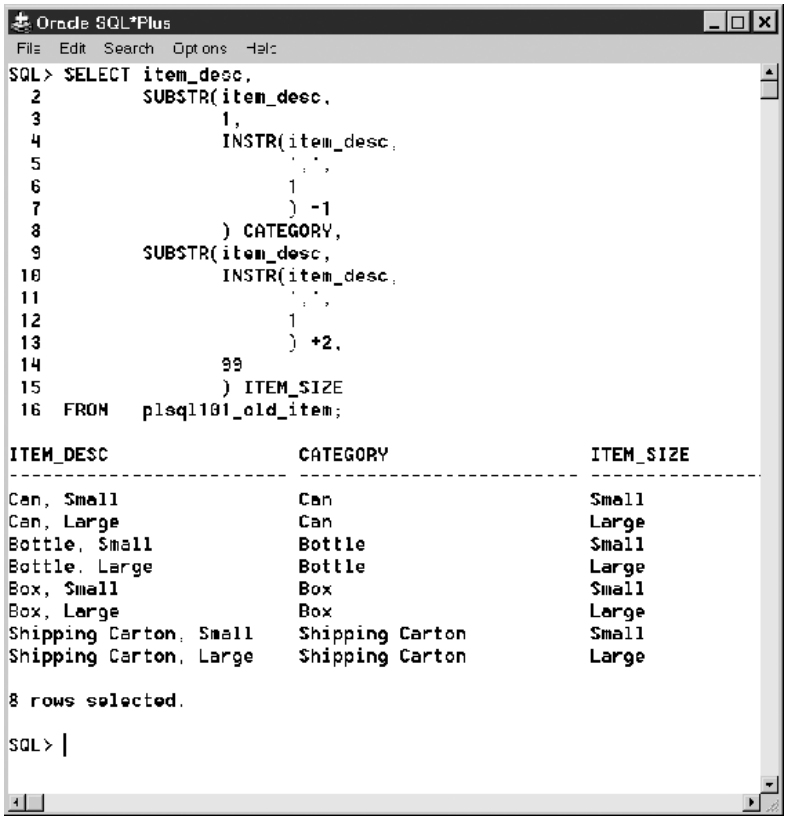


FIGURE 5-9. *Parse multiple variable-length substrings*

identical results from the following code, which contains exactly the same command in a more compact form:

```
SELECT item_desc,
       SUBSTR(item_desc, 1, INSTR(item_desc, ',', 1) -1)  CATEGORY,
       SUBSTR(item_desc, INSTR(item_desc, ',', 1) +2, 99) ITEM_SIZE
FROM   plsql101_old_item;
```

You will get a chance to work with substrings more a little later in the chapter, when you learn how to copy records from one table to another.

LTRIM and RTRIM

The best way to explain what these functions do is to show you the problem they solve. Enter the following code and compare your results with those in Figure 5-10:

```
SELECT 'Item  ' ||
       item_id ||
       ' is described as a ' ||
       item_desc ||
       '.'  "Item Description Sentence"
FROM   plsql101_old_item;
```

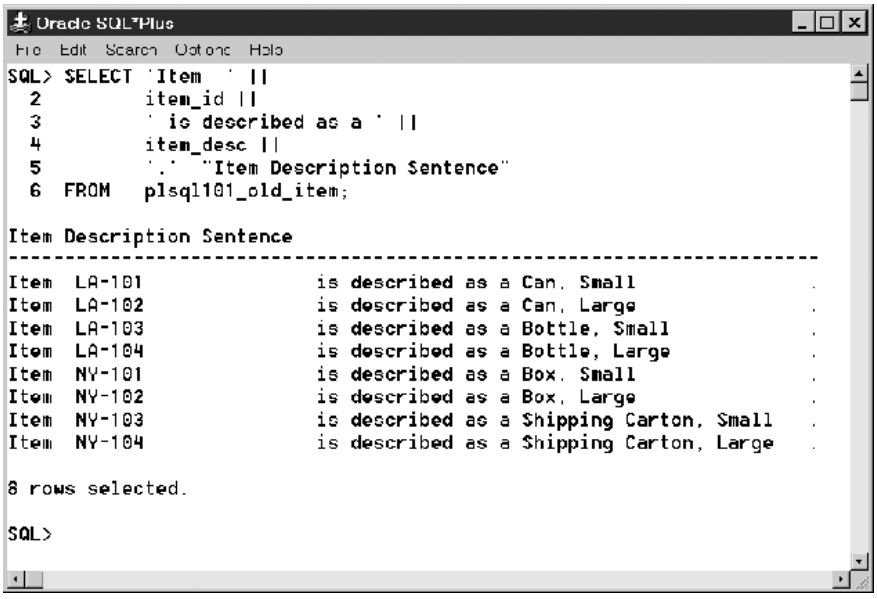


FIGURE 5-10. *Concatenate text from CHAR columns*

Why is there so much space after the ITEM_ID and ITEM_DESC values? Because both columns are defined as CHAR datatypes. Remember the difference between the VARCHAR2 datatype and the CHAR datatype? VARCHAR2 is variable length, while CHAR is fixed length. This means that data stored in a CHAR column is padded with spaces to fill out the data to the column's defined length. Those spaces become a problem when you want to concatenate the column's contents with anything else. They can also be unnecessary space-wasters when importing fixed-length data from another database system into your own tables.

Functions to the rescue! The process of removing extra spaces from the beginning or end of a text string is called *trimming*, and Oracle provides two functions that do it: LTRIM and RTRIM. The LTRIM function removes spaces from the beginning of a string, while the RTRIM function removes spaces from the end. The syntax for both functions is essentially identical:

LTRIM(*column_name*)

RTRIM(*column_name*)

In the ITEM_ID and ITEM_DESC columns, the problem is extra spaces at the end of each entry. The RTRIM function is the answer to this problem. You just wrap an RTRIM function around each column's name, as shown in the following code:

```
SELECT 'Item  ' ||
       RTRIM(item_id) ||
       ' is described as a ' ||
       RTRIM(item_desc) ||
       '.'  "Item Description Sentence"
FROM   plsql101_old_item;
```

Try this code and compare the results with those you see in Figure 5-11.

Ready to test your skills? Combine the SUBSTR and INSTR skills you learned earlier in this section with the RTRIM function to create a SELECT statement that produces these results from the PLSQL101_OLD_ITEM table shown in Figure 5-12.

There's nothing new about the techniques necessary to produce the listing shown in Figure 5-12. You just need to combine what you have already learned in a new way. I would provide an appropriate listing as an answer, but the fact is *it doesn't matter how you produce the answer, as long as the result matches the defined goal*. This is an important thing to know as you move into this line of work. Very few people will ever look at your code. They will only look at your results. I'm confident that you can create the results shown in Figure 5-12 using what you have learned so far. It will probably take a few test runs to work out the bugs, but you can do it. To make it simpler, create the code to produce just the first portion of the sentence—up to the size description—and work with that until

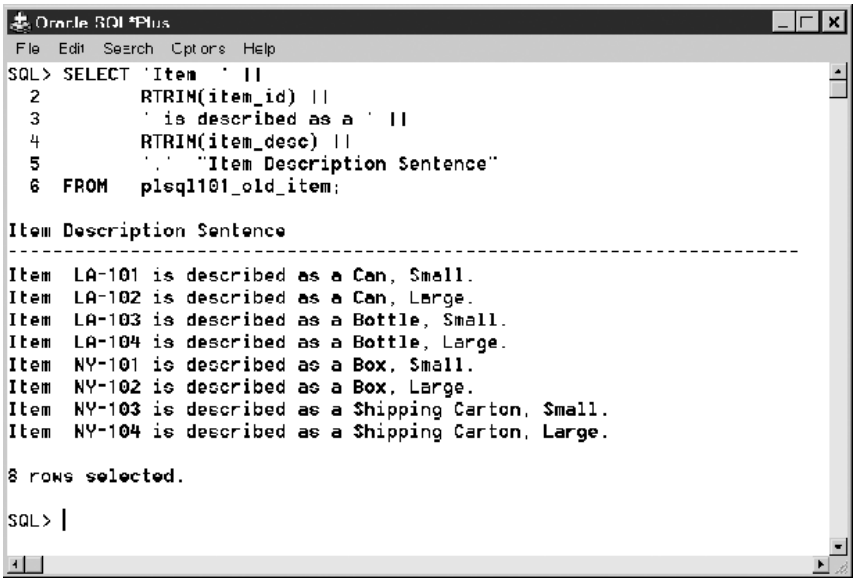


FIGURE 5-11. *Trim fixed-length text values*

you get it right. Then add the code to include the category…nothing further. When you have that working, add the item ID. This "piece-by-piece" process is a good idea for any code that is too complicated to just type from memory.

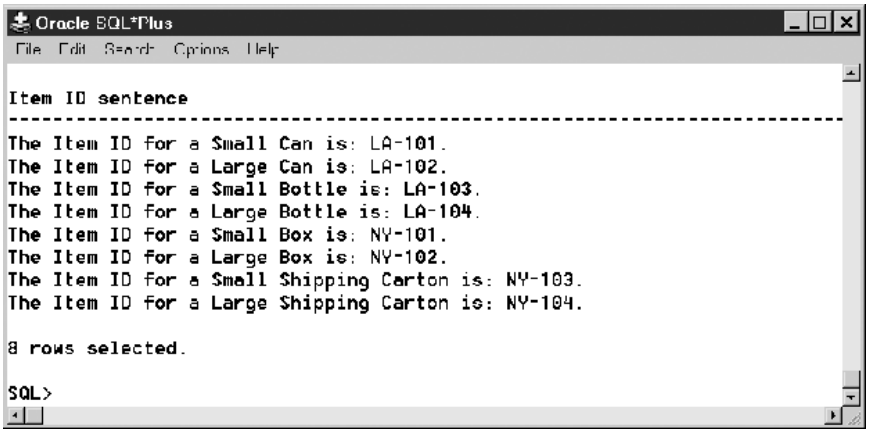


FIGURE 5-12. *Hone your skills by producing these results!*

Date

Oracle offers a number of functions designed to make it easier to work with dates. This section will start by showing you how to combine two functions you already know to create a new result that is useful in a lot of situations. Next, you will see how to use simple functions to do date tricks that would otherwise require a *lot* of thought and coding.

SYSDATE and TRUNC

To see the problem you're about to learn how to solve, enter the following code:

```
INSERT INTO plsql101_product VALUES
     ('Square Zinculator', 45, 1, SYSDATE);

SELECT * FROM plsql101_product;
```

Looks fine so far, right? You see the new record for the zinculator, and all the data for it appears correct. Now enter the following command, replacing the *dd-mmm-yy* with the current date (the one shown in your zinculator record):

```
SELECT * FROM plsql101_product
WHERE  last_stock_date = 'dd-mmm-yy';
```

If you enter these commands correctly, the result should be…no records displayed! Why isn't your zinculator record showing when you can see very clearly that it contains today's date?

The answer, of course, is that the date placed into the zinculator record was generated by using SYSDATE, and SYSDATE returns more than just the current date; it also returns the current time. Even though you can't see the time component of the date value (you will learn how to see time very soon), it is still there and it keeps the record's value from matching the date value for the current day. It's like trying to match 1 and 1.4 in a column that is formatted to not show decimal places: the difference is there, even if it doesn't show.

The solution: Use the TRUNC function to make your WHERE clause ignore the time value within the last stock date. To make this happen, you must wrap the TRUNC function around the reference to the LAST_STOCK_DATE column, as shown in the modified SELECT statement below:

```
SELECT * FROM plsql101_product
WHERE  TRUNC(last_stock_date) = 'dd-mmm-yy';
```

This will produce the results you expected the first time. This technique is very handy when you need to work with a table containing a column with date and time combined together.

An alternative use of the TRUNC function is to ensure that the date value stored in the database doesn't have a time component in the first place. Enter the following commands to see how this would work, and notice how the INSERT statement has a TRUNC function wrapped around its SYSDATE function:

```
DELETE FROM plsql101_product
WHERE  product_name = 'Square Zinculator';

INSERT INTO plsql101_product VALUES
     ('Square Zinculator', 45, 1, trunc(sysdate));

SELECT * FROM plsql101_product
WHERE  last_stock_date = 'dd-mmm-yy';
```

How can you decide whether to use the TRUNC function at the input stage or the output stage? It depends on the application. The time something occurs could be an important piece of information when you are recording transactions, tracking events, or storing auditing information. On the other hand, it may not be important at all if you are recording when something arrived, or identifying a follow-up date that is *nn* days from today. If you have an application that calls for automatic entry of today's date but is not concerned with time of day, you will save yourself (and others) a lot of confusion and extra work if you truncate the SYSDATE value before inserting it.

ADD_MONTHS

The ADD_MONTHS function returns a date that has the same day of the month as the original date it was provided, but is a specified number of months in the future (or the past). The function's syntax is as follows:

ADD_MONTHS('*starting_date*', *number_of_months*)

The *starting_date* can be today's date [using TRUNC(SYSDATE)], or it can be the name of a column in a table. The *number_of_months* is an integer representing the number of months you want added to or subtracted from the starting date. (If you want months subtracted, specify a negative value for the number of months.)

If want to see the function in action, try entering the following commands:

```
SELECT ADD_MONTHS(SYSDATE,1) FROM DUAL;
SELECT ADD_MONTHS(SYSDATE,12) FROM DUAL;
```

One interesting thing about the ADD_MONTHS function is that it is smart enough to understand when the day it's been given is the last day of the month and

adjust accordingly. To see what that means, enter the following commands and compare your results with those in Figure 5-13:

```
SELECT ADD_MONTHS('28-NOV-05', 1) FROM DUAL;
SELECT ADD_MONTHS('29-NOV-05', 1) FROM DUAL;
SELECT ADD_MONTHS('30-NOV-05', 1) FROM DUAL;
SELECT ADD_MONTHS('31-DEC-05', -1) FROM DUAL;
```

Notice that in the previous sample command, a month is subtracted from December 31. If you were to guess quickly, you might say the answer should be November 31—until you remembered that November only has 30 days. The ADD_MONTHS function is smart enough to know that and adjust accordingly. This adjustment only occurs when its starting date is the last day of a month. You can see in the preceding three sample commands that ADD_MONTHS adds precisely one month until it is given a starting date that is the last day of a month.

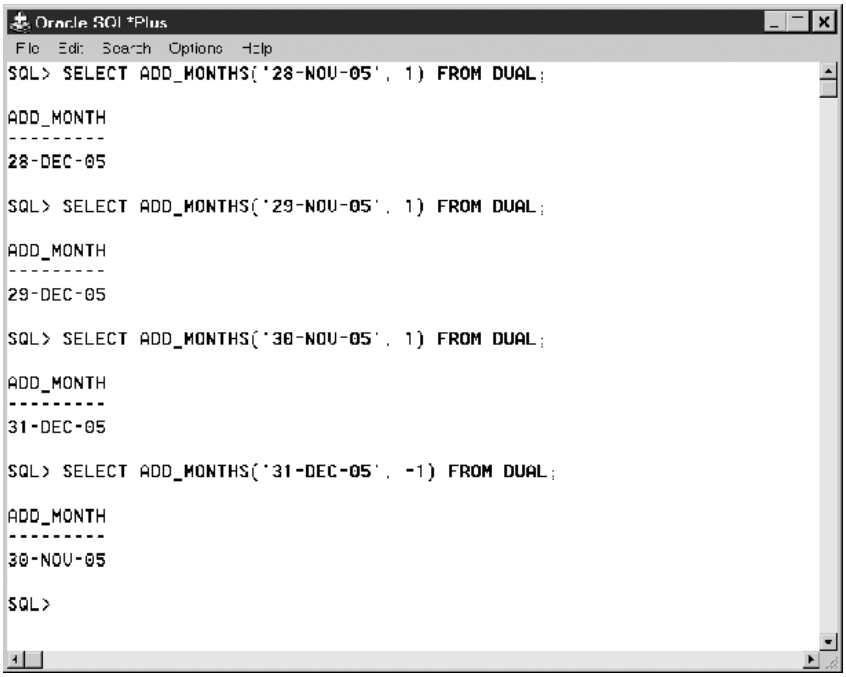


FIGURE 5-13. *Use the ADD_MONTHS function*

One example of when this would be useful might be a *tickler file*, where you want to record a date a month away when you will check up on something or get back in touch with someone. You can cause your INSERT or UPDATE statement to place the proper date in your table by including this function in the INSERT or UPDATE statement (typing this fragment *alone* into SQL*Plus® will not do anything):

```
ADD_MONTHS(TRUNC(SYSDATE), 1)
```

LAST_DAY

The LAST_DAY function performs a simple task that would be a lot more work to have to program yourself: It returns the last day of whatever month is included in the date it is given. Its syntax is the following:

LAST_DAY('*date*')

Like any other date function, it can be tested using SYSDATE as the *date* value. Try the following series of commands to see the results it produces:

```
SELECT LAST_DAY(SYSDATE) FROM DUAL;
SELECT LAST_DAY('01-JAN-05') FROM DUAL;
SELECT LAST_DAY('15-JAN-05') FROM DUAL;
SELECT LAST_DAY('31-JAN-05') FROM DUAL;
```

There are a number of business situations where this type of function can be handy. For instance, in many companies a new employee's health insurance coverage begins on the first day of whatever month follows their hire date—meaning that if they started working on April 1 then their insurance starts on May 1, and if they started working on April 30 then their insurance still starts on May 1. Take a moment now and think: how can a date function that returns the last day of a month be modified to instead return the first day of the following month?

The answer is to simply add 1 to the value returned by the LAST_DAY function. To see this in action, you will need to create a new table that contains people and hire dates. You can do this with the following commands:

```
CREATE TABLE plsql101_person (
     person_code VARCHAR2(3),
     first_name  VARCHAR2(15),
     last_name   VARCHAR2(20),
     hire_date   DATE
     )
;

INSERT INTO plsql101_person VALUES
```

```
     ('CA', 'Charlene', 'Atlas', '01-FEB-05');
INSERT INTO plsql101_person VALUES
     ('GA', 'Gary', 'Anderson', '15-FEB-05');
INSERT INTO plsql101_person VALUES
     ('BB', 'Bobby', 'Barkenhagen', '28-FEB-05');
INSERT INTO plsql101_person VALUES
     ('LB', 'Laren', 'Baxter', '01-MAR-05');
```

Now that you have a suitable table, you can see how the LAST_DAY function is useful for this purpose. Enter the SELECT command that follows, noting how the LAST_DAY function is used to determine the first day of the month following each person's hire date:

```
SELECT first_name,
       last_name,
       hire_date,
       LAST_DAY(hire_date)+1 INSURANCE_START_DATE
FROM   plsql101_person;
```

When you are done, the results of your SELECT statement should look like Figure 5-14.

You can produce some very interesting results by nesting date functions together. Consider this example: each record in your PLSQL101_PRODUCT table contains a date indicating when the item was last restocked. Let's say that in the fictional company you're working at, three months must go by before an item is restocked. To get the

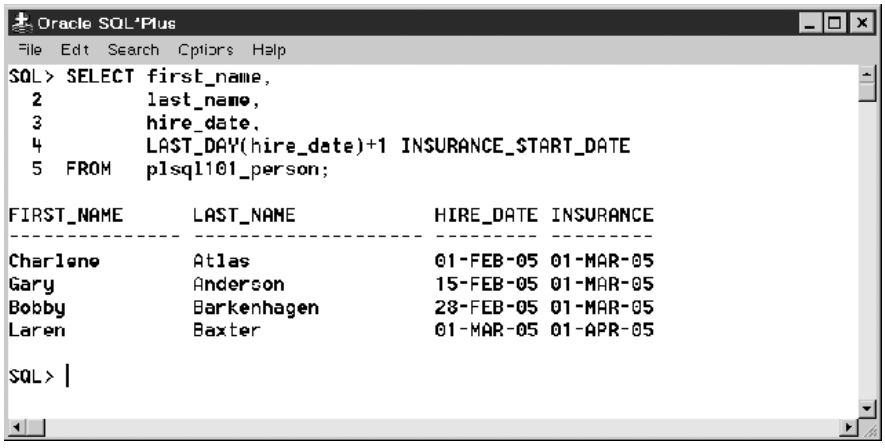


FIGURE 5-14. *Use the LAST_DAY function to determine the first day of the following month*

restock date, you could just use the ADD_MONTHS function to produce dates that are three months after the last restock date. But there's a twist…ordering only happens on the first of each month. So what you really want are dates that are three months after the last restock date, moved forward to the first day in whatever month follows. How can you accomplish this?

By combining the two techniques you just learned: adding a specified number of months to a date, and using the LAST_DAY function to get the last day of a month and add 1 to it. The resulting nested function syntax looks like this:

```
LAST_DAY(
      ADD_MONTHS(
         column_containing_restock_date,
         number_of_months_forward
             )
  )
    +1
```

Look at the code that follows, paying particular attention to the fourth item being selected. Note how the syntax just shown is used with the LAST_STOCK_DATE column and the three-month interval. To make it more realistic, the example code limits the products to those whose stock is low, and it sorts the records so the product names are listed alphabetically. Enter the code now and compare your results with those shown in Figure 5-15.

```
SELECT product_name,
       quantity_on_hand,
       last_stock_date,
       LAST_DAY(ADD_MONTHS(last_stock_date, 3))+1 RESTOCK_DATE
FROM   plsql101_product
WHERE  quantity_on_hand <= 100
ORDER BY product_name;
```

MONTHS_BETWEEN

MONTHS_BETWEEN is a simple little function that returns the number of months between any two dates. Its syntax is as follows:

```
MONTHS_BETWEEN(later_date, earlier_date)
```

This command is most useful for comparing two date columns, or for comparing one date column with today's date. For instance, if you wanted to see how long

items in your PLSQL101_PRODUCT table have been in stock, you could do so with this command:

```
SELECT product_name,
       last_stock_date,
       MONTHS_BETWEEN(SYSDATE, last_stock_date) STOCK_MONTHS
FROM   plsql101_product;
```

If you wanted to make the months a little bit easier to read, you could do so by wrapping a ROUND function around the MONTHS_BETWEEN function, like this:

```
SELECT product_name,
       last_stock_date,
       ROUND(MONTHS_BETWEEN(SYSDATE, last_stock_date),0) STOCK_MONTHS
FROM   plsql101_product;
```

If you wanted to see how many months you have been on this planet, you could do so with a command like this (fill in your birthdate where it says *birthdate*, and be sure to use a four-digit year):

```
SELECT MONTHS_BETWEEN(SYSDATE, 'birthdate') FROM DUAL;
```

Congratulations on surviving all those months! Makes the rest of this chapter seem like a walk in the park, doesn't it?

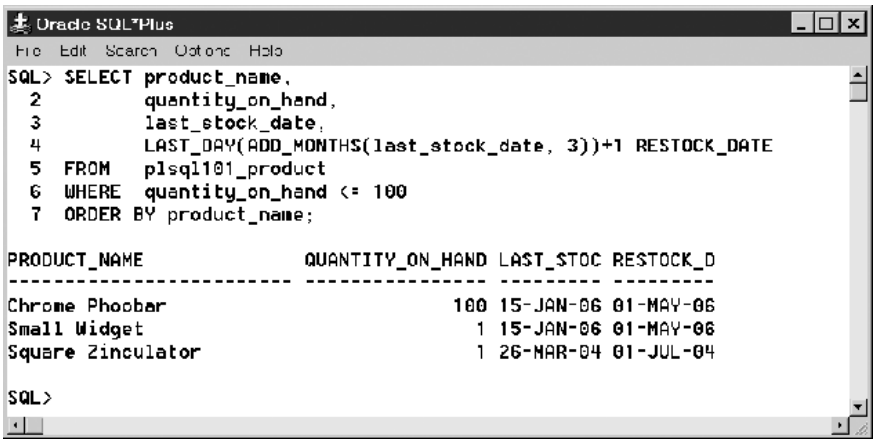


FIGURE 5-15. *Nesting date functions*

Datatype Conversion

Datatype conversion is the label used to describe converting information from one datatype to another—usually between text and dates, times, or numbers. Within your own Oracle database there will be relatively little need for converting datatypes, but the datatype conversion functions will still be useful for two reasons:

- They enable you to change the way dates, times, and numbers are displayed.
- They simplify importing data from other sources.

In this section, you will learn about functions designed to convert numbers, dates, times, and text.

TO_CHAR

The TO_CHAR function converts dates, times, or numbers to text. Its main value is giving you quite a bit of control over how dates, times, and numbers are displayed; the fact that they are text is irrelevant when they are scrolling across a SQL*Plus® screen.

You may have noticed that when you select data containing numbers from a table, the numbers don't have any particular formatting applied to them; they display with however many decimals they contain, so the list is not decimal-aligned. Dates, too, have their problems: They're displayed in a way that few of us would use on a daily basis, and they do not display any time component. TO_CHAR gives you the means to correct both of these situations.

Format Date and Time Values The syntax for a TO_CHAR function designed to change the way dates and times are displayed is as follows:

TO_CHAR(*input_value*, '*format_code*')

The *input_value* can be written directly into the TO_CHAR function, but is more commonly derived by referring to a column in a table. The *format_code* consists of one or more elements identifying how you want the function to represent portions of a date or time.

Enter the SELECT statement that follows to see a simple example of the TO_CHAR function in action:

```
SELECT TO_CHAR(SYSDATE, 'MM-DD-YYYY HH24:MI:SS') NOW
FROM DUAL;
```

As you can see from the results in SQL*Plus, the *format_code* portion of this example causes the current date to be displayed using a format that is familiar to many people, and it gives a way to (finally) see the time portion of SYSDATE. You can make up any format code you want, combining elements as your needs dictate. The elements you can use are shown in Table 5-3. Take a moment to look at the table now and, if you are like me, marvel at the incredible number of ways Oracle can display dates and times.

The DD format element that displays the day of the month has a couple of optional suffixes that add some nice cosmetic polish. You can follow the DD element with TH to

Element	Meaning

`-`
`/`
`,`
`.`
`;`
`:`
`'any text'`
	Punctuation and quoted text is reproduced in the result.

`AD` `A.D.`	AD indicator with or without periods.
`AM` `A.M.`	Meridian indicator with or without periods.
`BC` `B.C.`	BC indicator with or without periods.
`CC` `SCC`	One greater than the first two digits of a four-digit year; "S" prefixes BC dates with "-". For example, '20' from '1900'.
`D`	Day of week (1-7).
`DAY`	Name of day, padded with blanks to length of nine characters.
`DD`	Day of month (1-31).
`DDD`	Day of year (1-366).
`DY`	Abbreviated name of day.

TABLE 5-3. *TO_CHAR Date and Time Format Code Elements*

Element	Meaning
E	Abbreviated era name (Japanese Imperial, ROC Official, and Thai Buddha calendars).
EE	Full era name (Japanese Imperial, ROC Official, and Thai Buddha calendars).
FF	Fractions of seconds.
HH	Hour of day (1-12).
HH12	Hour of day (1-12).
HH24	Hour of day (0-23).
IW	Week of year (1-52 or 1-53) based on the ISO standard.
IYYY	Four-digit year based on the ISO standard.
IYY IY I	Last three, two, or one digit(s) of ISO year.
J	Julian day; the number of days since January 1, 4712 BC. Number specified with 'J' must be an integer.
MI	Minute (0-59).
MM	Month (01-12; JAN = 01).
MON	Abbreviated name of month.
MONTH	Name of month, padded with blanks to length of nine characters.
PM P.M.	Meridian indicator with or without periods.
Q	Quarter of year (1, 2, 3, 4; JAN-MAR = 1).
RM	Roman numeral month (I-XII; JAN = I).
RR	Given a year with two digits, returns a year in the next century if the year is <50 and the last two digits of the current year are >=50; returns a year in the preceding century if the year is >=50 and the last two digits of the current year are <50. This was introduced to deal with year-2000 issues.

TABLE 5-3. *TO_CHAR Date and Time Format Code Elements* (continued)

Element	Meaning
RRRR	Round year. Accepts either four-digit or two-digit input. If two-digit, provides the same return as RR. If you don't want this functionality, simply enter the four-digit year.
SS	Seconds (0-59).
SSSSS	Seconds past midnight (0-86399).
WW	Week of year (1-53) where week 1 starts on the first day of the year and continues to the seventh day of the year.
W	Week of month (1-5) where week 1 starts on the first day of the month and ends on the seventh.
Y,YYY	Year with comma in this position.
YEAR SYEAR	Year, spelled out; "S" prefixes BC dates with "-".
YYYY SYYYY	Four-digit year; "S" prefixes BC dates with "-".
YYY YY Y	Last three, two, or one digit(s) of year.

TABLE 5-3. *TO_CHAR Date and Time Format Code Elements* (continued)

have Oracle display "1ST" instead of "1" for the day (and "2ND" instead of "2", and so on). Try the following command to see how this works:

```
SELECT TO_CHAR(SYSDATE, 'MONTH DDTH')
FROM DUAL;
```

You can also follow the DD format element with SP to have Oracle spell out the day of the month. Enter the following code for an example:

```
SELECT TO_CHAR(SYSDATE, 'MONTH DDSP')
FROM DUAL;
```

By combining these two suffixes, you can make Oracle spell out the day of the month *and* include "st", "nd", "rd", or "th" after it. The following command demonstrates this:

```
SELECT TO_CHAR(SYSDATE, 'MONTH DDSPTH')
FROM DUAL;
```

You may notice in these last three examples that the resulting date formats could use a little more cosmetic help. For instance, the MONTH format element always pads the month name to nine characters in length, so there is a lot of space between the month and the date if you are dealing with a date whose month name is short. Also, the entire result is capitalized, giving it a somewhat glaring look. You can solve these problems by using some of the other functions you have already learned. A complete list of the cosmetic problems follows:

- Month is followed by unnecessary spaces.
- Month name is all caps.
- Suffix following date is all caps (for example, "TH" instead of "th")
- When SP format code element suffix is used, spelled-out date is all caps.

Let's look at how to use the functions you've learned to solve each problem step-by-step. For this example, we'll correct the display of the following date format:

```
SELECT TO_CHAR(SYSDATE, 'MONTH DDTH')
FROM DUAL;
```

To remove the extra spaces after the month name, you can use the RTRIM function. To do this, however, you will need to separate the month from the date that follows it. You can easily do that by selecting them as two separate items that are concatenated together. The following command shows how to separate the month name from the date. Enter it now, and you will see that the output it produces looks identical to that produced by the prior command.

```
SELECT TO_CHAR(SYSDATE, 'MONTH') ||
       ' ' ||
       TO_CHAR(SYSDATE, 'DDTH')
FROM DUAL;
```

Now it's time to get rid of the extra spaces following the month name. Wrap an RTRIM function around the TO_CHAR function that produces the month name, as shown in the code that follows:

```
SELECT RTRIM(TO_CHAR(SYSDATE, 'MONTH')) ||
       ' ' ||
       TO_CHAR(SYSDATE, 'DDTH')
FROM DUAL;
```

This produces the desired spacing. Next you want to change the capitalization of the month name, so that only its first letter is capitalized. The INITCAP function does just that. Surround the entire month-name portion of your SELECT statement with an INITCAP function, as shown in the following code:

```
SELECT INITCAP(RTRIM(TO_CHAR(SYSDATE, 'MONTH'))) ||
       ' ' ||
       TO_CHAR(SYSDATE, 'DDTH')
FROM DUAL;
```

The last change is making the date's TH element produce a lowercase suffix after the day of the month. I'd bet that you already have an idea how to do this. That's right: You place a LOWER function around the date portion of the SELECT statement, as shown in the following code:

```
SELECT INITCAP(RTRIM(TO_CHAR(SYSDATE, 'MONTH'))) ||
       ' ' ||
       LOWER(TO_CHAR(SYSDATE, 'DDTH'))
FROM DUAL;
```

Using the techniques you just practiced, take a moment now to "get it into your fingers" by improving the appearance of the date displayed by the following code:

```
SELECT TO_CHAR(SYSDATE, 'MONTH DDSPTH')
FROM DUAL;
```

Format Number Values The TO_CHAR function can also standardize the way numbers are displayed. For instance, look at the output produced by the following command:

```
SELECT * FROM plsql101_product;
```

The product prices are not decimal-aligned, which makes them harder to read than they need to be. By placing a simple TO_CHAR function around the reference to product price in your SELECT command, you can fix this problem. Try the following code to see how this works:

```
SELECT product_name,
       TO_CHAR(product_price, '$9,999.00') "Price",
       quantity_on_hand,
       last_stock_date
FROM   plsql101_product;
```

The results you get should look similar to those shown in Figure 5-16.

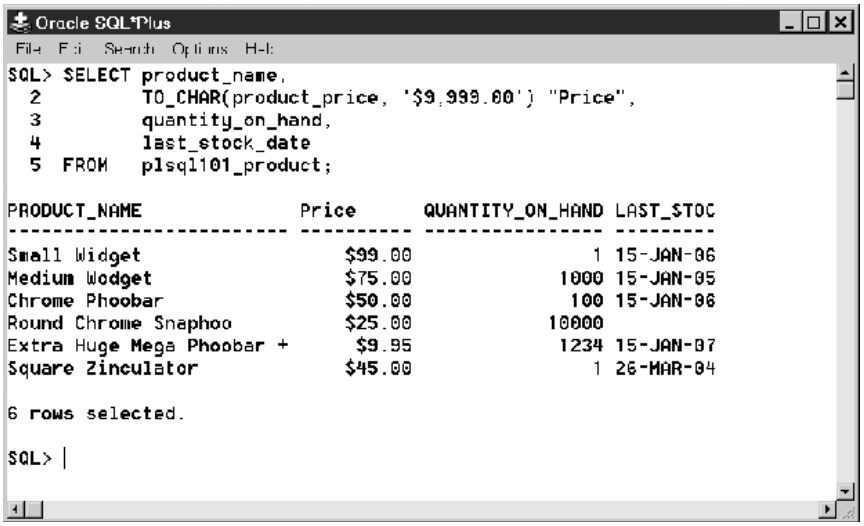


FIGURE 5-16. *Use the TO_CHAR function to improve appearance of numbers*

As was the case with date formats, number formats are made up of one or more elements that each represents a facet of the formatting being applied. Those elements are shown in Table 5-4. Take a moment to look over the number format code elements offered, and then practice your skills by producing a SELECT statement that formats your PLSQL101_PRODUCT table's QUANTITY_ON_HAND column so that it

Element	Example	Description
$	$9999	Places a dollar sign before the value
, (comma)	9,999	Places a comma in the position indicated
. (period)	99.99	Places a decimal point in the position indicated
MI	9999MI	Causes a "–" to be displayed after any negative value
S	S9999	Places a "+" for positive values and a "–" for negative values, in position indicated
PR	9999PR	Causes negative values to be surrounded by <angle brackets>

TABLE 5-4. *Number Format Code Elements*

Element	Example	Description
D	99D99	Displays your country's decimal character in the position indicated
G	9G999	Displays your country's group (thousand) separator in the position indicated
C	C999	Displays the ISO currency symbol in the position indicated
L	L999	Displays the local currency symbol in the position indicated
RN or rn	RN	Causes numbers to display as upper- or lowercase Roman numerals (limited to integers between 1 and 3999)
0	0999	Displays one or more leading zeros
0	9990	Causes empty values to display as zeros

TABLE 5-4. *Number Format Code Elements* (continued)

is more readable. While you're at it, the LAST_STOCK_DATE column could stand a makeover too. Try to make your command produce output whose format matches that shown in Figure 5-17. Note that the LAST_STOCK_DATE column has been pushed to the right a couple of spaces to make it easier to visually separate from the QUANTITY_ON_HAND column; I'll give you a hint and tell you that concatenation made that possible.

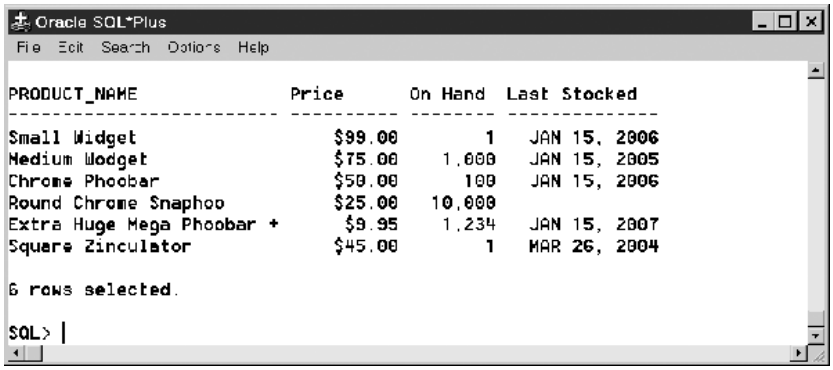


FIGURE 5-17. *Output formatted with various TO_CHAR functions*

TO_DATE

The TO_DATE function converts text that looks like a date (and/or time) into an actual Oracle date/time value. While its primary use is for importing text files containing dates and times from other databases, it is also handy when you want to enter a date manually using a format other than Oracle's default of DD-MON-YY, or a time. The syntax of the function is as follows:

TO_DATE(*input_value*, '*format_code*')

The TO_DATE function uses a subset of the format code elements used by the TO_CHAR function. The TO_DATE function's elements are shown in Table 5-5.

Element	Meaning
- / , . ; : 'any text'	Punctuation and quoted text is reproduced in the result.
AD A.D.	AD indicator with or without periods.
AM A.M.	Meridian indicator with or without periods.
BC B.C.	BC indicator with or without periods.
D	Day of week (1-7).
DAY	Name of day, padded with blanks to length of nine characters.
DD	Day of month (1-31).
DDD	Day of year (1-366).
DY	Abbreviated name of day.

TABLE 5-5. *Date and Time Format Code Elements*

Element	Meaning
HH	Hour of day (1-12).
HH24	Hour of day (0-23).
J	Julian day; the number of days since January 1, 4712 BC. Number specified with 'J' must be an integer.
MI	Minute (0-59).
MM	Month (01-12; JAN = 01).
MON	Abbreviated name of month.
MONTH	Name of month, padded with blanks to length of nine characters.
PM P.M.	Meridian indicator with or without periods.
RM	Roman numeral month (I-XII; JAN = I).
RR	Given a year with two digits, returns a year in the next century if the year is <50 and the last two digits of the current year are >=50; returns a year in the preceding century if the year is >=50 and the last two digits of the current year are <50.
RRRR	Round year. Accepts either four-digit or two-digit input. If two-digit, provides the same return as RR. If you don't want this functionality, simply enter the four-digit year.
SS	Seconds (0-59).
SSSSS	Seconds past midnight (0-86399).
Y,YYY	Year with comma in this position.
YYYY SYYYY	Four-digit year; "S" prefixes BC dates with "-".
YYY YY Y	Last three, two, or one digit(s) of year.

TABLE 5-5. *Date and Time Format Code Elements* (continued)

To see how the TO_DATE function enables you to insert dates and times more flexibly, enter the following code and compare your results with Figure 5-18:

```
SELECT product_name,
       product_price,
       quantity_on_hand,
       TO_CHAR(last_stock_date, 'MM-DD-YYYY HH24:MI') "Last Stocked"
FROM   plsql101_product;

UPDATE plsql101_product
SET    last_stock_date = TO_DATE('December 31, 2005, 11:30 P.M.',
                                 'Month dd, YYYY, HH:MI P.M.')
WHERE  product_name LIKE '%Zinc%';

SELECT product_name,
       product_price,
       quantity_on_hand,
       TO_CHAR(last_stock_date, 'MM-DD-YYYY HH24:MI') "Last Stocked"
FROM   plsql101_product;
```

Other Functions

This section presents a group of SQL functions whose only common trait is that they don't fit easily into any other group. That doesn't make them any less useful, though, and every one of these functions provides a valuable service that you are likely to use over and over.

DECODE

One of the differences between the SQL you have been learning and the PL/SQL programming language you will soon start to learn is that SQL has no "flow control" abilities: no loop, no "goto," no if-then-else. An SQL script starts at the top and goes straight to the bottom, one line at a time, with no variation. It has no decision-making abilities. However, it does offer one function that approximates the function of an if-then-else statement: DECODE. The DECODE function translates from one set of values to another set, using "before" and "after" values that you define. You could characterize what it does by saying that if the incoming value equals "A" then the DECODE function returns "B", and if the incoming value equals "C" then the DECODE function returns "D". You define what the values are for "A", "B", "C", and "D". This can be immensely helpful when translating data from one database system to another, because different systems usually use different sets of codes to represent similar information.

The syntax of the DECODE function is as follows:

DECODE(*incoming_source*,
    incoming_value_1, *outgoing_result_1*,

incoming_value_2, outgoing_result_2,
…
last_incoming_value, last_outgoing_result,
[*default_outgoing_result_if_no_match*]
)

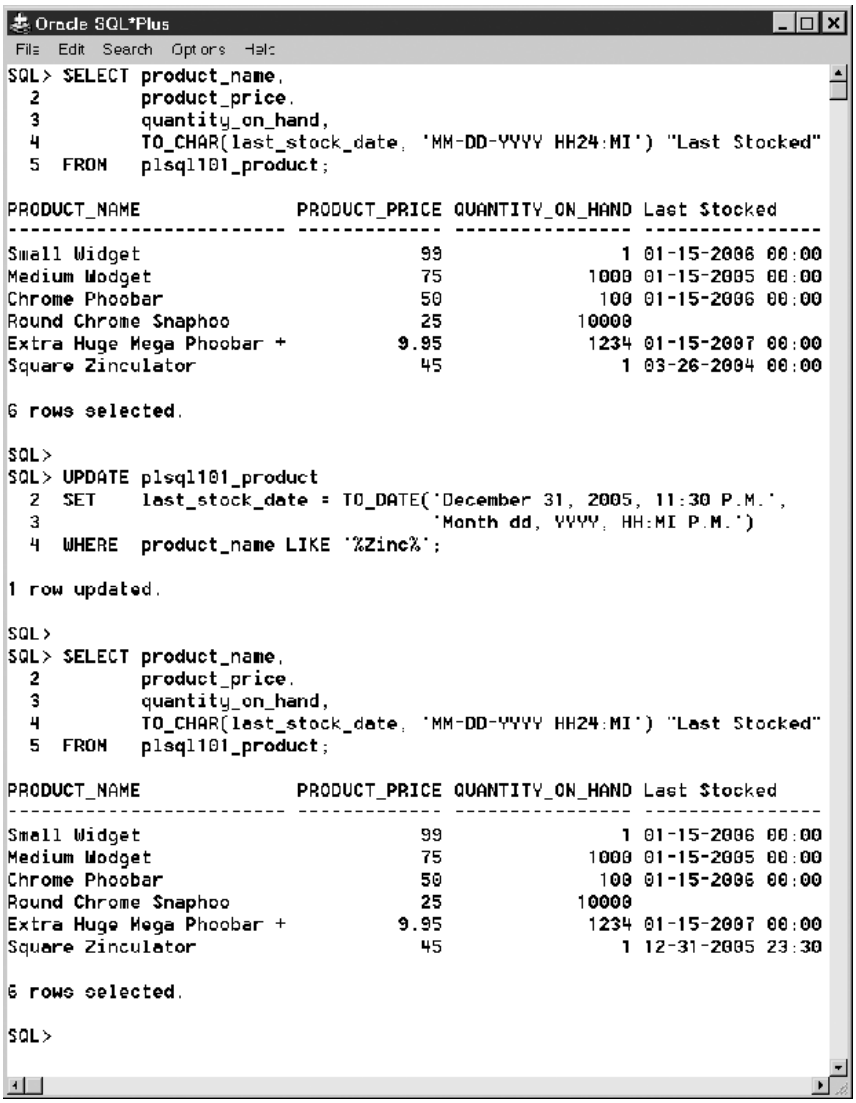


FIGURE 5-18. *Use TO_DATE to insert dates and times flexibly*

A few words about interpreting the syntax example just given:

- After specifying the *incoming_source*—usually a column name within some table—you define a series of incoming/outgoing pairs. The incoming side contains one of the values you know will be coming from the source data, and the outgoing side defines what you want that value translated into. You define as many of these as you want (that's what the "…" in the middle of the syntax example means).
- After defining the incoming/outgoing pairs, you can specify a single, final outgoing result with no incoming value. That outgoing result will be returned if the DECODE function encounters an incoming value that is not found in the list of incoming/outgoing pairs you have defined. (This is similar to the "else" portion of an if-then-else statement.) This part of the function is optional (which is why it's surrounded by square brackets "[" and "]"). It's usually a good idea to include one of these, so you will know if the incoming data contained anything you didn't expect.

To see how the DECODE function works, let's say that you have been given the PLSQL101_OLD_ITEM table and told you need to produce some listings of records from it. However, the structure of your company has changed since the old items were in use, and now, instead of identifying items by the city they came from ("NY-101", and so on), you need to show regions. Items with "NY" in their item ID belong to the "Eastern" region, while "LA" items come from the "Western" region. The three-digit item numbers that follow each city abbreviation in the original data still need to be displayed, so you'll also employ your knowledge of the SUBSTR function to parse them out as substrings. Look over the following code to see how the DECODE function is used to translate from cities to regions, and then enter it to try it out. Your results should match those shown in Figure 5-19.

```
SELECT DECODE(SUBSTR(item_id, 1, 2),
              'LA', 'Western',
              'NY', 'Eastern',
              '* Unknown *'
              )             "Region",
       SUBSTR(item_id, 4,3) "Item ID",
       item_desc
FROM   plsql101_old_item;
```

To see how the DECODE and other functions you have been learning get used in real life, read through the code listing in the box that follows. It is extracted from a data-transfer script I wrote for a client. It contains several items worth noting:

- Almost every column was given a new name. This was to match the old system's column names with those used by the new system.

- The old system stored dates in standard Oracle format, but the new system needed to have them inserted as text strings with the format YYYYMMDD.
- Social security numbers in the old system did not contain any dashes, while the new system wanted to see them with dashes. The solution was to parse the old number into pieces using SUBSTR functions and concatenate them with dashes. The resulting string was then given the name PATIENT_ID.
- The old system defined gender using the codes M, F, O (other—the client was in Los Angeles), and U (unknown). The new system wanted to see those values represented as 1, 2, 3, or 4. A classic DECODE scenario.
- The old system identified five different locations where patients were admitted. The new system just wanted to know which of the two local counties the facility was in—it didn't care which facility was used. In this case, the DECODE function still had one incoming/outgoing pair for every possible incoming code—for a total of five pairs—but there were only two different outgoing values generated by all those pairs (one for each county). Used in this way, the DECODE function served as a grouping mechanism.

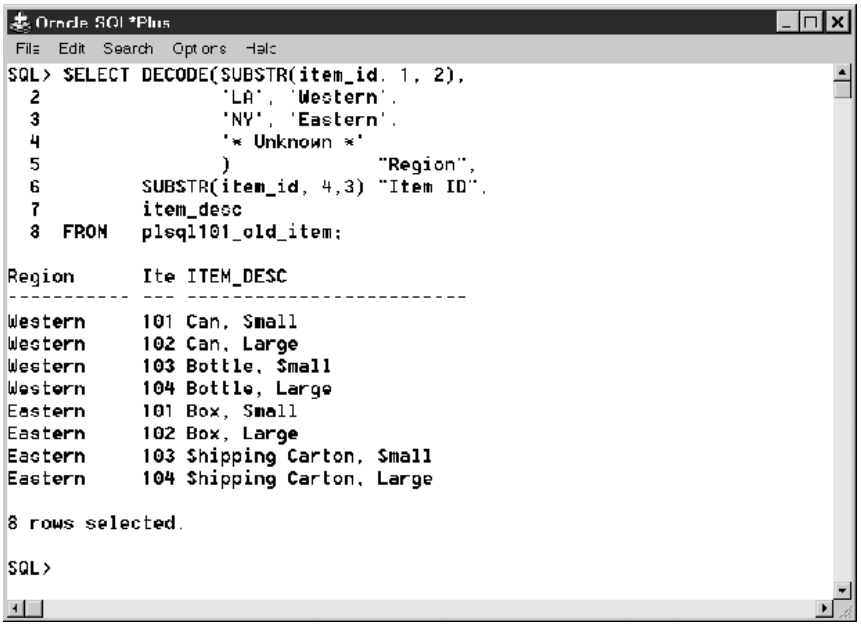


FIGURE 5-19. *Use the DECODE function to translate data*

- Many of the original system's items were entered sloppily, with unnecessary spaces before and/or after the actual data. This was cleaned up by wrapping the problematic columns in LTRIM and RTRIM functions.
- The old system stored the patient's age at their time of entry to a facility. Unfortunately, some facilities stored the age in years, some in months, and some in days. Fortunately, they had enough foresight to include a code indicating which age increment was being used in each record. Essentially, they wanted to convert old data laid out like this:

SOCIAL_SECURITY_NUMBER	AGE_TYPE	AGE_AT_ENTRY
111223333	Y	28
222334444	Y	65
333445555	M	18
444556666	D	3
555667777	D	10

into new data laid out like this:

PATIENT_ID	AGE_YRS	AGE_MOS	AGE_DAYS
111-22-3333	28		
222-33-4444	65		
333-44-5555		18	
444-55-6666			3
555-66-7777			10

This was accomplished using three separate DECODE functions. The first one looks in the old system's AGE_TYPE column and, if it finds a "Y" there, places the old system's AGE_AT_ENTRY value into the new system under a column named AGE_YRS. If the DECODE function does not find "Y" in the AGE_TYPE column, it leaves the AGE_YRS column blank. The next two DECODE functions do the same thing, looking for AGE_TYPE values of "M" and "D", and placing the AGE_AT_ENTRY values into the AGE_MOS or AGE_DAYS column, depending on what they find. These DECODE functions demonstrate a couple of interesting facts: more than one DECODE function can refer to a given column, and a DECODE function can return a value based on a column other than the one it looked at for decision-making purposes.

Example: Real-Life Use of the Functions You Have Learned

```
select to_char(EXIT_DATE, 'YYYYMMDD')              DISCHARGE_DATE,
     substr(SOCIAL_SECURITY_NUMBER,1,3) ||'-'||
     substr(SOCIAL_SECURITY_NUMBER,4,2) ||'-'||
     substr(SOCIAL_SECURITY_NUMBER,6,4)            PATIENT_ID,
     decode(GENDER,
          'M', '1',
          'F', '2',
          'O', '3',
          'U', '4')                                GENDER,
     substr(ZIP_CODE,1,5)                          ZIPCODE,
     decode(ltrim(rtrim(SITE)),
          '300', 'LA',
          '350', 'OC',
          '410', 'LA',
          '420', 'OC',
          '440', 'LA',
          '*N/A*')                                 COUNTY,
     ltrim(rtrim(PHYSICIAN))                       PHYSICIAN
     to_char(DATE_OF_BIRTH, 'YYYYMMDD')            DOB,
     decode(AGE_TYPE,
          'Y', AGE_AT_ENTRY,
          '')                                      AGE_YRS,
     decode(AGE_TYPE,
          'M', AGE_AT_ENTRY,
          '')                                      AGE_MOS,
     decode(AGE_TYPE,
          'D', AGE_AT_ENTRY,
          '')                                      AGE_DAYS,
from   ENCOUNTER
;
```

NVL

The NVL function performs a simple but useful function: Whenever it is presented with a value that is null, it returns a value of your choosing instead. This ability to fill in blank values automatically can help give your output a more finished look. The NVL function's syntax is as follows:

NVL(*input_value, result_if_input_value_is_null*)

As is often the case with functions, the *input_value* is usually the name of a column. The *result_if_input_value_is_null* can be anything you specify: a literal (that is, hard-coded) value, a reference to another column, or any other expression you want.

Enter the following example to see the NVL function in action. Your results should match what you see in Figure 5-20.

```
SELECT product_name,
       last_stock_date
FROM   plsql101_product;

SELECT product_name,
       NVL(last_stock_date, '01-JAN-2001') "Last Stocked"
FROM   plsql101_product;
```

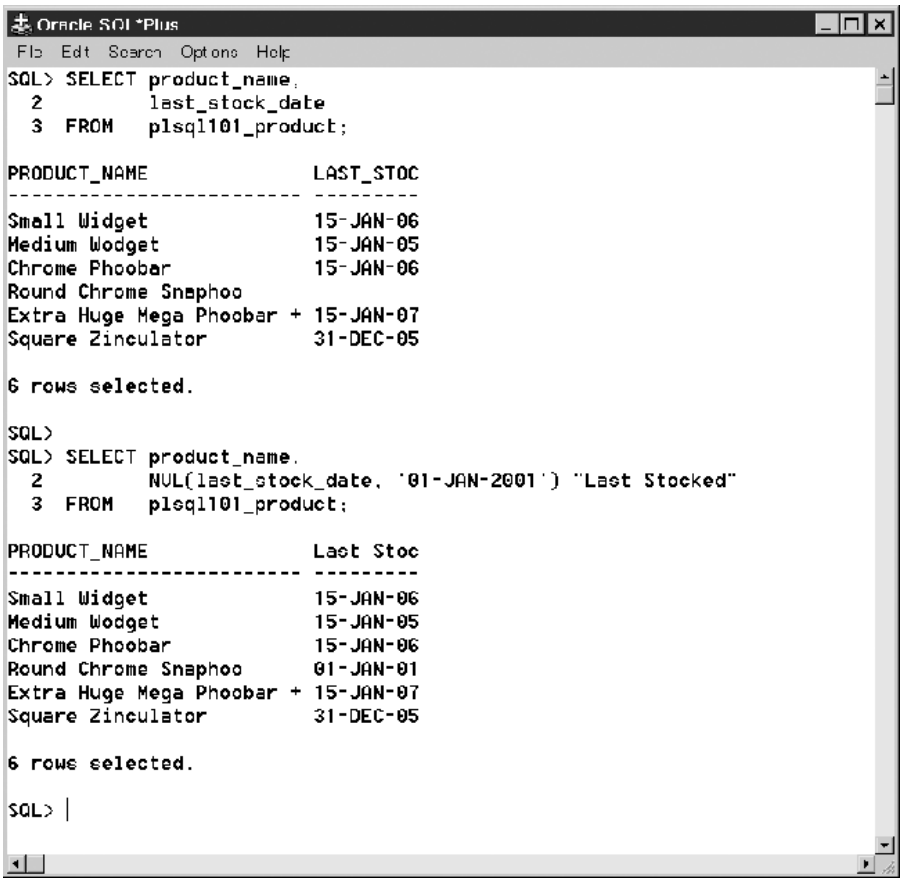


FIGURE 5-20. *NVL function filling null date with a default date*

As you can see from the example, the NVL function replaced the Round Chrome Snaphoo's empty LAST_STOCK_DATE value with the date specified in the NVL function. You could have had it replace the null value with today's date instead, by using the following code:

```
SELECT product_name,
       NVL(last_stock_date, TRUNC(SYSDATE)) "Last Stocked"
FROM   plsql101_product;
```

NOTE
The NVL function does not actually update any values in a table. The source data is left untouched.

One quirk with the NVL function is that it expects the datatypes for the *input_value* and *result_if_input_value_is_null* to be the same; if the *input_value* is a date, the *result_if_input_value_is_null* should also be a date, and so on. This becomes an issue if you want the function to display the popular "N/A" whenever it finds a null value, because "N/A" is text. If the column it gets as an *input_value* is a text column, then everything is fine. However, if the function is checking for nulls in a date or number column, you will need to wrap a TO_CHAR function around the *input_value* column name, so that the input value is also text. The following code demonstrates this: The first version of the command will fail, while the second one will succeed. Enter the code and compare your results with those shown in Figure 5-21.

```
SELECT product_name,
       NVL(last_stock_date, 'N/A') "Last Stocked"
FROM   plsql101_product;

SELECT product_name,
       NVL(TO_CHAR(last_stock_date), 'N/A') "Last Stocked"
FROM   plsql101_product;
```

Insert Comments in SQL Scripts

In Chapter 4, you learned how to create and run SQL script files. These files are essentially programs—simple programs at this stage, but programs nonetheless. And programs need to be documented. SQL scripts are rarely long enough to justify an external document explaining what they do, so the most common method of documenting a script file is to place comments directly within the file. When done correctly, these comments are ignored by Oracle, so you can leave them in the script file and still run the file as you normally would.

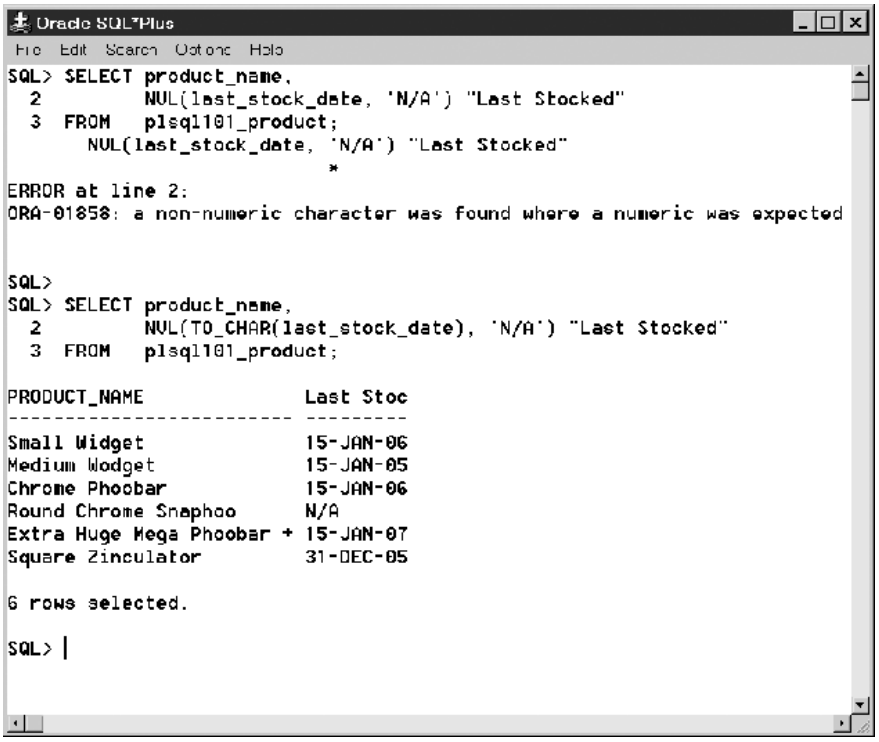


FIGURE 5-21. *Using the NVL function with different datatypes*

There are two types of comments. The first type is a single-line comment, which is good for little reminders, or to temporarily disable a portion of code you don't want to run but also don't want to delete. The second type can be as many lines long as you want, but is not quite as obvious, and therefore doesn't "jump out at you" when reading the script file. Both types have their place, and many script files incorporate both.

To create a single-line comment, you simply make the first two characters on the line a pair of dashes. Whatever follows the dashes is ignored by Oracle. Enter the following SQL lines to see this in action:

```
SELECT * FROM plsql101_product;
- This line will be ignored.  Oracle will not try to run it.
SELECT * FROM plsql101_purchase;
```

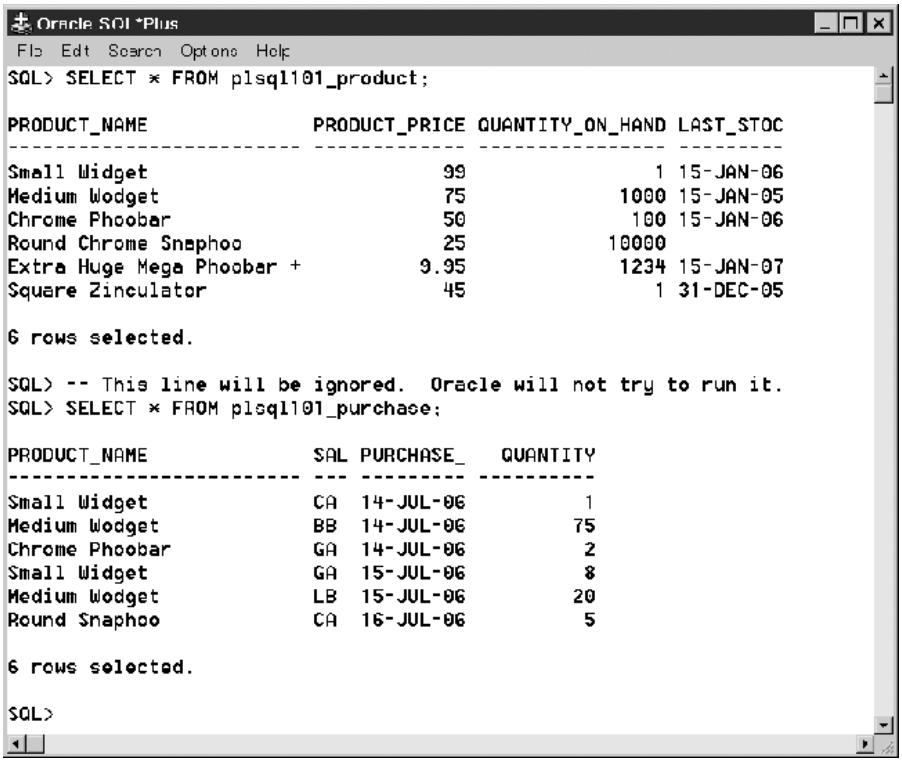


FIGURE 5-22. *Commenting out single lines in a SQL script*

The results you see should match those shown in Figure 5-22. You can use this approach for any number of lines, whether they are separate or grouped together.

TIP
A single-line comment can also be created by starting the line with "REM " instead of "—". This technique is used in other programming languages, and is thus familiar to programmers who are learning SQL after learning some other language. However, from a visual standpoint the "REM " does not catch your eye as easily as "—". Perhaps this is the reason that "—" is more common.

If you are going to have several lines of comments in a group, however, you may want to employ the other type of comment. In this approach, you place the

characters "/*" at the start of the comment section, and "*/" at the end. The lines in between are ignored. Try the following code to see this:

```
/*
This script is designed to show how multiple-line commenting works.
It is used in the PL/SQL 101 book by Oracle Press.
*/

SELECT * FROM plsql101_product;

SELECT * FROM plsql101_purchase;
```

The results you see should match those shown in Figure 5-23.

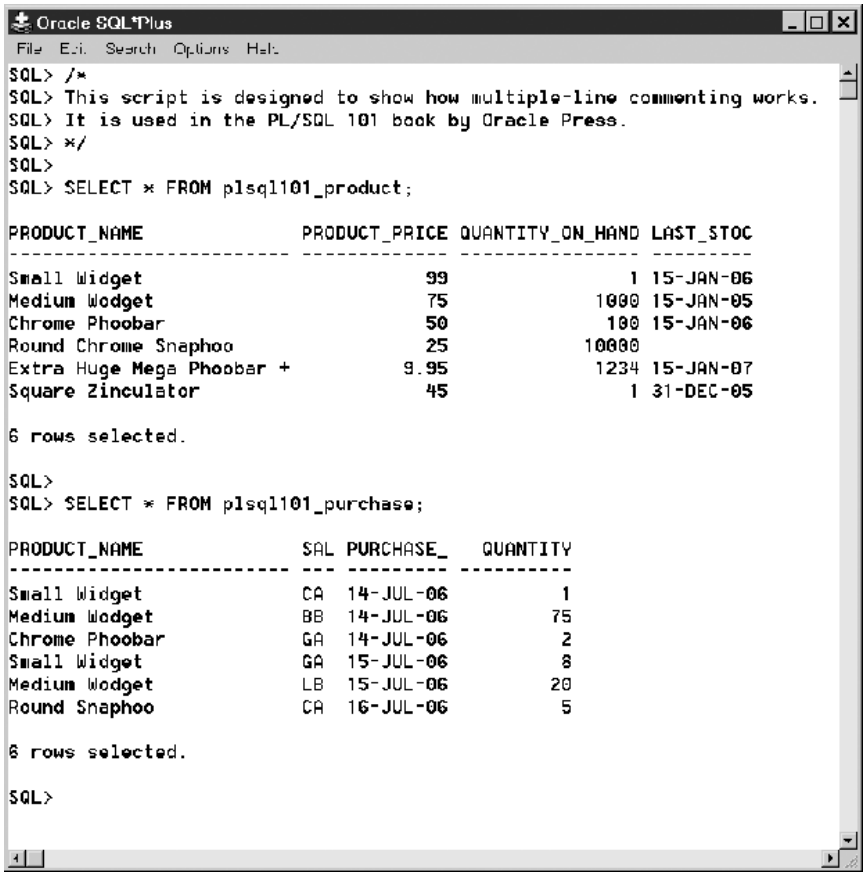


FIGURE 5-23. *Commenting out groups of lines in a SQL script*

Commonly Used Group Functions

So far, every function you have learned was designed to work on a row-by-row basis with records. Oracle also has *group functions* that return values useful when you are analyzing groups of records. A group of records is any collection of records that share something in common; for instance, they are for the same product, or the same department, or the same time range. You define what constitutes a group, and the group functions will provide you with totals, record counts, and average, smallest, and largest values within each group. These functions are very useful for statistical analysis.

This section will start by presenting the most-used group functions, and then it will show you how to define record groups so the functions return statistical information for each group. Since you will not know how to group records when you're first introduced to the functions, they will return values representing the entire set of records within your table.

SUM

The SUM function adds values and returns the total. Enter the following SQL statements to see it in action:

```
SELECT * FROM plsql101_purchase;
SELECT SUM(quantity) FROM plsql101_purchase;
```

COUNT

The COUNT function…you guessed it, counts records. You might be surprised how often this is useful. For instance, the easiest way to find out if a table contains any records is to use a command like this one:

```
SELECT COUNT(*) FROM plsql101_purchase;
```

One interesting facet of the COUNT function is that if you specify a column in the table whose records you are counting, the COUNT function only counts records that actually have a value in that column. You can use this to determine what percentage of records in a table is null in a specific column. As you enter the code that follows, notice that the first command tells the total number of records in the table; the second command produces the same number, because no records have a blank product name; the third command tells how many of the records have the LAST_STOCK_DATE column populated; and the final command gives you the percentage of records with that column populated. This kind of information can be handy if you want to determine how useful a particular column is. After entering your commands, compare your results with those shown in Figure 5-24.

```
SELECT COUNT(*) FROM plsql101_product;

SELECT COUNT(product_name) FROM plsql101_product;

SELECT COUNT(last_stock_date) FROM plsql101_product;

SELECT COUNT(last_stock_date) / COUNT(product_name) "Populated Records"
FROM plsql101_product;
```

AVG

The AVG function returns the average of the values in the column you specify. Since the function has to actually read the column values in order to do its job, there is no point in specifying "1" or any other literal value as the function's argument; you must specify a column name. For instance, to get the average

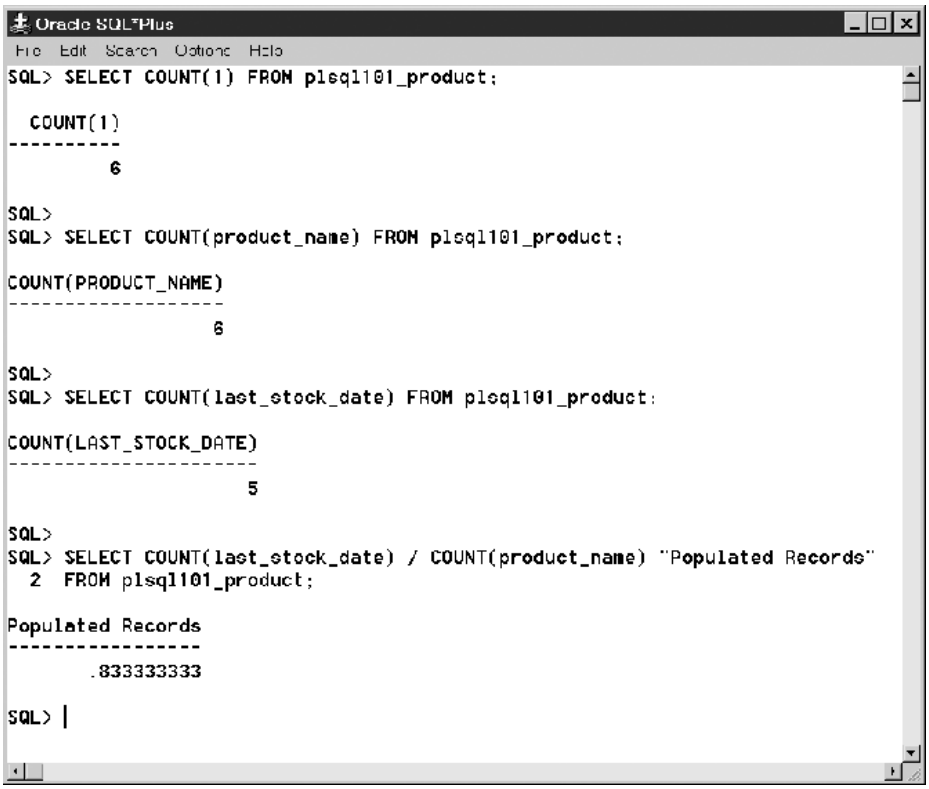


FIGURE 5-24. *Use the COUNT function*

price of the items in your PLSQL101_PRODUCT table's inventory, enter the following statement:

```
SELECT AVG(product_price) FROM plsql101_product;
```

MIN

The MIN function returns the smallest value found in the column specified in its argument. For instance, to get the price of the cheapest item in the table of products, you could issue this command:

```
SELECT MIN(product_price) FROM plsql101_product;
```

MAX

As you have probably guessed, the MAX function returns the largest value found in the column specified in its argument. For instance, to see the highest price in the table of products, you could use this command:

```
SELECT MAX(product_price) FROM plsql101_product;
```

The MAX function has a variety of useful capabilities. For example, there may be a time in the future when you are considering reducing the length of a text column in an existing table. You would want to know how much of the column's width is actually being used, and therefore need to know the length of the longest item within that column. You can do this easily by specifying the length of the column as a MAX function's argument, as shown in the second command in the following set:

```
DESC plsql101_purchase;
SELECT MAX(LENGTH(product_name)) FROM plsql101_purchase;
```

Group Data via the GROUP BY Clause

Now that you know about group functions, it's time to learn how to create groups. To accomplish this, add the clause GROUP BY to the SELECT statement, as shown in the following example:

```
SELECT * FROM plsql101_purchase;

SELECT product_name, SUM(quantity)
FROM   plsql101_purchase
GROUP BY product_name;
```

After entering this code, compare the results you get with those shown in Figure 5-25. Note that after the GROUP BY clause you simply state what column contains the values you want the groups to be based on. Generally, this is the first column in the SELECT list.

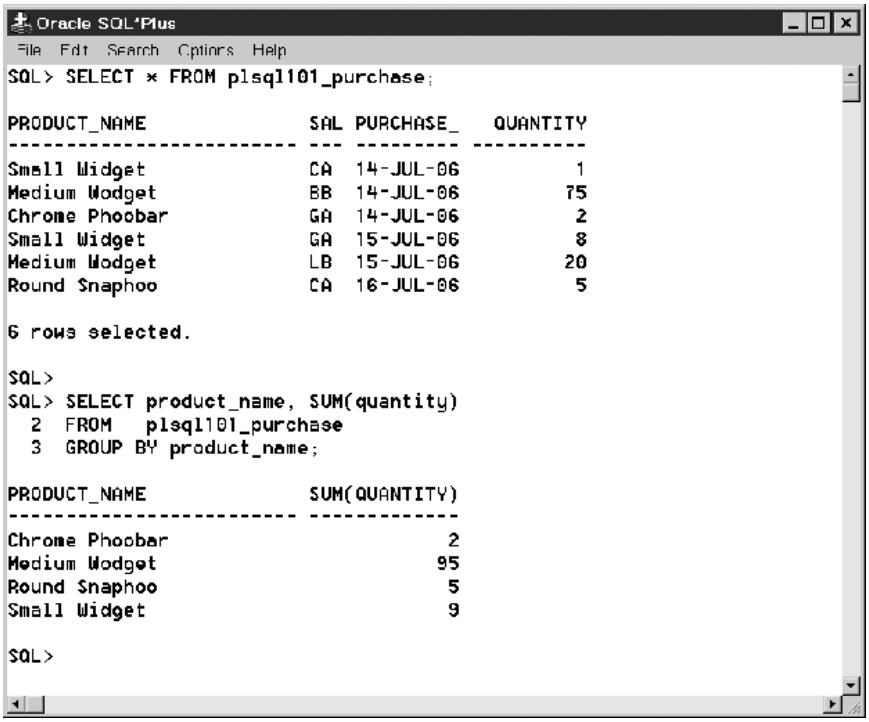


FIGURE 5-25. *Use the GROUP BY clause*

You can include several different group functions within a single SELECT statement. For instance, you could have the statement tell you the total quantity, count, average, and lowest and highest values within each group, all with a single SELECT command. The following code provides an example of how to do this. The code uses the SUBSTR function to narrow the PRODUCT_NAME column, in order to help the results fit on the screen.

```
SELECT SUBSTR(product_name, 1, 15) "Product",
       SUM(quantity) "Total Sold",
       AVG(quantity) "Average",
       COUNT(quantity) "Transactions",
       MIN(quantity) "Fewest",
       MAX(quantity) "Most"
FROM   plsql101_purchase
GROUP BY product_name;
```

After entering this command, compare the results you get with those in Figure 5-26.

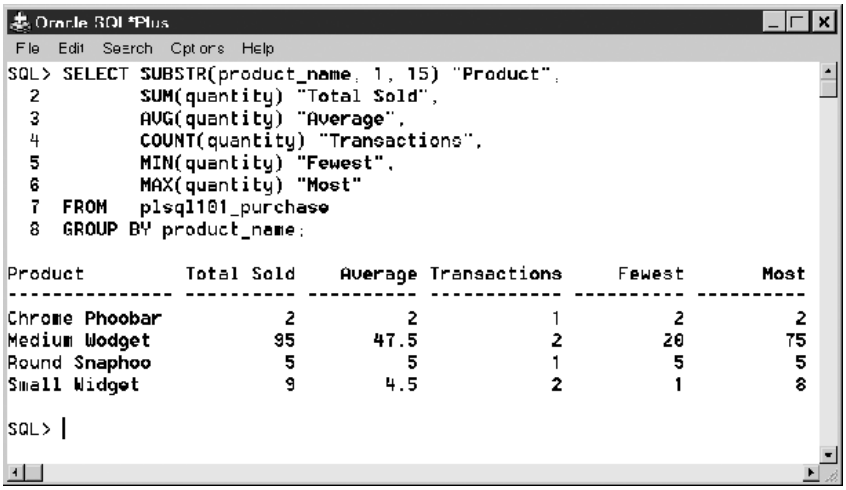


FIGURE 5-26. *Use multiple group functions in one SELECT statement*

Include and Exclude Grouped Rows via the HAVING Clause

You probably remember that a WHERE clause can filter which records are returned by a SELECT statement. (If you don't remember that, review Chapter 3 and then come back. I'll wait.) A WHERE clause works the same way when you are grouping records: It filters individual records, keeping them from ever being factored into the calculations done by the group functions.

Once the groups are created, however, there is a new need: to be able to filter the groups themselves, based on group information. For instance, let's say that your company is running out of warehouse space, and wants to reduce the number of products it carries in stock. To support this effort, you need to produce a list of the products that are selling poorly…products that have sold fewer than five items, for example. This is where the HAVING clause comes in. It filters *groups* based on *group values*. While the WHERE clause filters records before they are grouped, the HAVING clause filters entire groups. To see this in action, enter the following code (this command is identical to the prior one, with addition of a single line at the end, so you can save time by using the EDIT command and just adding the line that contains the HAVING clause):

```
SELECT SUBSTR(product_name, 1, 15) "Product",
       SUM(quantity) "Total Sold",
       AVG(quantity) "Average",
```

```
       COUNT(quantity) "Transactions",
       MIN(quantity) "Fewest",
       MAX(quantity) "Most"
FROM   plsql101_purchase
GROUP BY product_name
HAVING SUM(quantity) < 5;
```

As you can see, this causes the SELECT statement to include only those products that have been selling poorly. What if you wanted the opposite: a list of strong-selling products, with the performers excluded? Just change the criterion in the HAVING clause, as shown in the following code:

```
SELECT SUBSTR(product_name, 1, 15) "Product",
       SUM(quantity) "Total Sold",
       AVG(quantity) "Average",
       COUNT(quantity) "Transactions",
       MIN(quantity) "Fewest",
       MAX(quantity) "Most"
FROM   plsql101_purchase
GROUP BY product_name
HAVING SUM(quantity) >= 5;
```

Chapter Summary

This chapter has covered a lot of ground! You started by learning about single-row SQL functions. These include system variables (SYSDATE, USER, and USERENV), number functions (ROUND and TRUNC), text functions (UPPER, LOWER, INITCAP, LENGTH, SUBSTR, INSTR, LTRIM, and RTRIM), date functions (ADD_MONTHS, LAST_DAY, and MONTHS_BETWEEN), conversion functions (TO_CHAR and TO_DATE), and useful but hard-to-categorize functions such as DECODE and NVL. You also learned about group functions such as SUM, COUNT, AVG, MIN, and MAX, and you saw how you can get subtotal values from your data by including a GROUP BY clause in your SELECT statement. Finally, you saw how to exclude entire groups of subtotals from your output by placing a HAVING clause in your SELECT statement.

The following chapter has plenty of fascinating new things to learn. You will see how to speed up access to large tables, enforce your own requirements on the quality of data coming into a table, create relationships between tables, and use multiple-table groups to produce some pretty sophisticated results.

Chapter Questions

1. **On which line will the following command fail?**

```
INSERT INTO plsql101_product (
     product_name,
     product_price,
     quantity_on_hand,
     last_stock_date )
VALUES (
     'New Product',
     1.95,
     10,
     TO_CHAR(USER) )
;
```

   A. 1

   B. 2

   C. 7

   D. 10

   E. The command will succeed.

2. **Which statement below is true?**

   A. ROUND(4.5, 0) < TRUNC(4.5, 0)

   B. ROUND(4.1, 0) < TRUNC(4.2, 0)

   C. ROUND(8.9, 0) > TRUNC(8.9, 0)

   D. ROUND(8.9, 1) > TRUNC(8.95, 2)

3. **What would be the result of the following DECODE function?**

```
DECODE('B',
    'A', 'One',
    'E', 'Five',
    'I', 'Nine',
    'O', 'Fifteen',
```

```
        'U', 'Twenty-one',
        'N/A'
    )
```

A. One

B. Two

C. Five

D. N/A

4. What will be the result of the following SUBSTR function when presented with an input value of 'Psychic trance, Medium' in the ITEM_DESC column?

```
SUBSTR(item_desc,
        INSTR(item_desc,
            ',',
            1
            ) +2,
        99
        )
```

A. Medium

B. Psychic trance

C. Psychic trance, Medium

5. Which of the following functions would return the last day of the year 2005?

A. SELECT ADD_MONTHS(LAST_DAY('14-OCT-05'), 1) FROM DUAL;

B. SELECT ADD_MONTHS(LAST_DAY('15-OCT-05'), -1) FROM DUAL;

C. SELECT ADD_MONTHS(LAST_DAY('16-OCT-05'), 2) FROM DUAL;

D. SELECT ADD_MONTHS(LAST_DAY('17-OCT-05'), -2) FROM DUAL;

Answers to Chapter Questions

1. D. 10

Explanation Even if the TO_CHAR function shown contained the formatting codes it needs, it would not work as an input value for a date column.

2. C. ROUND(8.9, 0) > TRUNC(8.9, 0)

Explanation Choice A resolves to 5 < 4, which is false. Choice B resolves to 4 < 4, which is also false. Choice D resolves to 8.9 > 8.95, which is…you guessed it. Choice C resolves to 9 > 8, which is true.

3. D. N/A

Explanation Because the input value ('B') is text, it must find an exact match in the DECODE options, or else it will return the "else" value at the end of the function. In this case, there are no exact matches, so the 'N/A' value is the one returned.

4. A. Medium

Explanation For a refresher on this topic, review the section titled "Text Functions."

5. C. SELECT ADD_MONTHS(LAST_DAY('16-OCT-05'), 2) FROM DUAL;

Explanation Since the LAST_DAY function is involved, you can ignore the day portion of the date supplied—all four LAST_DAY functions will resolve to October 31, 2005. Adding two months to that date, as the ADD_MONTHS function in choice C does, brings you to December 31, 2005.

CHAPTER 6

Using Indexes and Constraints

uilding on the fundamental knowledge of tables, columns, and SQL that you have acquired, this chapter introduces you to concepts and techniques that are squarely in the realm of database geeks. (Wear the label proudly, and don't forget to mention it at your next salary review.) This chapter starts by explaining what indexes are, and then shows you how to use them to help your database operate more quickly. Next, you will see how to create database constraints that check incoming data and stop any command that attempts to insert data that doesn't meet the requirements you specify. After that, you will learn about relationships between tables, which ushers you into the fascinating world of relational database design. Finally, you will see how to write queries that incorporate other queries, which can produce some pretty sophisticated results with very little code.

If you just started reading in this chapter and have not yet created the test tables used in prior chapters, use the following code to create the test tables before proceeding:

```
INSERT INTO plsql101_product VALUES
     ('Small Widget', 99, 1, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Medium Wodget', 75, 1000, '15-JAN-05');
INSERT INTO plsql101_product VALUES
     ('Chrome Phoobar', 50, 100, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Round Chrome Snaphoo', 25, 10000, null);
INSERT INTO plsql101_product VALUES
     ('Extra Huge Mega Phoobar +',9.95,1234,'15-JAN-07');
INSERT INTO plsql101_product VALUES
     ('Square Zinculator', 45, 1,
      TO_DATE('December 31, 2005, 11:30 P.M.',
              'Month dd, YYYY, HH:MI P.M.')
     );

DROP TABLE plsql101_person;
CREATE TABLE plsql101_person (
     person_code VARCHAR2(3),
     first_name  VARCHAR2(15),
     last_name   VARCHAR2(20),
     hire_date   DATE
     )
;

INSERT INTO plsql101_person VALUES
     ('CA', 'Charlene', 'Atlas', '01-FEB-05');
INSERT INTO plsql101_person VALUES
     ('GA', 'Gary', 'Anderson', '15-FEB-05');
```

```
INSERT INTO plsql101_person VALUES
     ('BB', 'Bobby', 'Barkenhagen', '28-FEB-05');
INSERT INTO plsql101_person VALUES
     ('LB', 'Laren', 'Baxter', '01-MAR-05');


DROP TABLE plsql101_purchase;
CREATE TABLE plsql101_purchase (
     product_name  VARCHAR2(25),
     salesperson   VARCHAR2(3),
     purchase_date DATE,
     quantity      NUMBER(4,2)
     )
;

INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'CA', '14-JUL-06',1);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'BB', '14-JUL-06',75);
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'GA', '14-JUL-06',2);
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'GA', '15-JUL-06',8);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'LB', '15-JUL-06',20);
INSERT INTO plsql101_purchase VALUES
     ('Round Snaphoo', 'CA', '16-JUL-06',5);


DROP TABLE plsql101_old_item;
CREATE TABLE plsql101_old_item (
     item_id   CHAR(20),
     item_desc CHAR(25)
     )
;

INSERT INTO plsql101_old_item VALUES
     ('LA-101', 'Can, Small');
INSERT INTO plsql101_old_item VALUES
     ('LA-102', 'Can, Large');
INSERT INTO plsql101_old_item VALUES
     ('LA-103', 'Bottle, Small');
INSERT INTO plsql101_old_item VALUES
     ('LA-104', 'Bottle, Large');
INSERT INTO plsql101_old_item VALUES
     ('NY-101', 'Box, Small');
INSERT INTO plsql101_old_item VALUES
     ('NY-102', 'Box, Large');
```

```
INSERT INTO plsql101_old_item VALUES
     ('NY-103', 'Shipping Carton, Small');
INSERT INTO plsql101_old_item VALUES
     ('NY-104', 'Shipping Carton, Large');
```

Indexes

You are undoubtedly familiar with the concept of an index at the back of a book. In fact, the book you are reading has an index; take a moment now and look at it.

What did you see? A word or two defining each subject or idea, followed by one or more page numbers. You can look up a subject in the index, find the page numbers related to that subject, and go directly to those pages. Indexes are useful because they let you find something specific within a book without having to look through every one of the book's pages.

Indexes in Databases

You can apply the same indexing concept to a table in a database. When a table contains a lot of records, it can take a long time for Oracle (or any other database program) to look through the table to locate specific records—just like it would take a long time to look at every page in a book to find pages discussing a specific topic. Oracle has an easy-to-use feature that creates a second, hidden table containing one or more important columns from the main table, along with pointers to rows in the main table. In this case, instead of page numbers, the pointers in the hidden second table—which I'm going to start calling the main table's index—will be row numbers. By looking in the index, Oracle can know exactly what rows to jump to in order to find a specific piece of data (as long as the data being asked for is in the columns that make up the index). Since the index is much smaller than the table it refers to—just like a book's index is much smaller than the book's complete text—finding data in a table with an index can be dramatically faster than in a table without an index. For example, while I was writing this I ran a little SQL routine that inserted one million rows into a test table. (You will learn how to create a routine like this in Chapter 8.) Selecting records matching a specific value from this million-record table takes 18.9 seconds. After creating an index on the table, the same query takes only 0.6 seconds to finish. Adding an index to the table made it possible for the table to answer queries 31 times faster!

Figure 6-1 shows how a standard index on the PLSQL101_PERSON table would look. In this figure, the PLSQL101_PERSON table has been indexed, with the PERSON_CODE column being the basis of the index. Note that the index is sorted by PERSON_CODE, even though the table stores records in the order they were entered. An index always sorts its entries by the columns it contains. The index's ROWNUM column keeps track of each row's original location in the table.

PLSQL101_PERSON TABLE

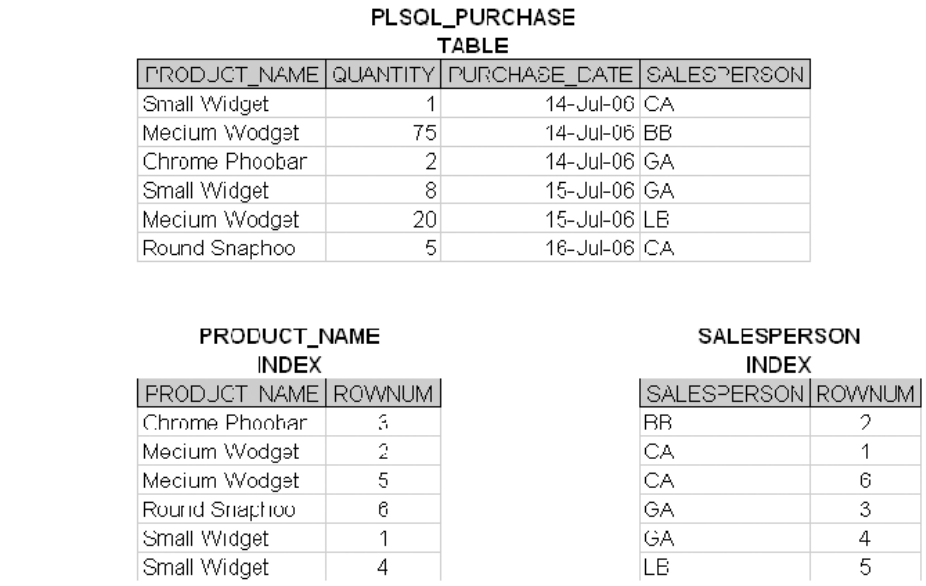
PERSON_CODE	FIRST_NAME	LAST_NAME	HIRE_DATE
CA	Charlene	Allas	01-Feb-05
CA	Cary	Ancerson	15-Feb-05
BB	Bobby	Barkenhagen	28-Feb-05
LB	Laren	Baxter	01-Mar-05

PERSON_CODE INDEX

PERSON_CODE	ROWNUM
BB	3
CA	1
GA	2
LB	4

FIGURE 6-1. *Table with one index*

Figure 6-2 shows a similar relationship between the PLSQL101_PURCHASE table and two indexes. That's right, a table can have more than one index. Why would you want to do that? The answer is well demonstrated by the PLSQL101_PURCHASE table. It contains at least two columns that are likely candidates for indexes: product and salesperson. It's very likely that queries against the table will often be based on a



PLSQL_PURCHASE TABLE

PRODUCT_NAME	QUANTITY	PURCHASE_DATE	SALESPERSON
Small Widget	1	14-Jul-06	CA
Medium Widget	75	14-Jul-06	BB
Chrome Phoobar	2	14-Jul-06	GA
Small Widget	8	15-Jul-06	GA
Medium Widget	20	15-Jul-06	LB
Round Snaphoo	5	16-Jul-06	CA

PRODUCT_NAME INDEX

PRODUCT_NAME	ROWNUM
Chrome Phoobar	3
Medium Widget	2
Medium Widget	5
Round Snaphoo	6
Small Widget	1
Small Widget	4

SALESPERSON INDEX

SALESPERSON	ROWNUM
BB	2
CA	1
CA	6
GA	3
GA	4
LB	5

FIGURE 6-2. *Table with indexes on two different columns*

particular product, and it's just as likely that other queries will often be based on salesperson. By creating a separate index for each of these columns, you generate the same improvement in access speed described earlier for a table with one index…but that improvement is available when searching by product name *or* by salesperson.

Once you have created an index on a table, Oracle automatically keeps the index synchronized with that table. Any INSERT, UPDATE, or DELETE on the table automatically changes the index as well, and any SELECT on the table will automatically be routed through an index, if one exists containing the columns needed by the SELECT statement. You can add or drop indexes without affecting the table's operations—any program that used the table before will still operate. It may operate more slowly, however. If you drop a table, any indexes that are associated with the table will automatically be dropped too, since an index has no purpose without its associated table.

The syntax for dropping an index is as follows:

DROP INDEX *index_name*;

When Do Indexes Help?

Indexes improve the response time of commands that have to read a table's contents in order to perform their operations. That means SELECT, UPDATE, and DELETE commands can all work more quickly if the table they're working on has an index relevant to the commands.

Adding indexes to a table will *not* speed up data entry via INSERT commands; in fact, the opposite is true. Why would the presence of an index make an insert take longer? Remember that an index is really a table itself. So when you add a record to a table that has an index, Oracle has to add a record to both the table and the index—in essence, Oracle has to perform *two* inserts for every record. Because of this, adding an index to a table will cause inserts to take a little more than twice as long (the time doubles for the two inserts, plus a little extra time is needed for handling the coordination between them). Adding two indexes makes inserts take three times as long, three indexes makes indexes take four times as long, and so on.

So the use of indexes is a trade-off. They make data entry take longer, but make reading data faster. Therefore an application in which data entry must happen as quickly as possible is not a good candidate for adding indexes to tables. For example, store point-of-sale systems need their cash registers to turn around sales transactions (which, in case you haven't thought about it, are inserts into a database) as rapidly as possible. In this case, placing an index on the table storing transactions would be a mistake, because it would make the inserts slower. On the other hand, at the same time the same business could have executives who want to run queries analyzing transactions, and these queries would benefit greatly from having well-indexed tables. How do you handle these conflicting needs? In many systems, the transactions are copied out of the transaction table automatically every night, and the duplicates are

placed into a well-indexed table that is used the next day for analysis. The inserts into the well-indexed table take much longer than they did for the index-free transaction table, but nobody cares because the stores are closed, no customers are waiting, and computers are doing the work.

The larger a table, the more benefit you will see from creating indexes on that table. For instance, the tables you have created so far in this book are so small that everything you do to them is essentially instantaneous. As a result, indexes on those tables will not produce a noticeable benefit. As tables get larger, the benefit increases. Using the million-record table once again as an example, Table 6-1 shows how long various DML operations took with and without an index on the table. The first row of statistics repeats the SELECT information you read earlier, while the subsequent rows show the impact of an index on UPDATE and DELETE commands. All times are measured in seconds. Look at how much faster the operations are, and imagine what kind of a hero you would be if you started a new job and in the first day reduced the time required for a database process from hours to minutes.

How to Create Indexes

Creating an index is very easy. The syntax for the command is as follows:

```
CREATE INDEX index_name ON table_name (column_name);
```

If you want the index to contain more than one column from the table, the syntax would look like this:

```
CREATE INDEX index_name ON table_name (
        first_column_name,
        second_column_name
        )
;
```

Operation	Without Index	With Index	Speed Increase
SELECT 50 records	18.9	0.6	31.5 times faster
UPDATE 50 records	19.7	0.5	39.4 times faster
DELETE 50 records	19.6	0.06	326.7 times faster

TABLE 6-1. *Execution Times for DML Operations With and Without an Index*

Applying this to your own test tables, you can create the index shown in Figure 6-1 by issuing the following command:

```
CREATE INDEX plsql101_person_code_index
ON plsql101_person(person_code);
```

This index would be most useful in searches referring to the PERSON_CODE in the WHERE clause. If, on the other hand, most of your searches were going to be based on a person's first and last name, an index based on those columns would be more useful. The following command would create such an index:

```
CREATE INDEX plsql101_person_name_index
ON plsql101_person(last_name, first_name);
```

This is an example of a *composite index* (sometimes called a *concatenated index*). A composite index is simply an index based on more than one column in a table. It is appropriate whenever the table contains columns that are likely to be used together in a query's WHERE clause—for instance, first and last name, or city, state, and ZIP code. As long as the WHERE clause includes either *all* of the columns in the composite index or the *first* column in the composite index, Oracle will use the index and your query will return more quickly. You can place columns in the index in any order you want—they don't have to be in the same order as in the table—so if you need to rearrange them to make the first column the one you're most likely to name in a WHERE clause, you can. Columns in a composite index do not have to be next to each other in the table they came from.

NOTE
The largest number of columns you can include in a standard Oracle index is 32.

Take a moment now to practice creating indexes by writing commands to produce the two indexes shown back in Figure 6-2.

Different Index Types

As you have probably deduced by now, an index is basically a way to summarize the locations of records based on what those records contain. The contents of a database can vary dramatically from system to system, and different kinds of content benefit from different kinds of organization. Oracle offers several different types of indexes, each using a different organizational approach. This section describes the two most common types of indexes; the others are used only in highly complicated databases and are better suited for a book on database administration.

B*-Tree Indexes

By default, an Oracle index organizes records into what is called a B*-Tree. Figure 6-3 shows how a B*-Tree index organizes records.

When creating a B*-Tree index, Oracle analyzes the values in the column(s) being indexed and determines how to split the table into *leaf blocks* with equal numbers of records. It then creates layers of *branch blocks* enabling records in the lower leaf blocks to be located in as few steps as possible.

TIP

In the example shown in Figure 6-3, the branch blocks split the alphabet evenly. In real life, the branch points are determined by the values in the records. For instance, if a table contained many more records whose names started with "A" than any other letter, an entire branch block might be devoted to "A" , with the next branch block starting at "B" .

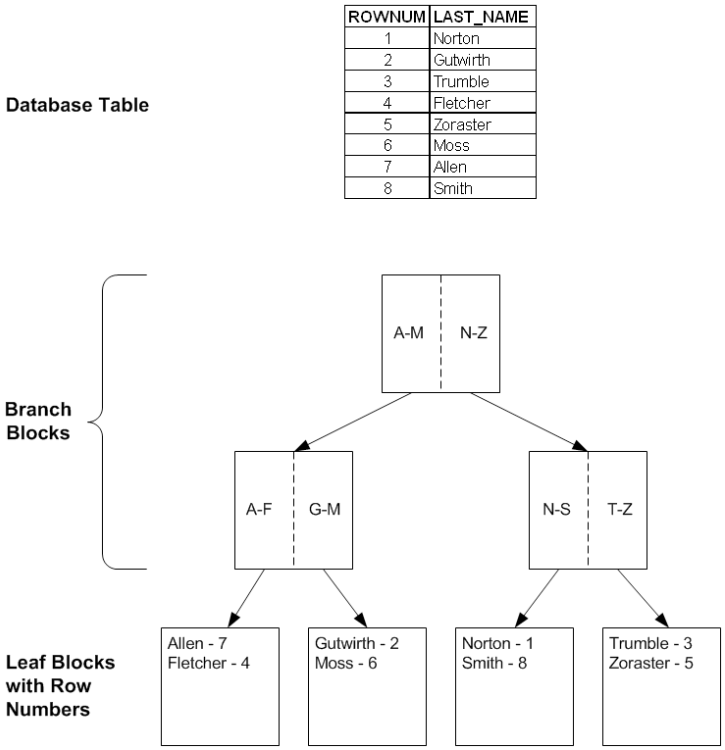


FIGURE 6-3. *How a B*-Tree index organizes records*

The beauty of a B*-Tree index is that it quickly allows Oracle to identify records it does not need to read. By minimizing the amount of data that must be read—and therefore the amount of work it has to do—Oracle can return answers to you much more quickly. (Remember that the improvements listed in Table 6-1 were realized using Oracle's default index type of B*-Tree.) For example, consider a table that contains a billion records, and you want to see the record that has a specific ID number. The table isn't necessarily sorted by ID number, so Oracle may have to read as many as a billion records to find the one you want. If a B*-Tree index is defined for the table, however, Oracle can find the record in a maximum of 31 steps. Each step eliminates half of the records in the table, so Oracle can reduce the job to manageable proportions very quickly. Table 6-2 shows how quickly a B*-Tree index reduces the number of records involved in an operation.

Since a B*-Tree index works by dividing data into sets and subsets based on content, this type of index works best when the column being indexed contains a wide variety of values, such as names or dates. For columns that contain a narrow range of values—such as gender, for instance—a bitmap index is a better choice. Read on to learn more about bitmap indexes.

Step	Number of Records That Must Be Searched to Find Desired Value
1	1,000,000,000
2	500,000,000
3	250,000,000
4	125,000,000
5	62,500,000
6	31,250,000
7	15,625,000
8	7,812,500
9	3,906,250

TABLE 6-2. *Number of Steps Needed for a B*-Tree Index to Find a Specific Value*

Step	Number of Records That Must Be Searched to Find Desired Value
10	1,953,125
11	976,563
12	488,281
13	244,141
14	122,070
15	61,035
16	30,518
17	15,259
18	7,629
19	3,815
20	1,907
21	954
22	477
23	238
24	119
25	60
26	30
27	15
28	7
29	4
30	2
31	1

TABLE 6-2. *Number of Steps Needed for a B*-Tree Index to Find a Specific Value* (continued)

Bitmap Indexes

If a B*-Tree index structure is optimal for indexing a column containing many unique values, then it stands to reason that a different index structure may be better suited for a column that contains only a few unique values. For example, a gender column would probably contain just three possible values: "M," "F," or "U" (for "Unknown"). Placing this small number of unique values into a B*-Tree index structure would not make sense, because the "divide into subgroups step-by-step" approach that makes the B*-Tree structure so useful for diverse values offers little benefit when there are only a few unique values. In this situation, using a bitmap index makes more sense. Figure 6-4 contains a somewhat simplified depiction of how a bitmap index is designed.

TIP

The term cardinality refers to the number of unique values a column contains. A column that can contain very few unique values—like gender or any true/false column—has low cardinality. A column with many unique values—like price or name—has high cardinality.

In SELECT queries in which the WHERE clause is a low-cardinality column (such as gender or any other column with only a few possible values), creating a bitmap index on that column beforehand can greatly decrease the time it takes to get your answers. The speed increase is the result of two factors: bitmap indexes can be quite small (because bits require only a fraction of the storage space needed by other

ROWNUM	LAST_NAME	GENDER
1	Norton	F
2	Gutwirth	M
3	Trumble	M
4	Fletcher	M
5	Zoraster	F
6	Moss	M
7	Allen	F
8	Smith	U

ROWNUM	FEMALE	MALE	UNKNOWN
1	1	0	0
2	0	1	0
3	0	1	0
4	0	1	0
5	1	0	0
6	0	1	0
7	1	0	0
8	0	0	1

FIGURE 6-4. *How a bitmap index organizes records*

datatypes that would be in a standard index), and the "1" or "0" value stored in a bitmap index can be evaluated very quickly by a computer.

The syntax for creating a bitmap index is almost identical to that for a standard index; you just add the word "BITMAP", as shown in the following example:

CREATE BITMAP INDEX *index_name* ON *table_name*(*column_name*);

Function-Based Indexes

Normally, indexes refer to columns in a table, but they can also refer to Oracle functions. This can be useful if searches will frequently look at variations on a column's content; for instance, when case does not matter (in other words, matches should be returned whether they are lowercase or uppercase).

To illustrate this point, the following command would create an index based on uppercase contents of the name columns in the PERSON table:

```
CREATE INDEX plsql101_person_caps_index
ON plsql101_person(UPPER(last_name),
                   UPPER(first_name)
                   )
;
```

Ensure Data Integrity: Constraints

One of your most important jobs when designing tables is to ensure that the data people put into those tables is of the highest quality possible. "Dirty data" contains invalid codes, numbers that are too big or too small, dates that don't make any sense, or values that are simply left blank rather than filled in. You can exercise a lot of control over what goes into a table.

What's a Constraint?

A *constraint* is a way for you to define one or more conditions that data must satisfy before Oracle accepts the data into your table. Constraints are stored as part of a table's definition; once created, they operate automatically. When someone attempts to perform an INSERT or UPDATE command that contains data violating a constraint, Oracle interrupts the command, rolls back the INSERT or UPDATE, and presents an error message.

How to Create Constraints

In this section, you will learn how to create three different kinds of constraints (Not Null, Unique, and Check). When used together, these constraints can go a long way toward ensuring that the data in your tables is "clean."

Not Null

You learned how to specify one type of constraint in Chapter 2, by specifying that one or more columns are NOT NULL in a CREATE TABLE command. To save you from flipping pages back to that chapter for a refresher, the command employed was the following (*do not try to run the command now*):

```
CREATE TABLE plsql101_purchase (
     product_name  VARCHAR2(25) NOT NULL,
     product_price NUMBER(4,2)  NOT NULL,
     purchase_date DATE
     )
;
```

Now it's time to learn how to alter existing tables so that columns no longer accept null values when records are inserted or updated. The syntax for changing an existing column to NOT NULL status is as follows:

ALTER TABLE *table_name* MODIFY (*column_name* NOT NULL);

Let's try this out on one of your own tables. The PLSQL101_PERSON table contains FIRST_NAME and LAST_NAME columns, and it's reasonable to say that a record without these names would be unsatisfactory. To make those columns mandatory, enter the following commands, and compare your results with those shown in Figure 6-5:

```
ALTER TABLE plsql101_person MODIFY (first_name NOT NULL);
ALTER TABLE plsql101_person MODIFY (last_name NOT NULL);
```

Now test the constraint by entering the following code. Compare the results you get with those shown in Figure 6-6.

```
INSERT INTO plsql101_person VALUES (
     'XL', 'Xaviera', NULL, '15-NOV-06'
     )
;
```

As you can see from the results on your screen (or in Figure 6-6), Oracle interrupts the operation and tells you, in its own clunky way, what the problem is. (In Chapter 8, you will learn how to intercept Oracle's error messages and, instead, show the user messages that are a little easier to understand.)

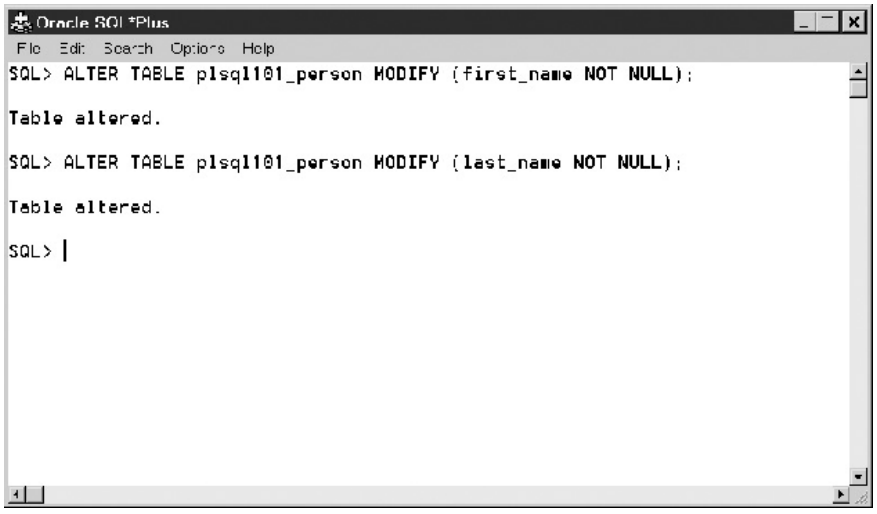


FIGURE 6-5. *Alter an existing table to make columns mandatory*

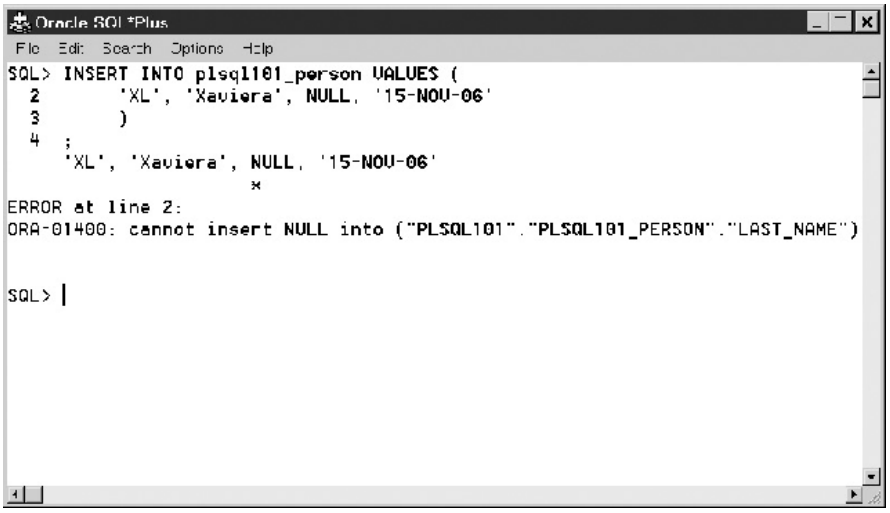


FIGURE 6-6. *Test a NOT NULL constraint*

Unique

With the last exercise you ensured that records going into the PLSQL101_PERSON table will contain a first and last name. However, nothing is keeping a user from entering a person more than once. Do you think they'd know better? In an ideal world, they would. But people get interrupted, forget what they've already done, and sometimes just aren't paying attention; part of the human condition is that we make mistakes. Remember the following motto:

> If they *can* do it,
> they *WILL* do it.

I don't mean that a given person will make every possible mistake. What I'm saying is that over the course of a database's life, many people are going to use it, and within that group, every possible mistake is likely to be made by *somebody*. Part of your job is to think ahead and make sure that their unintentional attempts to enter bad data do not succeed.

Which brings us back to the subject of creating constraints that guarantee a record doesn't get entered twice. In the case of the PLSQL101_PERSON table, the first impulse might be to create a unique constraint stating that a given combination of first and last name can only be entered once. That's a good start, but limiting just by name might prove to be unreasonably restrictive—there are a lot of Bob Smiths out there, and it's very possible your company could hire more than one of them. The solution is to include the hire date in the equation, because it's extremely unlikely that two people with the same name would be hired on the same day.

With that in mind, take a look at the syntax used to add a constraint that guarantees unique values:

> ALTER TABLE *table_name*
> ADD CONSTRAINT *constraint_name* UNIQUE
> (*column_names*);

To see this in action, enter the following code. Note that even though the second command has a different person code, it still fails because its first name, last name, and hire date are identical to those in the first command, as shown in Figure 6-7.

```
ALTER TABLE plsql101_person
ADD CONSTRAINT plsql101_person_unique UNIQUE (
first_name,
last_name,
hire_date
)
```

```
;
INSERT INTO plsql101_person VALUES (
     'LN', 'Linda', 'Norton', '01-JUN-06');

INSERT INTO plsql101_person VALUES (
     'NL', 'Linda', 'Norton', '01-JUN-06');
```

As you can see, the second record is rejected. Even though it had a different person code than the first record, the person's name and hire date were the same, so the record was not accepted. Note also that the error message includes the name of the constraint that is stopping the record from being inserted (PLSQL101_PERSON_UNIQUE). Because of this, it's a good idea to make the constraint name as clear as possible (within the 30 characters you are allowed for the name). I recommend starting the constraint name with the name of the table, followed by an indication of the purpose of the constraint.

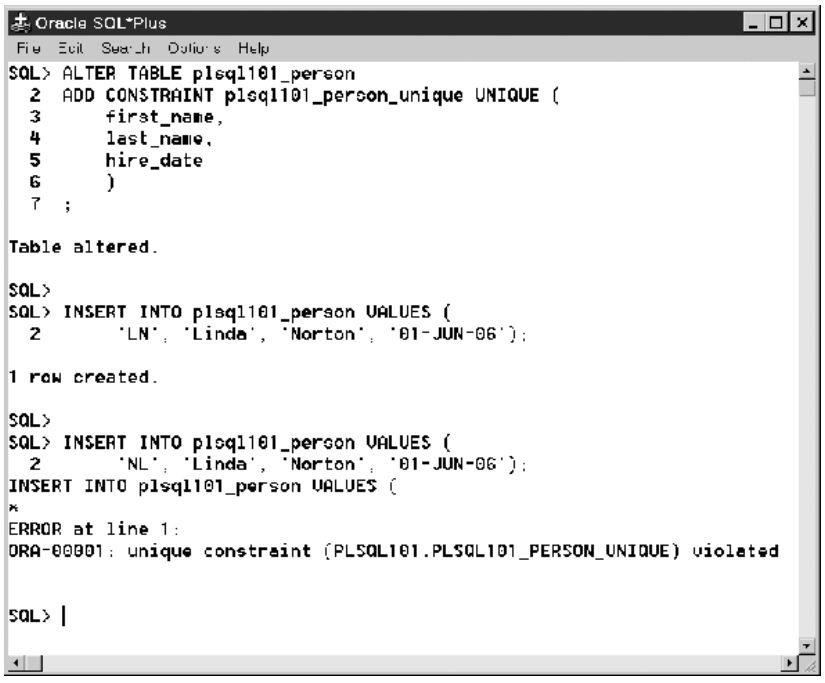


FIGURE 6-7. *Create and test a unique constraint*

When you create a unique constraint, Oracle creates a *unique index* behind the scenes. The index contains the columns you specified in your ALTER TABLE…ADD CONSTRAINT command, and it has the same name you gave the constraint. Oracle uses the unique index to help it identify duplicate records. When Oracle creates the unique index, it reads all existing records in the table and represents them in the index. Because of this, creating a unique constraint will only succeed if the records already in the table do not violate the constraint. If the table contains any records with duplicate values in the columns you specify, the ALTER TABLE…ADD CONSTRAINT command will fail with an error message explaining the problem.

The unique constraint you just created has one shortcoming: it will still allow duplicate names if the case of the names is different. For instance, even though you just entered a record for a person named "Linda Norton", you can still enter another record for "LINDA NORTON".

A more robust way to enforce unique names is with a constraint that is not case sensitive. You can do that by creating a unique index based on the uppercase values of the first and last name columns. Try the following code, and compare your results with Figure 6-8:

```
INSERT INTO plsql101_person VALUES (
     'ZZ', 'Linda', 'Norton', '01-JUN-06');

INSERT INTO plsql101_person VALUES (
     'ZZ', 'LINDA', 'Norton', '01-JUN-06');

DELETE FROM plsql101_person
WHERE first_name = 'LINDA';

ALTER TABLE plsql101_person
DROP CONSTRAINT plsql101_person_unique;

CREATE UNIQUE INDEX plsql101_person_unique_upper
ON plsql101_person (
    UPPER(first_name),
    UPPER(last_name),
    hire_date
    )
;

INSERT INTO plsql101_person VALUES (
     'ZZ', 'LINDA', 'Norton', '01-JUN-06');
```

Check

A *check constraint* allows you to define what must be true about incoming data in order for it to be accepted into your Oracle database. You can define a check

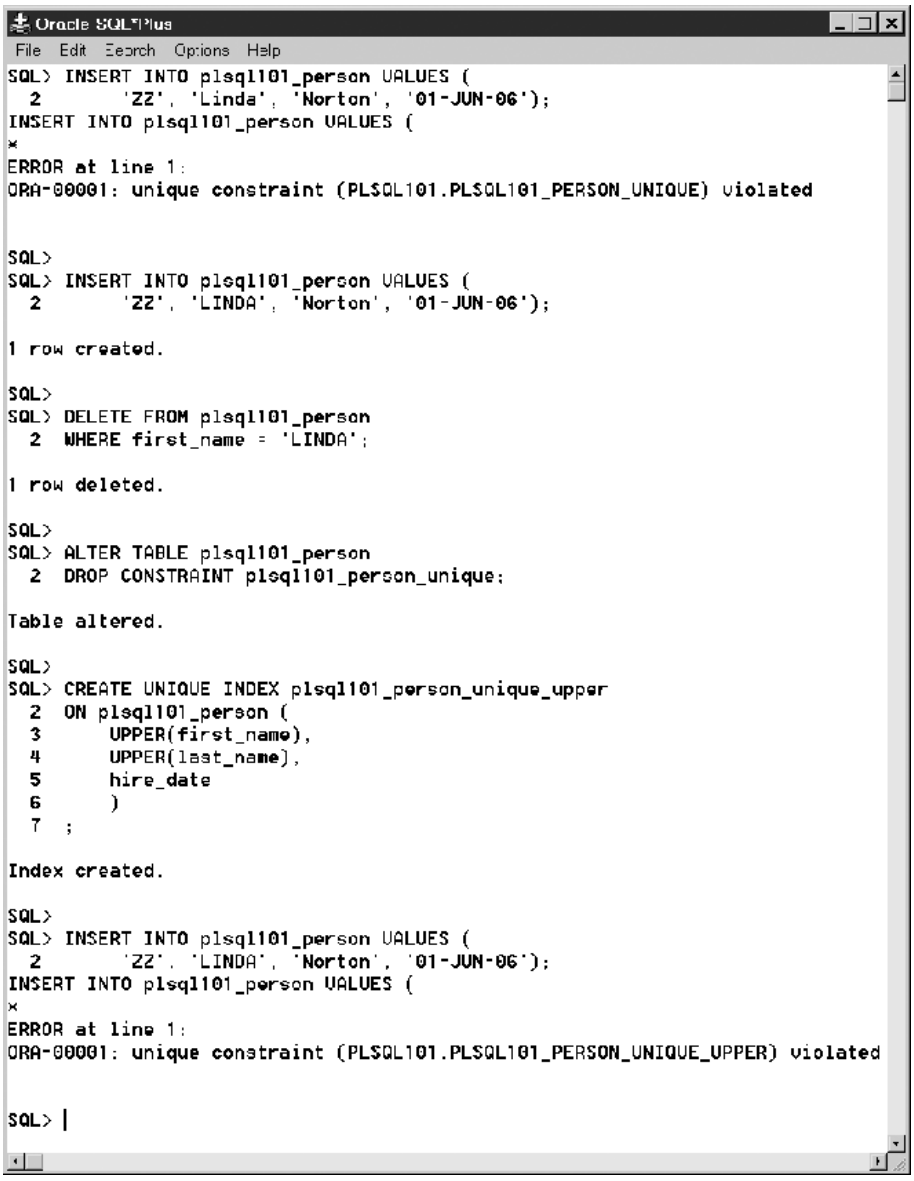


FIGURE 6-8. *Case-independent unique index*

constraint for each column in a table. This allows you to state that an entry for a price column must be a positive number, for instance, while also requiring that

values for a date column be within a certain range. Check constraints are one of your most powerful tools for ensuring that your database will contain clean data.

The syntax for creating a check constraint on a column in an existing table is as follows:

```
ALTER TABLE table_name ADD
        CONSTRAINT [constraint_name]
        CHECK(column_name condition_to_satisfy)
;
```

The *table_name* parameter identifies the table whose column should be checked, of course. The optional *constraint_name* parameter lets you assign your own name to the constraint. If you omit this parameter, Oracle will assign a name to the constraint itself, and the name it assigns will have no inherent meaning—so it will essentially be indecipherable. It's better to assign a constraint name yourself, so that when a user violates the constraint, the resulting Oracle error will refer to *your* constraint name, which will presumably be more informative than the one Oracle would have assigned.

The *column_name* parameter is where you identify the column to which the constraint applies. Finally, the *condition_to_satisfy* parameter is where you define what must be true about the data attempting to make its way into that column in order for the attempt to succeed. Together, the *column_name* and *condition_to_satisfy* parameters look just like a condition you would place after the word WHERE in a SELECT statement's WHERE clause.

Now it's time to create a check constraint of your own. This first exercise will help keep data in your PLSQL101_PURCHASE table clean by ensuring that only reasonable purchase dates are accepted. (For the purposes of this exercise, we're defining "reasonable" as June 30, 2003. In the real world, the definition of a "reasonable" date varies from application to application.) A few things are noteworthy in the following exercise:

- The check constraint evaluates two different conditions before letting data pass through. The two conditions are connected by an AND clause, of course.
- The first condition ensures that the column contains a value (if you do not include this condition, the check constraint will only evaluate records that have values in the constraint's column, thereby allowing records with null values in that column to pass through).
- The second condition checks that the date entered is on or after a date defined by the developer who created the constraint.

Enter the following commands, and compare the results you see with those shown in Figure 6-9.

```
ALTER TABLE plsql101_purchase ADD (
     CONSTRAINT reasonable_date CHECK(
          purchase_date IS NOT NULL
          AND
          purchase_date >= '30-JUN-2003'
          )
     )
;

INSERT INTO plsql101_purchase VALUES (
     'Small Widget', 'GA', '28-FEB-03', 10);
```

There may also be times when you would like to assign a check constraint to a column, but still allow null values; in other words, the column can be empty, but if it does contain a value, the value must satisfy one or more conditions. That is how Oracle interprets check constraints by default. As long as you do not include an IS

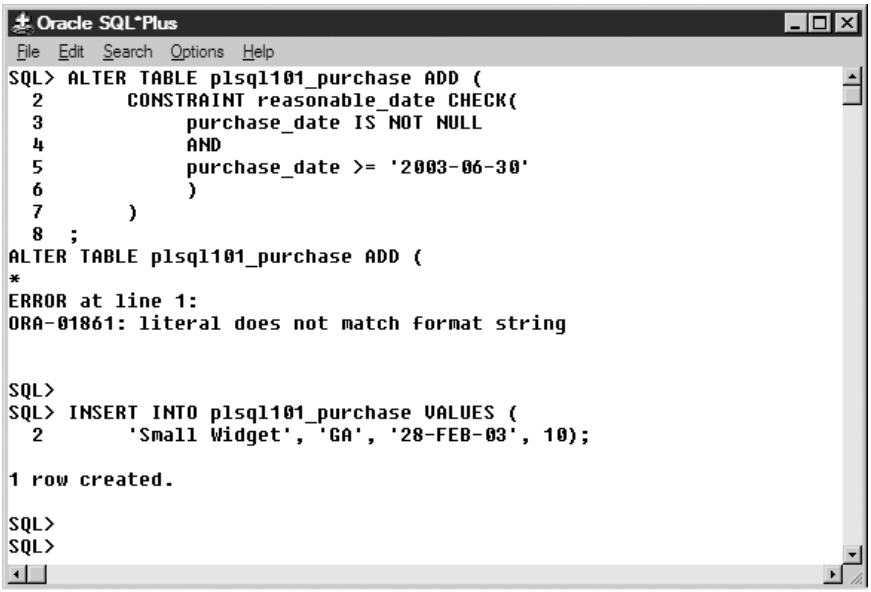


FIGURE 6-9. *Use a check constraint to require entry of a valid date*

NOT NULL clause in the check constraint, null values will still be accepted. Enter the following code to see this in action, and compare the results you get with those shown in Figure 6-10.

```
ALTER TABLE plsql101_product
ADD CONSTRAINT reasonable_stock_date CHECK(
          last_stock_date >= '31-DEC-2004'
          )
;

INSERT INTO plsql101_product VALUES (
     'Anodized Framifier', 49, 5, NULL)
;

INSERT INTO plsql101_product VALUES (
     'Spring-Loaded Pit Puller', 49, 5, '30-DEC-04')
;
```

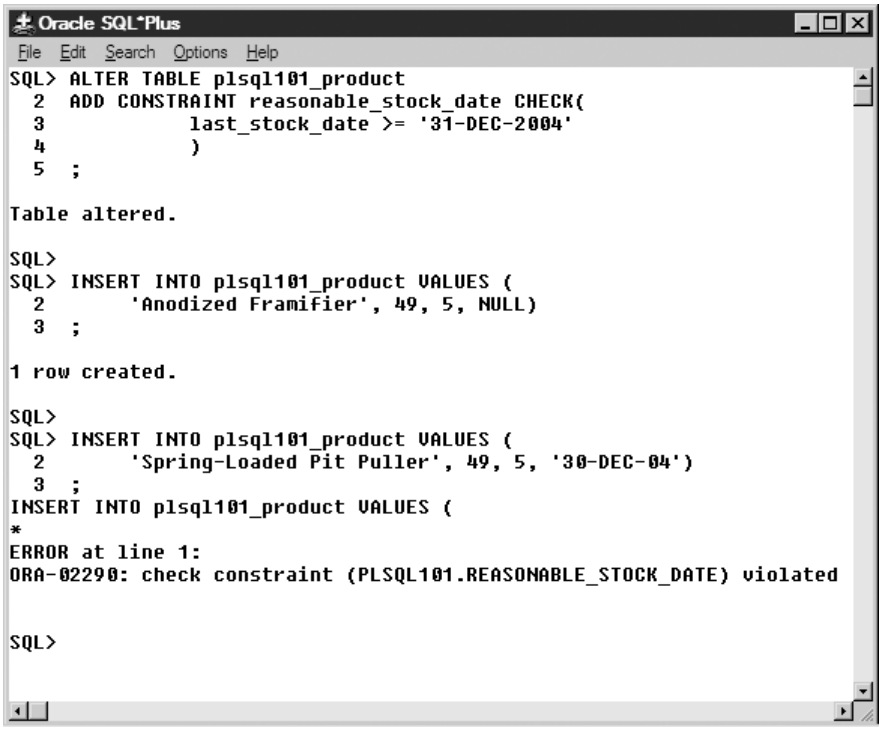


FIGURE 6-10. *Add a check constraint that allows null values*

In the examples you have done so far, check constraints have always been added after a table has been created. You don't have to wait until a table is created to define check constraints; you can do that when you create the table. You simply added the check constraint information to the definition of the relevant column, following the column's datatype and null option. The following code segment demonstrates how to do this. (Because the code creates tables you already have, don't try to run it. Just look it over and note how the check constraint information is included.)

```
CREATE TABLE plsql101_person (
     person_code VARCHAR2(3) NULL,
     first_name  VARCHAR2(15) NOT NULL,
     last_name   VARCHAR2(20) NOT NULL,
     hire_date   DATE NULL
                 CONSTRAINT reasonable_hire_date CHECK (
                      hire_date >= '01-JAN-1930'
                 )
     )
;

CREATE TABLE plsql101_product (
     product_name     VARCHAR2(25) NULL,
     product_price    NUMBER(4,2) NULL
                      CONSTRAINT valid_price CHECK (
                           product_price BETWEEN 0 AND 10000
                      ),
     quantity_on_hand NUMBER(5) NULL
                      CONSTRAINT positive_quantity CHECK (
                           quantity_on_hand >=0
                      ),
     last_stock_date  DATE NULL
                      CONSTRAINT reasonable_stock_date CHECK (
                           last_stock_date
                                >= '31-DEC-2004'
                      )
     )
;
```

As a final option, you can also write a check constraint that compares values in more than one column. This is useful for performing "reality checks" on values that have some logical relationship to each other. None of the tables you have created from this book so far contain columns that lend themselves to this type of check. The following example shows how you could create a constraint in the fictional table EMPLOYEE that ensures an employee's current salary is at least as much as he

or she was making the year before, but not more than 25 percent more than the prior year's amount:

```
ALTER TABLE employee ADD (CONSTRAINT realistic_current_salary CHECK (
     salary BETWEEN prior_year_salary AND (prior_year_salary*1.25))
     )
;
```

Enable and Disable Existing Constraints

There are times when it is useful to temporarily disable constraints, and then re-enable them later. For instance, when loading data from an external source, you could know beforehand that some of the data does not satisfy a particular constraint, but prefer to fix the offending data within Oracle. In times like this, you can use an ALTER TABLE command to turn a constraint off temporarily without dropping it permanently. You can then load the data you know contains undesirable values, fix the values, and re-enable the constraint.

The syntax of the command is as follows:

ALTER TABLE *table_name* DISABLE CONSTRAINT *constraint_name*;

Similarly, the syntax of the command to re-enable constraints is as follows:

ALTER TABLE *table_name* ENABLE CONSTRAINT *constraint_name*;

To see the impact of disabling and enabling constraints, enter the following commands. The first command attempts to insert a record whose LAST_STOCK_DATE value is too early to satisfy the constraint on that column. The next command disables the constraint, and the following one attempts to insert the record again—this time successfully. The subsequent command tries to re-enable the constraint, but fails because a record in the table fails to satisfy the constraint's condition. Once that record's value is changed, the constraint is successfully re-enabled. As you go through these commands, compare the results of each one with those shown in Figure 6-11.

```
INSERT INTO plsql101_product VALUES (
     'Red Snaphoo', 1.95, 10, '30-DEC-04')
;

ALTER TABLE plsql101_product DISABLE CONSTRAINT reasonable_stock_date;

INSERT INTO plsql101_product VALUES (
     'Red Snaphoo', 1.95, 10, '30-DEC-04')
;
```

```
ALTER TABLE plsql101_product ENABLE CONSTRAINT reasonable_stock_date;

UPDATE plsql101_product
SET    last_stock_date = '31-DEC-04'
WHERE  last_stock_date = '30-DEC-04';

ALTER TABLE plsql101_product ENABLE CONSTRAINT reasonable_stock_date;
```

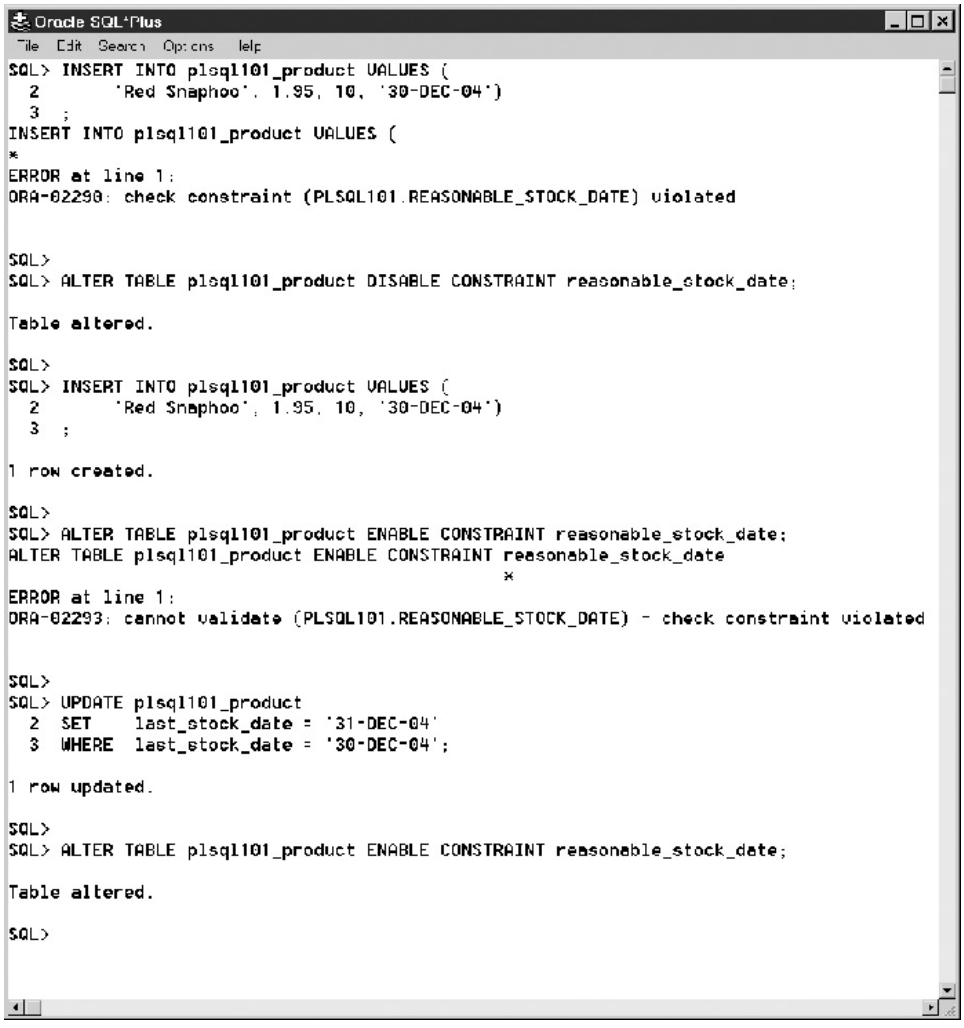


FIGURE 6-11. *Impact of disabling and enabling constraints*

Alter and Drop Existing Constraints

Life is unpredictable, requirements change, and at some point you will need to modify or remove existing constraints on a table. For instance, it's very common to need to change whether a column accepts null values. The syntax to tell a column it should start accepting null values is as follows:

ALTER TABLE *table_name* MODIFY (*column_name* NULL);

The syntax to tell a column it should *stop* accepting null values is as follows:

ALTER TABLE *table_name* MODIFY (*column_name* NOT NULL);

To see this concept in action, enter the following commands and compare the results you get with those shown in Figure 6-12:

```
ALTER TABLE plsql101_person MODIFY (first_name NULL);
ALTER TABLE plsql101_person MODIFY (last_name NULL);
```

If you want to drop a constraint entirely, you can do so using the following syntax.

ALTER TABLE *table_name* DROP CONSTRAINT *constraint_name*;

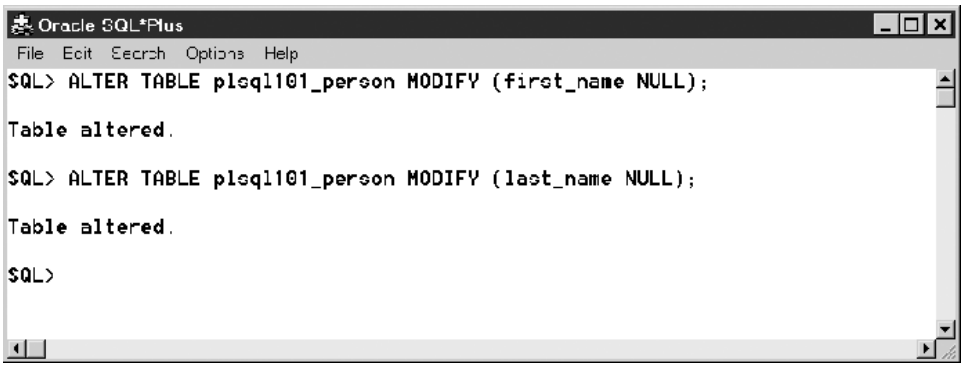


FIGURE 6-12. *Change a column's NULL status*

TIP
Keep in mind that dropping a constraint is a permanent action. If you think you may need the constraint again later, consider disabling it instead of dropping it.

To see this technique in action, enter the following series of commands, and compare the results you get with those shown in Figure 6-13:

```
INSERT INTO plsql101_product VALUES (
     'Blue Snaphoo', 1.95, 10, '30-DEC-04')
;

ALTER TABLE plsql101_product DROP CONSTRAINT reasonable_stock_date;

INSERT INTO plsql101_product VALUES (
     'Blue Snaphoo', 1.95, 10, '30-DEC-04')
;
```

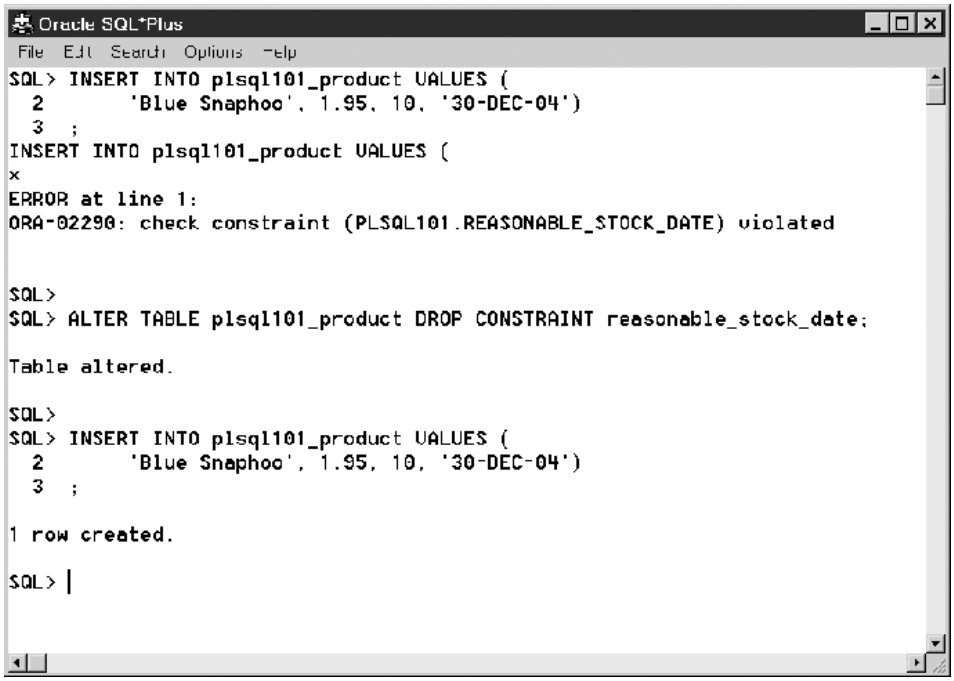


FIGURE 6-13. *Impact of dropping a constraint*

Should a Constraint Be in the Database, in the Software That Uses the Database, or Both?

This section has introduced you to techniques for enforcing constraints from within the database. It is also possible to enforce constraints on the *front end*—that is, within the entry form people use to enter data. (The database is called the *back end* of a system.) There are benefits to both approaches.

When constraints are placed on the front end, they can be evaluated without having to make a trip to the database server. This eliminates unnecessary network traffic (because faulty data isn't being transmitted), reduces the load on the database, and allows constraints to be checked instantaneously. The result is a system that operates quickly and uses its network and server resources efficiently. This is ideal for systems that cannot wait for server processing (like a point-of-sale system in cash registers), use slow network connections (like Internet applications), or have a lot of users.

However, what happens if someone connects to the database using some means other than the approved entry forms? You have seen how easy it is to connect to a database using SQL*Plus®, and it is almost as easy using office-productivity products such as Microsoft Access or Excel. If the database's constraints are only enforced by the approved data-entry forms, then a person connecting to the database using another method can make changes that do not necessarily satisfy the constraints. This can cause major problems such as sales orders referring to products that no longer exist, or personnel whose employment-start dates are in the 1800s. Remember: If people *can* do it, someone *will* do it. Including constraints in the database is the only way to ensure they will be enforced regardless of the method used to connect to the database.

From my perspective, the question really isn't whether to enforce constraints on the front end or the back end. Enforcing them on the back end is essential, period. The question is whether to *also* enforce them on the front end. If your application will have many users or a slow network connection and needs extremely fast response, consider having the programmers build the constraints into their front-end application as well.

NOTE

If you do include constraints on both the front end and the back end, you will need to establish standards for changing them. Otherwise, they will surely get out of sync as the application is revised and a back-end designer forgets to tell a front-end designer about a change, or vice versa.

Relationships Between Tables

In this section, you will learn how to make Oracle enforce relationships between tables, so that (for instance) a purchase record must refer to a product that actually exists in the product table. You will also learn how to select information from more than one table at a time, so you can retrieve related information from multiple tables simultaneously and present it in a single spreadsheet-like list.

Introduction to Data Modeling

The tables you have been working on throughout this book already have implied relationships with each other. The product names in PLSQL101_PRODUCT are used in each record in PLSQL101_PURCHASE, and the person codes in PLSQL101_PERSON are referred to in PLSQL101_PURCHASE within the SALESPERSON column. These types of relationships form the basis of a relational database system. They allow you to enter data in one table and then refer to that data in other tables, thereby eliminating the need to enter it again.

Figure 6-14 shows a logical representation of how the tables are related. The lines connecting one table to another represent relationships allowing, for instance, a product name in a purchase record to be used to find out more information about that product in the product table. In the example shown in Figure 6-14, the PLSQL101_PRODUCT table is the *parent table*, and PLSQL101_PURCHASE is the *child table*. Similarly, PLSQL101_PERSON and PLSQL101_PURCHASE have a *parent/child relationship*. In a parent/child relationship, a single record in the parent table can be referred to by any number of records in the child table. In this example, a person can make any number of sales, so a person code in one PLSQL101_PERSON record could be referred to in the salesperson column of any number of PLSQL101_PURCHASE records. Looking from the other direction, a PLSQL101_PURCHASE record can refer to only one salesperson, simply because it does not have the ability to store more than one salesperson code per purchase record. This is the most common type of relationship between tables, and it is called a *one-to-many relationship* (indicating that one record in the person table can be referred to by many records in the purchase table).

You may have noticed that the relationship lines between tables in the figure have a solid circle on one end of each line. This circle identifies the "many" end of a one-to-many relationship. There are a variety of standards for depicting relationships such as these. The one used in Figure 6-14 uses a standard called IDEF1X—the "IDEF" part of the name stands for "Integration DEFinition for Information Modeling," and the "1X" identifies which of the IDEF standards this is (there are other IDEF standards describing how other types of diagrams should look). Another common standard is called IE, which stands for "Information Engineering." This standard, which is shown in Figure 6-15, is often referred to

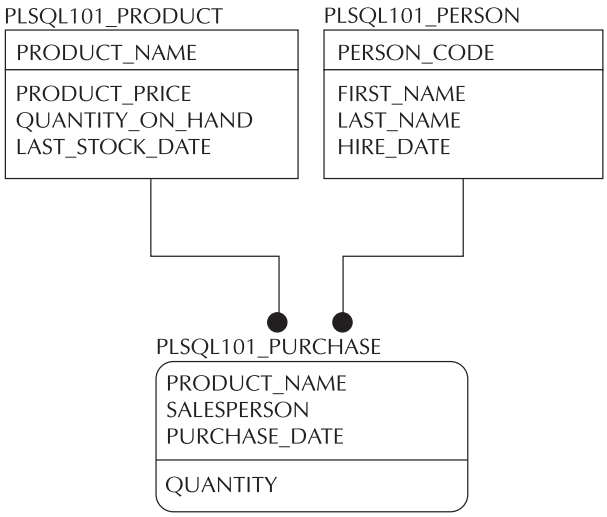


FIGURE 6-14. *Relationships of PL/SQL 101 tables (IDEF1X display)*

as the "Crow's Foot" methodology because of the three-line "V" shape it uses to identify the "many" end of a one-to-many relationship.

Diagrams like those shown in Figures 6-14 and 6-15 are known as *Entity Relationship Diagrams,* or *ERDs*. They are also commonly referred to as *data models*. They are the most effective way to depict the design of a database.

Use Constraints to Enforce Relationships Between Tables

In order for a relationship to exist between two tables, two things must be true:

- The parent table must have a column (or set of columns) that uniquely identifies every record it contains.
- The child table must have an identical column (or set of columns) to contain the values that uniquely identify the parent record.

For example, in the PLSQL101_PRODUCT table, each product has a product name. That value is what uniquely identifies each product record. It is called the

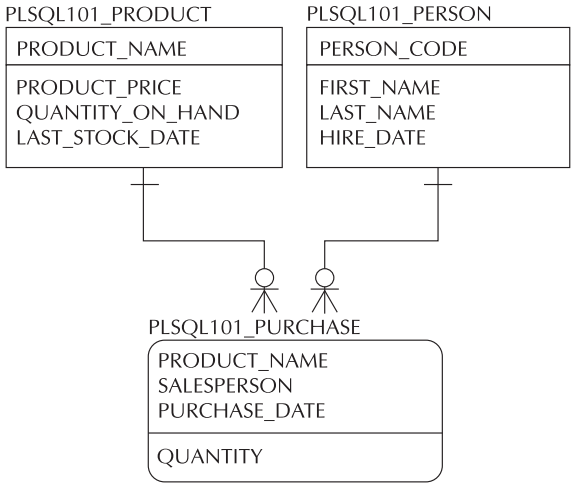


FIGURE 6-15. *Relationships of PL/SQL 101 tables (IE display)*

table's *primary key*. The primary key is the main way you refer to records in a table. The primary key in the PLSQL101_PERSON table is the person code.

There are many examples of primary keys in daily life. Walk into a store—or call your local pizza-delivery service—and if you already have an account with them, they will probably ask for your phone number to look up the account. In their database's list of people, the phone number is the primary key—the main way of uniquely identifying each person in the list. Schools assign their students ID numbers, employers assign their employees employee numbers, and mail-order catalogs ask for product numbers. All of these are primary keys for their respective tables.

In order for a parent table's primary key to be used in a relationship, it must be referred to in the child table. To do this, include a column (or set of columns) in the child table that has exactly the same datatype(s) as the parent table's primary key. When you want to create a child-table record referring to a parent-table record, include the parent record's primary-key value(s) in the child record. For instance, to identify what product was purchased in a transaction, you must include the product's name or number—whichever is used as the primary key in the product table—in the transaction record.

The child-table columns that contain primary-key values from a parent table are called *foreign keys*. A foreign key allows a child record to refer to a parent record. For instance, in the PLSQL101_PURCHASE table, the product name column is a foreign key back to the PLSQL101_PRODUCT table. Similarly, the salesperson column in PLSQL101_PURCHASE is a foreign key back to the PLSQL101_PERSON

table. Figure 6-16 shows a data model of your test tables with the foreign keys marked with "(FK)."

NOTE
There are several excellent books explaining how to design relational databases properly. Further discussion of the topic is beyond the scope of this book. You can search your favorite book retailer for books on data modeling; a couple of classics are ***Data Model Patterns: Conventions of Thought*** *by David C. Hay (published by Dorset House), and* ***The Data Model Resource Book*** *by Len Silverston (published by John Wiley & Sons, Inc.).*

Create a Primary Key

The syntax for specifying what column(s) to use as the primary key in an existing table is as follows:

```
ALTER TABLE table_name
ADD PRIMARY KEY (column_name_1, column_name_2, ...);
```

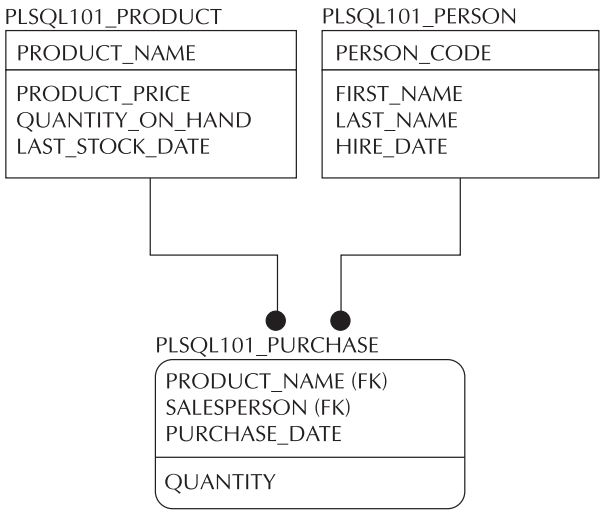


FIGURE 6-16. *Relationships in current test tables*

NOTE
When you create a primary key, Oracle automatically creates an index on the column(s) in the primary key. This will cause data entry to slow down slightly, and will speed up any queries that use the primary-key column(s) as the first column(s) in a WHERE clause.

To create a primary key on the PLSQL101_PRODUCT column, enter the following command and compare your results with those shown in Figure 6-17:

```
ALTER TABLE plsql101_product
ADD PRIMARY KEY (product_name);
```

Using this technique, you can create primary keys in the other two tables by entering the following commands:

```
ALTER TABLE plsql101_person
ADD PRIMARY KEY (person_code);

ALTER TABLE plsql101_purchase
ADD PRIMARY KEY (product_name,
                 salesperson,
                 purchase_date
                 )
;
```

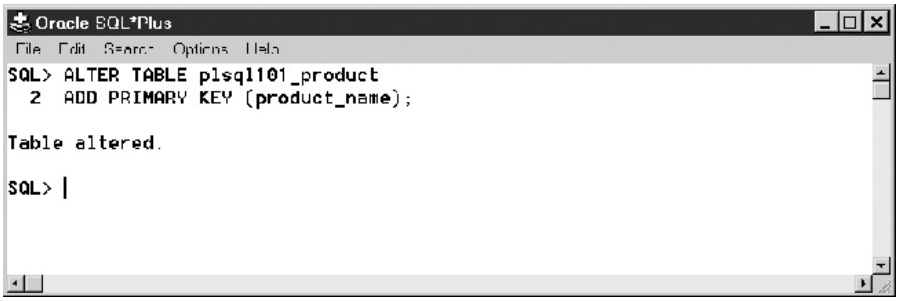


FIGURE 6-17. *Add a primary key to an existing table*

It is also possible to define a primary key when you first create a table. For example, the following code shows how to create a table with the same structure as the PLSQL101_PRODUCT table and define its primary key all in one command:

```
CREATE TABLE plsql101_product2 (
     product_name     VARCHAR2(25) PRIMARY KEY,
     product_price    NUMBER(4,2),
     quantity_on_hand NUMBER(5,0),
     last_stock_date  DATE
     )
;
```

Create a Foreign Key Constraint

Primary keys and foreign keys are the physical components that make a relationship between tables possible. However, by themselves they do not enforce relational integrity—meaning that even if the columns in the primary key and foreign key have exactly the same names and datatypes, Oracle does not assume they are related until you say they are. This last step is crucial: You must define a constraint on the child table so it checks the parent table's primary key before accepting values into its foreign key. Without such a constraint, a user can enter values into the child table's foreign key that do not actually exist in the parent table.

As a matter of fact, your test tables contain a record with this problem already. Enter the following code, compare your results with Figure 6-18, and see if you can find the child record with the rogue product name:

```
SELECT product_name
FROM   plsql101_product
ORDER BY product_name;

SELECT DISTINCT product_name
FROM   plsql101_purchase
ORDER BY product_name;
```

As you can see, the PLSQL101_PURCHASE table contains a transaction for a "Round Snaphoo", while no such product exists in the PLSQL101_PRODUCT table. You will need to change the product name in the purchase table before you can create a foreign-key constraint to the product table. Before you do, though, go ahead and try to create the constraint in order to see how Oracle responds to the situation. The syntax for creating a foreign-key constraint is the following:

```
ALTER TABLE child_table_name
ADD CONSTRAINT constraint_name
      FOREIGN KEY (column_name(s)_in_child_table)
      REFERENCES parent_table_name
;
```

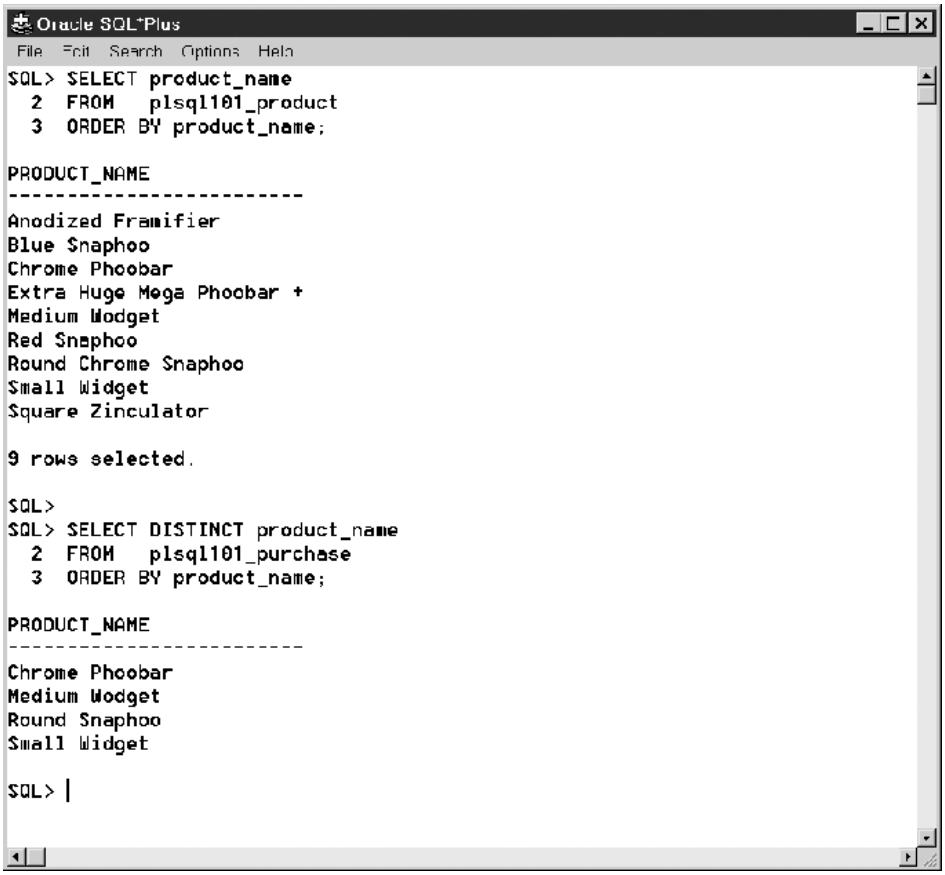


FIGURE 6-18. *Manually locate a child record with no matching parent record*

Apply this syntax to your product and purchase tables to produce the following command:

```
ALTER TABLE plsql101_purchase
ADD CONSTRAINT plsql101_purchase_fk_product
               FOREIGN KEY (product_name)
               REFERENCES plsql101_product
;
```

Enter this command now, and you will see the results shown in Figure 6-19. The error message's "Parent key not found" phrase is your clue that the child table contains one or more product names that are not in the parent table. To make the

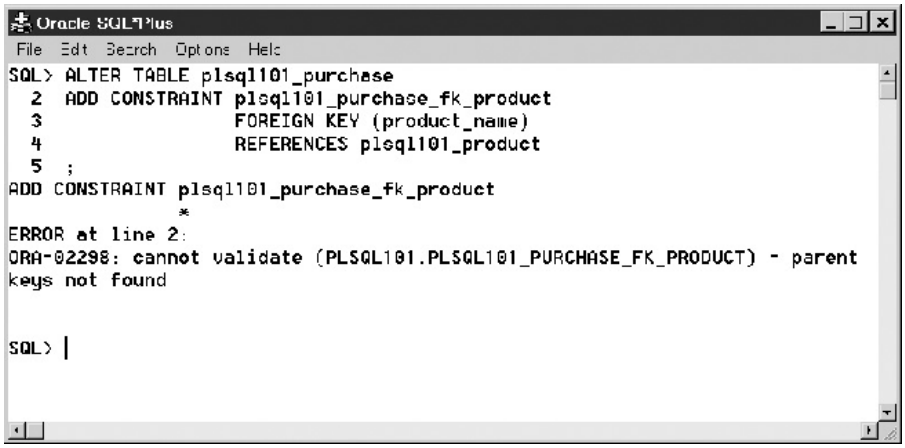


FIGURE 6-19. *Attempt to create a foreign-key constraint with non-matching child values*

constraint work, you will need to update the rogue product name in the child table. Enter the following commands to do this and re-try the constraint creation:

```
UPDATE plsql101_purchase
SET    product_name = 'Round Chrome Snaphoo'
WHERE  product_name = 'Round Snaphoo';

ALTER TABLE plsql101_purchase
ADD CONSTRAINT plsql101_purchase_fk_product
               FOREIGN KEY (product_name)
               REFERENCES plsql101_product;
```

To test your new foreign-key constraint, try entering a record using the following command:

```
INSERT INTO plsql101_purchase VALUES (
     'Small Widgee', 'CA', '17-JUL-06', 1)
;
```

Compare your results with those shown in Figure 6-20. As you can see, the purchase table will no longer accept records containing product names that do not exist in the product table. Try this corrected command to see what happens when the product name does exist in the product table:

```
INSERT INTO plsql101_purchase VALUES (
     'Small Widget', 'CA', '17-JUL-06', 1)
;
```

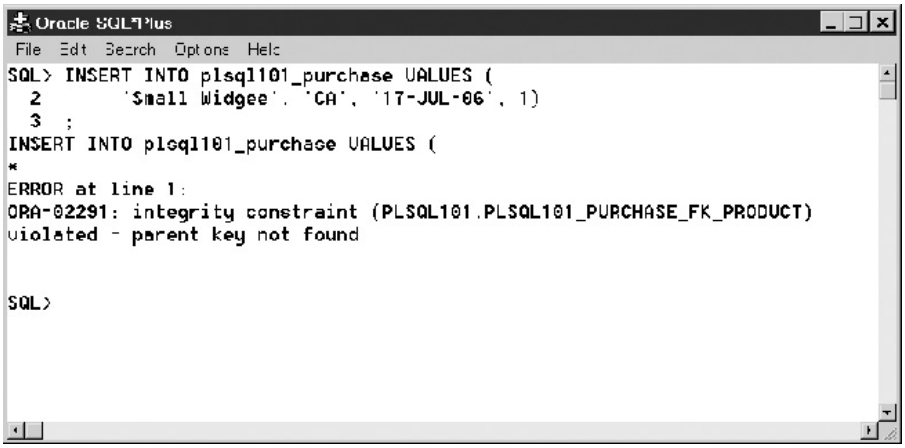


FIGURE 6-20. *Attempt to enter a child record without a matching parent record*

Using the technique you just learned, create a foreign-key constraint on the PLSQL101_PURCHASE table so that it checks the PLSQL101_PERSON table before accepting values into its SALESPERSON column.

NOTE
When creating a foreign-key constraint, you usually only need to name the child table, parent table, and child table's foreign-key column(s) in the ALTER TABLE command. You do not need to name the parent table's primary-key columns, because Oracle can determine the table's primary key based on the table name. If the columns are not in the same order, however, you will need to name them for both the child table and the parent table.

Write SELECT Statements to Display Data from More Than One Table

Now that you have seen how to create relationships between tables, it's time to learn how to join information from these related tables together. For instance, what if you want to get a list of purchases that identifies the salespeople by name, rather than by their person code? This type of need is very common, and it's easy to fulfill. The syntax of a SELECT statement that draws from two tables is as follows:

```
SELECT table_1_name.column_name,
     table_2_name.column_name
FROM   table_1_name,
?    table_2_name
WHERE parent_table_name.primary_key = child_table_name.foreign_key
;
```

Being the perceptive reader that you are, you probably noticed that even though the SELECT statement is supposed to join data from only two tables, the example syntax I've written refers to *four* different generic table names: TABLE_1_NAME, TABLE_2_NAME, PARENT_TABLE_NAME, and CHILD_TABLE_NAME. The four generic names do apply to only two tables. The reason I've used more than one generic name per table is that when you are specifying columns, you can do them in any order: the parent table's column(s) can be first, or the child table's column(s) can be first, or you can mix them—it doesn't matter, as long as you identify which table each column comes from (by preceding the column name with the name of its table and a period). However, when you write the WHERE clause of the command, it is essential that you identify the primary key column(s) in the *parent* table, and the foreign key column(s) in the *child* table. By describing the parent/child relationship in your SELECT statement, you allow Oracle to understand how information in the parent table should be linked to information in the child table.

Let's put this theory into practice by getting a list of purchases with the full names of their salespeople. You can achieve this result by entering the following command:

```
SELECT plsql101_purchase.product_name,
       plsql101_person.last_name,
       plsql101_person.first_name,
       plsql101_purchase.quantity
FROM   plsql101_purchase,
       plsql101_person
WHERE  plsql101_person.person_code = plsql101_purchase.salesperson
;
```

Compare your results with those shown in Figure 6-21.

Writing a command that combines data from more than one table into a single list is called creating a *join*. The most important thing to remember about a join is this: *You must include a WHERE clause describing how the parent table's primary key relates to the child table's foreign key.* If you do not, Oracle will join *every* record in the parent table with *every* record in the child table, creating what could be a very, very long list. (This type of mistake can slow a database to a crawl while it is processing the incorrectly written request, so it is to be avoided.) To see the

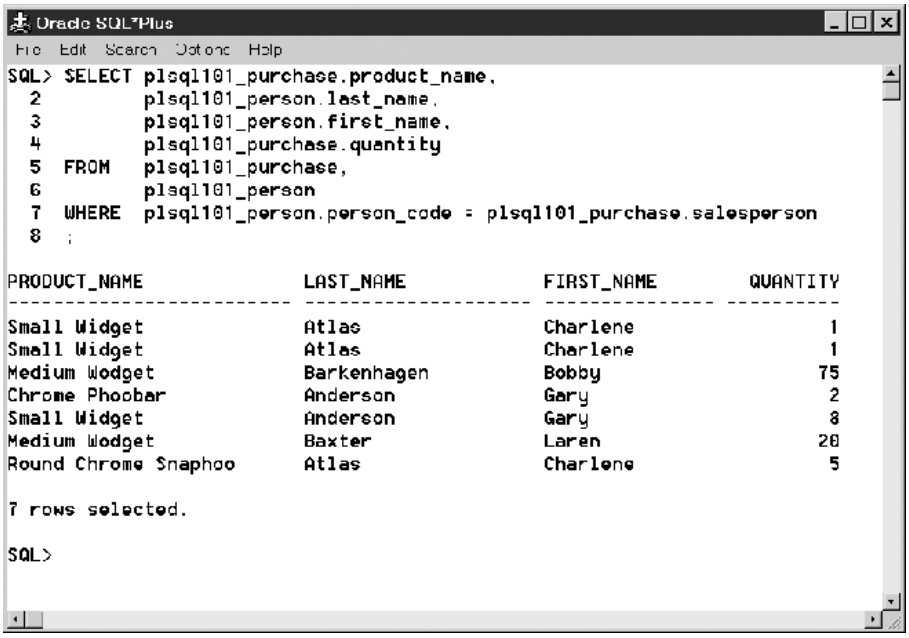


FIGURE 6-21. *Write a SELECT statement that joins records from two tables*

results of a join without a WHERE clause, enter the following code and compare your results with those shown in Figure 6-22.

```
SELECT plsql101_purchase.product_name,
       plsql101_person.last_name,
       plsql101_person.first_name,
       plsql101_purchase.quantity
FROM   plsql101_purchase,
       plsql101_person
;
```

With five records in the PLSQL101_PERSON table and seven records in the PLSQL101_PURCHASE table, the join produces 35 rows of completely useless results. This type of result, created by issuing a join without a WHERE clause, is called a *Cartesian product*.

You can join records from many different tables into a single SELECT statement. To do so, you simply have to ensure that (a) the tables are logically related via primary-key/foreign-key relationships, and (b) you define each of those relationships in the WHERE clause of the SELECT statement.

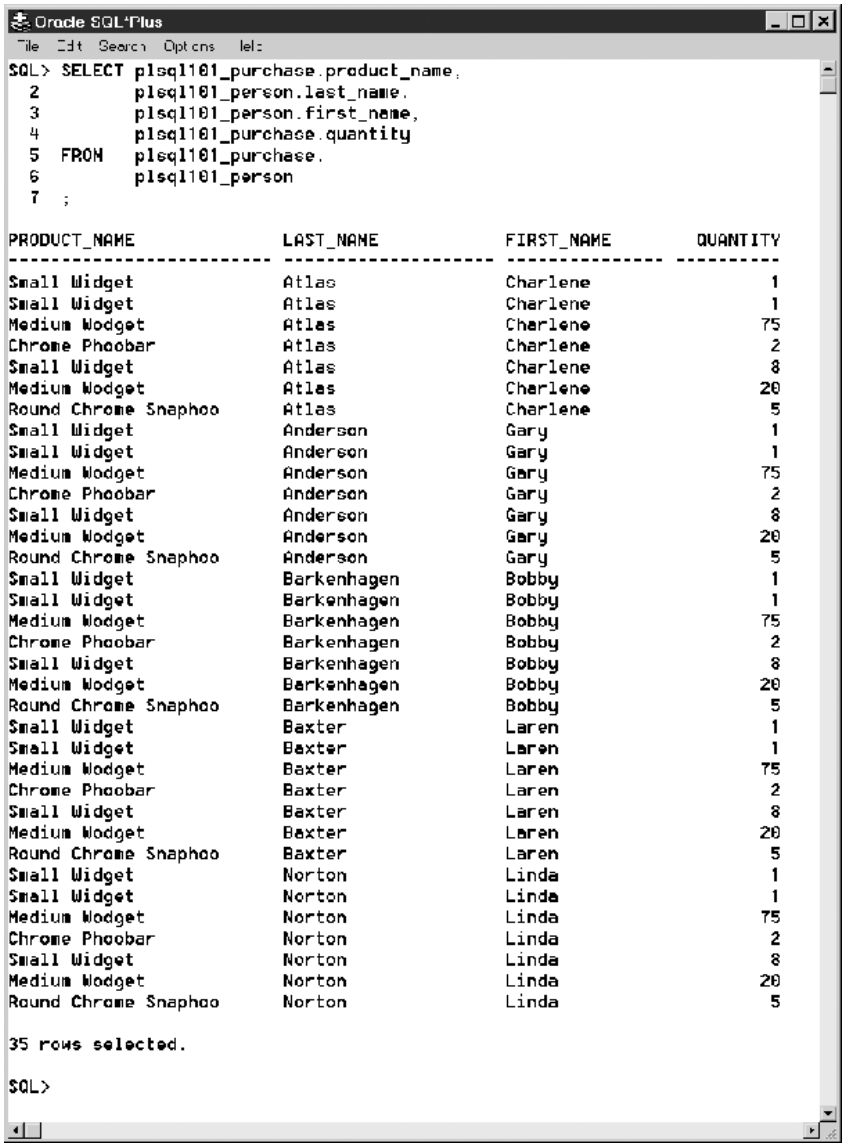


FIGURE 6-22. *Create a join without a WHERE clause*

For example, let's say you want to get a list of each purchase, the price of the product purchased, and the last name of the salesperson who made the sale. This information resides in three different tables. The code to perform this join is as follows:

```
SELECT plsql101_purchase.product_name,
       plsql101_product.product_price,
       plsql101_purchase.quantity,
       plsql101_person.last_name
FROM   plsql101_product,
       plsql101_person,
       plsql101_purchase
WHERE  plsql101_product.product_name = plsql101_purchase.product_name
  AND  plsql101_person.person_code = plsql101_purchase.salesperson
;
```

Enter this code now and review your results. Now try to create a SELECT statement that displays each purchase's date and quantity, the last stock date for the item purchased, and the last name of the salesperson.

You may have noticed while entering these commands that it can become tedious to enter the table names over and over. You can assign a short *table alias* to each table, and refer to the tables by their aliases throughout the command. The table alias goes right after the table name in the FROM section of the statement. Using this approach, the most recent command could be rewritten as follows:

```
SELECT c.product_name,
       a.product_price,
       c.quantity,
       b.last_name
FROM   plsql101_product  a,
       plsql101_person   b,
       plsql101_purchase c
WHERE  a.product_name = c.product_name
  AND  b.person_code = c.salesperson
;
```

This is definitely less typing, but the command is hard to read, because you have to keep checking which table is represented by alias a, b, or c. It's much better to make each alias something that immediately reminds you what table the alias refers to, so an abbreviation of the table's name is commonly used. Since the tables in this example all have names that are very similar, it isn't possible to create one-letter aliases that intuitively remind you which table they refer to. Instead, we'll have to use a few letters for each alias. The result of this modification follows:

```
SELECT purc.product_name,
       prod.product_price,
       purc.quantity,
       pers.last_name
FROM   plsql101_product  prod,
       plsql101_person   pers,
       plsql101_purchase purc
```

```
WHERE  prod.product_name = purc.product_name
  AND  pers.person_code = purc.salesperson
;
```

To save further keystrokes, you can also skip identifying the tables of any columns whose names are unique among the tables being selected from. In other words, if Oracle can look at a column name and see that it exists in only one of the tables, then you don't need to specify which table it is in. However, I don't recommend using this shortcut in joins, for two reasons: It slows down the processing somewhat (because Oracle has to look in all tables before determining that a column can only come from one of them), and it makes the command harder to read.

Outer Joins

To understand the problem this topic solves, enter the following code:

```
SELECT product_name FROM plsql101_product ORDER BY product_name;

SELECT prod.product_name,
       prod.product_price,
       purc.purchase_date,
       purc.quantity
FROM   plsql101_product  prod,
       plsql101_purchase purc
WHERE  prod.product_name = purc.product_name
ORDER BY prod.product_name;
```

Look closely at the product names in the two lists, and you will see that there are several product names that do not show up in the second list. This is because the WHERE clause in the SELECT statement requires an exact match on the product names in both tables, and any product name that is in one table but not the other will not be shown.

There are times when that is desirable—for instance, when you want a list of what has actually sold. However, there will be many situations where you will want (for instance) a complete list of products, along with information about transactions—and the list needs to show every product, even if there are no transactions for some of them. In order to achieve this result, you must tell Oracle that the child table may not have records to match every record in the parent table. You can do this by placing the characters **(+)** after the child table's name in the WHERE clause. The resulting command looks like this:

```
SELECT product_name FROM plsql101_product ORDER BY product_name;

SELECT prod.product_name,
       prod.product_price,
```

```
       purc.purchase_date,
       purc.quantity
FROM   plsql101_product  prod,
       plsql101_purchase purc
WHERE  prod.product_name = purc.product_name (+)
ORDER BY prod.product_name;
```

Enter this code, and you will see that the listing it produces contains every product name, even if there have been no sales transactions for a product. This is called creating an *outer join*. When creating an outer join, you place the **(+)** characters after the name of one table in each of the *parent_table_name.primary_key = child_table_name.foreign_key* statements in the WHERE clause. The **(+)** characters identify which table may not have matching records for every record in the other table. In other words, you place the **(+)** characters after the table that may produce some blanks for the column being matched. Generally, you will place the **(+)** characters after the name of the child table, and not the parent table. This is because if your referential integrity is working properly (meaning you have foreign-key constraints in place), the parent table can contain records that are not matched in the child table, but the child table should never contain records that are not matched by records in the parent table.

Starting in Oracle9*i*, you can use another syntax to create outer joins. This new syntax is compliant with the SQL 1999 standard. The new syntax replaces the WHERE clause with an ON clause, with a new phrase of OUTER JOIN identifying which table is driving the resulting output.

For example, the previous command could be duplicated in SQL 1999 standard syntax using this command:

```
SELECT prod.product_name,
       prod.product_price,
       purc.purchase_date,
       purc.quantity
FROM   plsql101_product  prod LEFT OUTER JOIN plsql101_purchase purc
  ON   (prod.product_name = purc.product_name)
ORDER BY prod.product_name;
```

By using the phrase LEFT OUTER JOIN, this command specifies that the table *before* the phrase is driving the output—in other words, the first table's records will all be represented in the output, even if some of them don't have matching records in the second table.

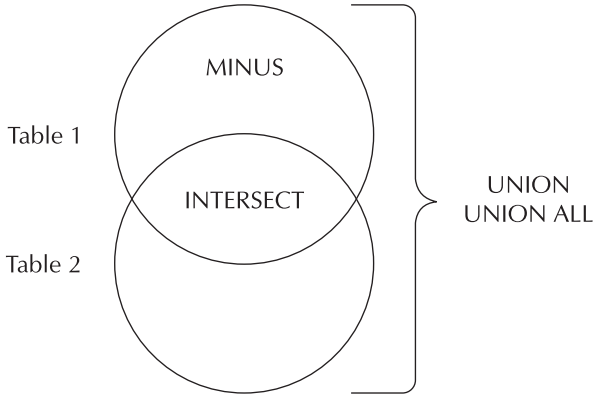
You can also use RIGHT OUTER JOIN to indicate that the table *after* the phrase should drive the resulting output. If both tables can have values that are unmatched in the other table (which is not very good relational design, but it does happen, especially when you are trying to combine data from separate systems), you can

specify FULL OUTER JOIN to ensure that both tables' records are fully represented, even if there are some non-matching records on both sides.

Join Operators

Now that you know how to make a traditional join between tables, it is time to show you some alternative types of joins. These are useful for different situations: times when you want to combine the contents of multiple tables that have similar layouts, or when you want to compare records in different tables and see which ones either are in both or are in one but not the other.

You can accomplish this by using *join operators* to connect two SELECT statements. There are four main join operators, and they are shown in Table 6-3. The following illustration gives a graphical representation of the results produced by each join operator:



Join Operator	Results Produced
UNION	All rows from both SELECT statements, with duplicate values removed
UNION ALL	All rows from both SELECT statements, with duplicate values shown
INTERSECT	Rows that were returned by both SELECT statements
MINUS	Rows that were returned by the first SELECT statement, minus those returned by the second SELECT statement

TABLE 6-3. *Join Operators*

In order to see the join operators work in a way that is useful, you will need to create a new table and populate it with a few records. The following commands will give you the data you need to try the next examples:

```
CREATE TABLE plsql101_purchase_archive (
     product_name  VARCHAR2(25),
     salesperson   VARCHAR2(3),
     purchase_date DATE,
     quantity      NUMBER(4,2)
     )
;

INSERT INTO plsql101_purchase_archive VALUES
     ('Round Snaphoo', 'BB', '21-JUN-04', 10);
INSERT INTO plsql101_purchase_archive VALUES
     ('Large Harflinger', 'GA', '22-JUN-04', 50);
INSERT INTO plsql101_purchase_archive VALUES
     ('Medium Wodget', 'LB', '23-JUN-04', 20);
INSERT INTO plsql101_purchase_archive VALUES
     ('Small Widget', 'ZZ', '24-JUN-05', 80);
INSERT INTO plsql101_purchase_archive VALUES
     ('Chrome Phoobar', 'CA', '25-JUN-05', 2);
INSERT INTO plsql101_purchase_archive VALUES
     ('Small Widget', 'JT', '26-JUN-05', 50);
```

UNION

The UNION join operator performs the useful task of combining data from multiple tables into a single list. This differs from the relational techniques you used earlier in this chapter in that the UNION join operator is usually used when the *structure* of the two tables is similar or identical, but the *content* of the tables differs. The UNION join operator provides a way to easily combine the contents of such tables into one listing.

To see this in action, enter the following commands and compare your results with those shown in Figure 6-23:

```
SELECT product_name FROM plsql101_purchase
ORDER BY product_name;
SELECT product_name FROM plsql101_purchase_archive
ORDER BY product_name;

SELECT product_name FROM plsql101_purchase
UNION
SELECT product_name FROM plsql101_purchase_archive
ORDER BY product_name;
```

Note that each of the tables being queried contains products the other table does not. The PLSQL101_PURCHASE table contains a Round Chrome Snaphoo

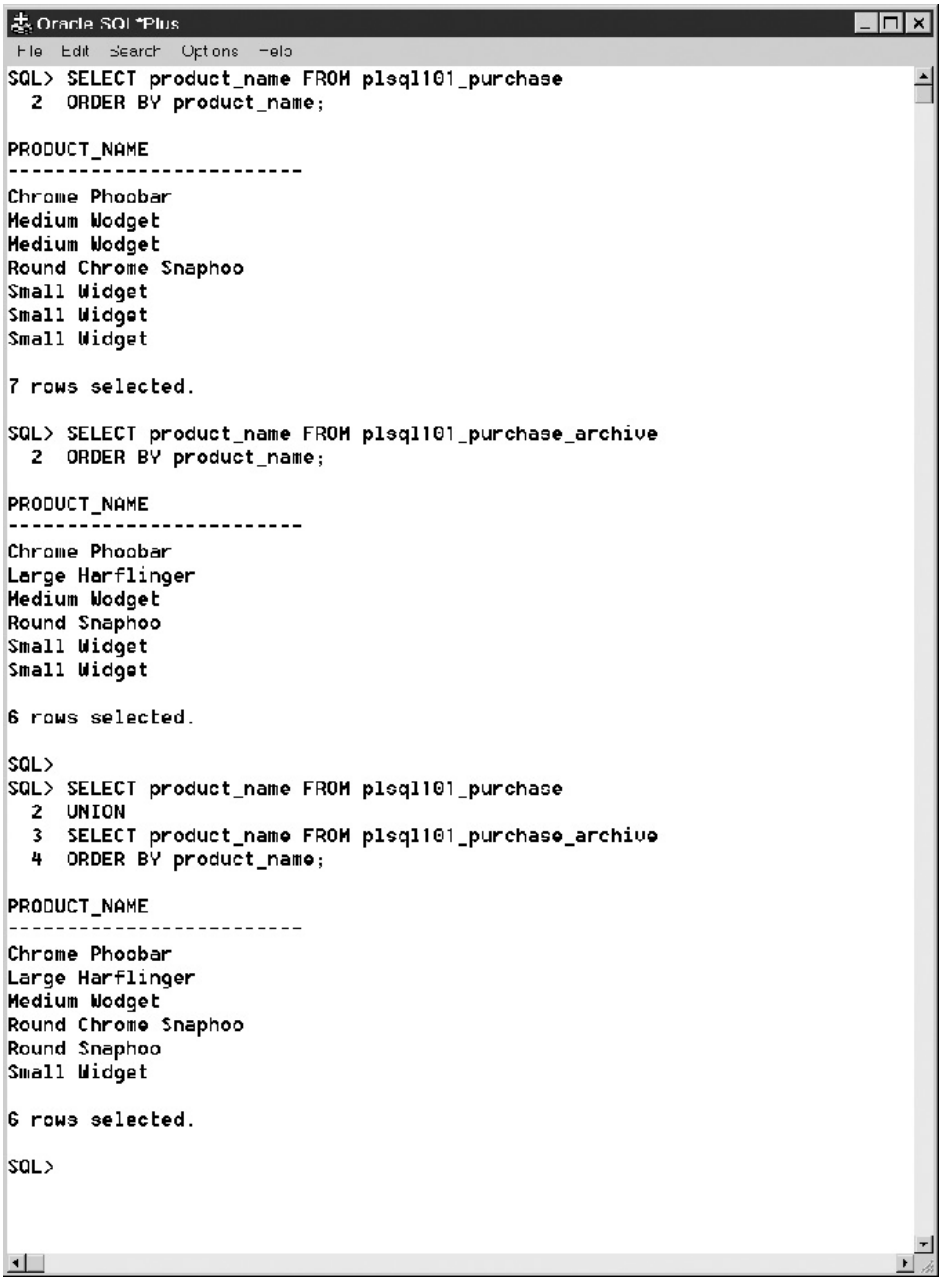


FIGURE 6-23. *The UNION join operator*

not found in the PLSQL101_PURCHASE_ARCHIVE table, while the latter contains a Large Harflinger that is absent from the former. The list of product names produced by the UNION join operator contains both, as well as all the other products shared by both tables.

UNION ALL

The UNION ALL join operator functions similarly to the UNION join operator, except that UNION ALL causes every row to be returned, instead of just one distinct row for each unique value. To see the difference this makes, enter the following command:

```
SELECT product_name FROM plsql101_purchase
UNION ALL
SELECT product_name FROM plsql101_purchase_archive
ORDER BY product_name;
```

This can be useful when you would like to count the number of instances of each value in more than one table.

INTERSECT

The INTERSECT join operator returns only the values that are present in *both* tables. If a value is found in one table but not the other, it is ignored by the INTERSECT join operator. This is very useful when you need to find out what values are shared in common by a pair of tables. An example of this join operator follows:

```
SELECT product_name FROM plsql101_purchase
INTERSECT
SELECT product_name FROM plsql101_purchase_archive
ORDER BY product_name;
```

MINUS

The MINUS join operator does essentially the opposite task from the INTERSECT join operator you just tried. The MINUS join operator shows you records in one table that are *not* in another table. Being able to easily uncover records in one table that are not being used in a second table is useful when you want to know what zero-activity items can be archived, or when you need to find out what values in one table are not being represented in another. The MINUS join operator works as shown in the following code example:

```
SELECT product_name FROM plsql101_purchase
MINUS
SELECT product_name FROM plsql101_purchase_archive
ORDER BY product_name;
```

Write Subqueries

Continuing with our theme of multiple-table operations, this section covers *subqueries*. Within this section, you will learn what subqueries are, when to use them, and how to write them.

What Is a Subquery?

A subquery is a standard SELECT query that is nested within a SELECT, UPDATE, or DELETE command. It is used to provide data for the FROM or WHERE portions of the parent statement.

A subquery can even contain subqueries within itself. The Oracle documentation claims that you can nest subqueries to an infinite number of levels of depth. Usually, a specification of "unlimited" translates to "it depends on the amount of computer resources available, but in any case it's likely to be more than you will ever use."

Types of Problems Subqueries Can Solve

A subquery enters the picture when one question must be answered before a larger question can be addressed. For instance, to find out which products are selling better than average, you must first determine what "average" is. To find out how much money has been made by your top salesperson, you first need to know who the top salesperson is. To identify products that are selling less than they did a year ago, you need to know what they sold a year ago. These are all situations where a subquery can provide the needed information.

Single-Row Subqueries

Let's consider an example. You've discovered that the most recent shipment of Small Widgets was intercepted while on its way to you, and replaced with cheap knockoffs. You want to know what else arrived that day, so you can check those products, as well. You don't know what date the Small Widgets arrived, so you can't specify the date explicitly in the WHERE clause. You can, however, have Oracle derive that date for you and use it as if you had typed it in by hand. You'll accomplish this by telling the SELECT statement's WHERE clause that it must retrieve the last stock date for the Small Widgets itself, and then use that date to filter other product records for you. Enter the following command, and compare your results with those shown in Figure 6-24:

```
SELECT *
FROM   plsql101_product
WHERE  last_stock_date = (
       SELECT last_stock_date
       FROM   plsql101_product
```

```
        WHERE  product_name = 'Small Widget'
        )
;
```

To practice this technique further, create a new SELECT statement that returns all product records that have the same price as the Red Snaphoo. Your results should match those shown in Figure 6-25. Be sure not to simply type the price of 1.95 into the WHERE clause; make the statement find out for itself what the Red Snaphoo's price is.

A key characteristic of the subqueries you just wrote is that they are capable of returning only one value. For example, when you write a subquery that finds the last stock date for a Small Widget, only a single value can be returned; the Small Widget cannot have more than one last stock date, because there's only one column set aside to store that value in the product table. Since you can be sure that the subquery will return only one value, you can write the WHERE clause with an equals sign between the parent statement's WHERE clause and the subquery. You could not use the equals sign if the subquery had the potential for returning multiple values, because the parent statement's last stock date could never equal more than one value. This type of subquery is called a *single-row subquery,* because the subquery can only return one row of answers. (The parent statement can return any number of rows based on the subquery's one answer, of course.)

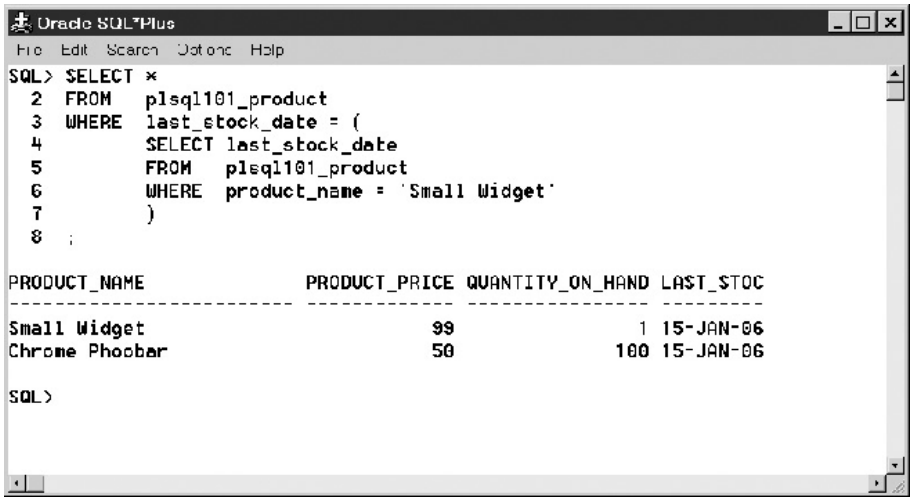


FIGURE 6-24. *Subquery based on last stock date*

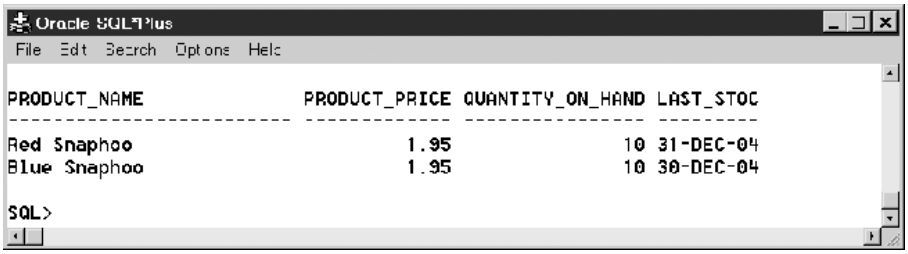


FIGURE 6-25. *Subquery based on product price*

The subquery and the parent statement can refer to completely different tables, if you wish. For example, let's say you wanted to see all the sales made by Gary Anderson. You know the salesperson's name, but not the code that would be used to represent him or her in the purchase table. (That part may not make much sense with these test tables, where the person code is simply the person's initials, but in a real database the person would most likely be represented by a number that had no obvious relation to who the person is, and would therefore be difficult to guess.) You can make the SELECT statement go and find Gary Anderson's code for you, and still show you his sales records. Enter the following code to see how to make this happen:

```
SELECT * FROM plsql101_purchase
WHERE  salesperson = (
       SELECT person_code
       FROM   plsql101_person
       WHERE  first_name = 'Gary' AND last_name = 'Anderson'
       )
;
```

As a last example of a single-row subquery, consider a situation where you want to know which of your products are the most expensive. You can accomplish this by writing a subquery that determines the average price of a product, as shown in the following code:

```
SELECT *
FROM   plsql101_product
WHERE  product_price > (
       SELECT AVG(product_price)
       FROM   plsql101_product
       )
;
```

Multirow Subqueries

As you may have guessed, a *multirow subquery* is one in which the subquery has the potential of returning more than one row of answers. The reason you need to think about this ahead of time is that it affects what comparison operator you use: You cannot compare something using an equals sign if the subquery is going to return more than one row of answers. Instead of the equals sign, you can use the **IN** function for multirow subqueries.

For example, let's say you want to know which products are not selling. To do that, you can tell your subquery to get a list of all the product names in the purchase table, and then provide that list back to the parent statement so those product names can be excluded from the product records returned to you. To see this in action, enter the following code and compare your results with those shown in Figure 6-26:

```
SELECT *
FROM  plsql101_purchase
ORDER BY product_name;

SELECT *
FROM   plsql101_product
WHERE  product_name NOT IN (
       SELECT DISTINCT product_name
       FROM   plsql101_purchase
       )
ORDER BY product_name
;
```

As mentioned earlier, you can also use subqueries in UPDATE and DELETE statements. For example, let's say you have been instructed to make a 10 percent reduction in the price of any item that has not sold. You can do that with a single UPDATE command by placing a subquery in its WHERE clause to determine which products have not sold. Enter the following code to see how this works:

```
SELECT * FROM  plsql101_product;

UPDATE plsql101_product
SET    product_price = product_price * .9
WHERE  product_name NOT IN (
       SELECT DISTINCT product_name
       FROM   plsql101_purchase
       )
;

SELECT * FROM  plsql101_product;
```

Notice that after the UPDATE command has been run, the prices have been changed only on those products that were not selling. Handy, eh?

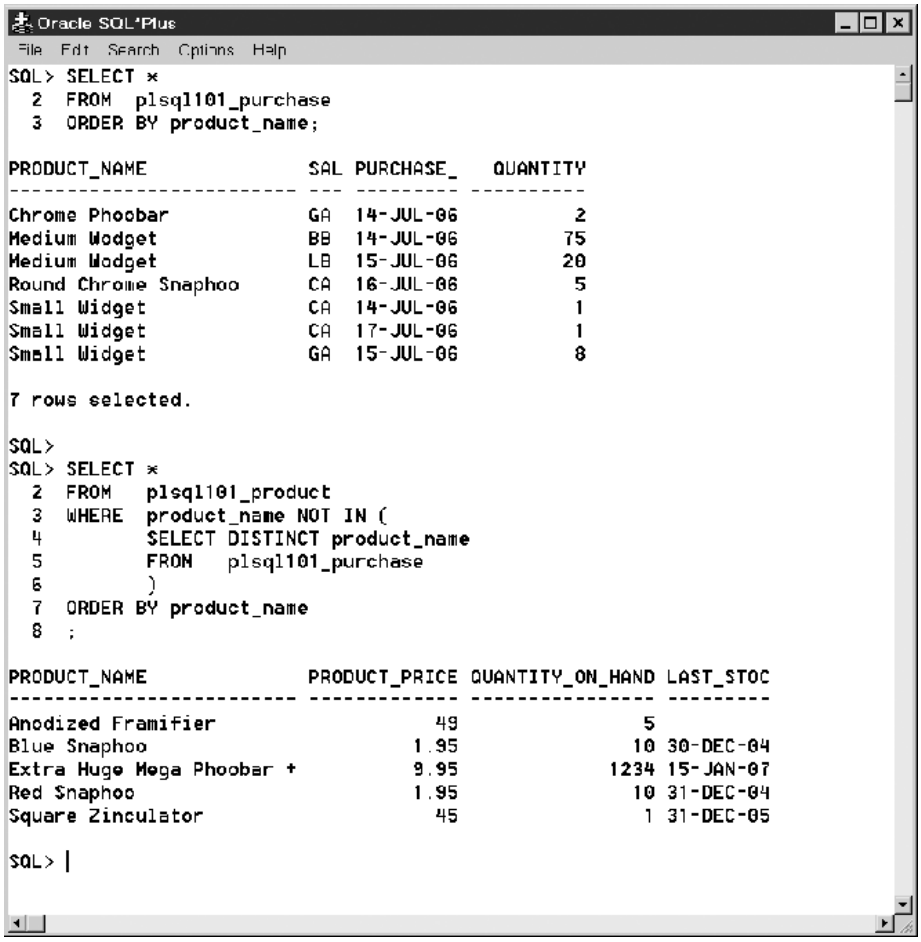


FIGURE 6-26. *Use a multirow subquery to find unmatched records*

Multicolumn Subqueries

Each of the subqueries you have seen so far retrieves just a single column of data. It's possible to use subqueries that return multiple columns of data, too. To demonstrate this, the following code evaluates the product names and purchase dates in the PLSQL101_PURCHASE table to return only the most recent purchase of each product. (When I interview people for PL/SQL jobs, I give a little quiz that includes a question that requires this technique to answer; *very* few people get it right.)

```
SELECT *
FROM   plsql101_purchase
ORDER BY product_name, purchase_date;
```

```
SELECT *
FROM   plsql101_purchase
WHERE  (product_name, purchase_date)
IN     (SELECT product_name, MAX(purchase_date)
        FROM   plsql101_purchase
        GROUP BY product_name
       )
;
```

Chapter Summary

This chapter has given you a thorough grounding in how to use indexes and constraints in Oracle. Database indexes work similarly to the index in a book: A database index contains key information from each row in a table, along with pointers to the related rows in that table. This provides a much quicker way to find rows matching a specific characteristic—as long as that characteristic is in the index. Once you have created an index on a table, Oracle automatically handles keeping the index synchronized with that table. Any INSERT, UPDATE, or DELETE on the table automatically changes the index as well, and any SELECT on the table will automatically be routed through an index, if one exists containing the columns needed by the SELECT statement. You can add or drop indexes without affecting the table's operations—any program that used the table before will still operate. It may operate more slowly, however. If you drop a table, any indexes associated with that table will automatically be dropped too, since an index has no purpose without its associated table.

Indexes improve the response time of commands that have to read a table's contents in order to perform their operations. Adding indexes to a table will *not* speed up data entry via INSERT commands; in fact, indexes slow down entry into the indexed table, because data must also be inserted into the table's index(es). So the use of indexes is a trade-off. They make data entry take longer, but make reading data faster.

The most common types of indexes are B*-Tree indexes and bitmap indexes. B*-Tree indexes are Oracle's default type, and they are appropriate for columns that contain a large number of unique values—for instance, names, person IDs, or phone numbers. Bitmap indexes make more sense on columns that contain a small number of unique values, such as gender or any kind of yes/no column. For columns with low cardinality, bitmap indexes are faster than B*-Tree indexes.

When the time comes to think about the quality of your database's data, you can use constraints to ensure that data meets certain minimum standards. When creating a constraint, you define one or more conditions that a user's entry must satisfy before Oracle accepts the data into your table. Constraints are stored as part of a table's definition, and once created, they operate automatically. When someone attempts to perform an INSERT or UPDATE command that contains data

violating a constraint, Oracle interrupts the command, rolls back their INSERT or UPDATE, and presents them with an error message.

A constraint can be as simple as requiring that a column contain data—any data. Or it can check to ensure that values in a column are all unique, with no duplicate entries. It can even check the values being entered and accept only those that satisfy any condition you specify, which can be useful to eliminate things like product prices that are below zero, transaction dates from a hundred years ago, or states that don't exist. This last example reflects Oracle's ability to have a constraint compare values being inserted in one table against values that are already present in another table, which is a good way to avoid problems like sales transactions for products that don't actually exist.

Once you have related data in separate tables, you need a way to reconnect that data and present it in a single list. You can do this in your SELECT statements by including a WHERE clause that identifies the primary key [unique identifying column(s)] in the parent table and the related foreign key in the child table.

Chapter Questions

1. **Which of the following is NOT a benefit of indexes?**

   A. Faster operation during INSERT commands

   B. Faster operation during UPDATE commands

   C. Faster operation during SELECT commands

   D. Faster operation during DELETE commands

2. **On which line will the following command fail?**

```
CREATE INDEX plsql101_purchase_pk ON plsql101_purchase (
     product_name,
     salesperson,
     purchase_date
     );
```

   A. 1

   B. 2

   C. 3

   D. 4

   E. The command will succeed.

3. **Which of the following index types is best suited for a column with high cardinality?**

   A. Composite

   B. B*-Tree

   C. Bitmap

   D. Other

4. **Which of the following commands would ensure that products entered into a purchase record exist in the product table?**

   A. CREATE INDEX *index_name* ON *table_name*(*column_name*);

   B. ALTER TABLE *table_name* MODIFY (*column_name* NOT NULL);

   C. ALTER TABLE *table_name* ADD CONSTRAINT *constraint_name* UNIQUE (*column_name*);

   D. ALTER TABLE *table_name* ADD CONSTRAINT *constraint_name* CHECK (*column_name condition_to_satisfy*);

   E. ALTER TABLE *table_name* ADD CONSTRAINT *constraint_name* FOREIGN KEY (*column_name*) REFERENCES *parent_table_name*;

5. **What will be the result of the following command if table 1 contains five records and table 2 contains ten records?**

```
SELECT table_1_name.column_name_1,
       table_2_name.column_name_2
FROM   table_1_name,
       table_2_name
;
```

   A. The five records from table 1 will display.

   B. The ten records from table 2 will display.

   C. Fifteen records will display, with data from both tables.

   D. Fifty records will display, with data from both tables.

   E. The number of records displayed will depend on how many records in table 1 share values with records in table 2.

Answers to Chapter Questions

1. A. Faster operation during INSERT commands

Explanation Because indexes are essentially additional tables, they slow down INSERT commands because the insert effort is being duplicated. The purpose of indexes is not to speed up inserts; it is to speed up any command that reads the data afterward.

2. E. The command will succeed.

Explanation For a refresher on the syntax for the CREATE INDEX command, refer to the section titled "How to Create Indexes."

3. B. B*-Tree

Explanation A composite index simply means that many columns are indexed at once, which isn't an issue related to the columns' cardinality. Bitmap indexes are designed for columns with low cardinality—that is, columns with a small number of different values. The "other" category (choice D) is meaningless, so the remaining choice is B*-Tree, which is designed for columns with a large number of different values.

4. E. ALTER TABLE *table_name* ADD CONSTRAINT *constraint_name* FOREIGN KEY (*column_name*) REFERENCES *parent_table_name*;

Explanation The tip-off here is the word "REFERENCES" in the command. This is the essential ingredient for creating a mechanism to enforce referential integrity between two tables.

5. D. Fifty records will display, with data from both tables.

Explanation Because the SELECT statement draws from two tables but does not include a WHERE clause to explain how they should be joined, it will produce a Cartesian product. Every *table_1_name.column_name_1* value will be joined with every *table_2_name.column_name_2* value, resulting in 5*10, or 50, records.

CHAPTER 7

Other Useful Oracle Techniques

his chapter is a "catch-all" that presents a variety of tips and tools that will round out your knowledge of Oracle from a SQL standpoint. In it you will learn how to transfer data between tables; rename tables and change their structure; use the Oracle® Data Dictionary; and create and use views, sequences, and synonyms. Once you know the information in this chapter, you will be well equipped for the upcoming chapters on PL/SQL programming.

If you have not done the examples from the previous chapter, enter the following code to create the tables and data used in this chapter. (If you already have these tables and data, jump over the following code listing and go directly to the section titled "Transfer Data Between Tables".)

```
DROP TABLE plsql101_purchase;
DROP TABLE plsql101_product;
DROP TABLE plsql101_person;
DROP TABLE plsql101_old_item;
DROP TABLE plsql101_purchase_archive;

CREATE TABLE plsql101_person (
     person_code VARCHAR2(3) PRIMARY KEY,
     first_name  VARCHAR2(15),
     last_name   VARCHAR2(20),
     hire_date   DATE
     )
;

CREATE INDEX plsql101_person_name_index
ON plsql101_person(last_name, first_name);

ALTER TABLE plsql101_person
ADD CONSTRAINT plsql101_person_unique UNIQUE (
     first_name,
     last_name,
     hire_date
     )
;

INSERT INTO plsql101_person VALUES
     ('CA', 'Charlene', 'Atlas', '01-FEB-05');
INSERT INTO plsql101_person VALUES
     ('GA', 'Gary', 'Anderson', '15-FEB-05');
INSERT INTO plsql101_person VALUES
     ('BB', 'Bobby', 'Barkenhagen', '28-FEB-05');
INSERT INTO plsql101_person VALUES
     ('LB', 'Laren', 'Baxter', '01-MAR-05');
INSERT INTO plsql101_person VALUES
     ('LN', 'Linda', 'Norton', '01-JUN-06');
```

```
CREATE TABLE plsql101_product (
     product_name     VARCHAR2(25) PRIMARY KEY,
     product_price    NUMBER(4,2),
     quantity_on_hand NUMBER(5,0),
     last_stock_date  DATE
     )
;

ALTER TABLE plsql101_product ADD CONSTRAINT
positive_quantity CHECK(
     quantity_on_hand IS NOT NULL
     AND
     quantity_on_hand >=0
     )
;

INSERT INTO plsql101_product VALUES
     ('Small Widget', 99, 1, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Medium Wodget', 75, 1000, '15-JAN-05');
INSERT INTO plsql101_product VALUES
     ('Chrome Phoobar', 50, 100, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Round Chrome Snaphoo', 25, 10000, null);
INSERT INTO plsql101_product VALUES
     ('Extra Huge Mega Phoobar +',9.95,1234,'15-JAN-07');
INSERT INTO plsql101_product VALUES ('Square Zinculator',
     45, 1, TO_DATE('December 31, 2005, 11:30 P.M.',
                    'Month dd, YYYY, HH:MI P.M.')
     )
;
INSERT INTO plsql101_product VALUES (
     'Anodized Framifier', 49, 5, NULL);
INSERT INTO plsql101_product VALUES (
     'Red Snaphoo', 1.95, 10, '31-DEC-04');
INSERT INTO plsql101_product VALUES (
     'Blue Snaphoo', 1.95, 10, '30-DEC-04')
;

CREATE TABLE plsql101_purchase (
     product_name  VARCHAR2(25),
     salesperson   VARCHAR2(3),
     purchase_date DATE,
     quantity      NUMBER(4,2)
     )
;
```

```
ALTER TABLE plsql101_purchase
ADD PRIMARY KEY (product_name,
                 salesperson,
                 purchase_date
                 )
;

ALTER TABLE plsql101_purchase
ADD CONSTRAINT reasonable_date CHECK(
     purchase_date IS NOT NULL
     AND
     TO_CHAR(purchase_date, 'YYYY-MM-DD') >= '2003-06-30'
     )
;

ALTER TABLE plsql101_purchase
ADD CONSTRAINT plsql101_purchase_fk_product FOREIGN KEY
     (product_name) REFERENCES plsql101_product;

ALTER TABLE plsql101_purchase
ADD CONSTRAINT plsql101_purchase_fk_person FOREIGN KEY
     (salesperson) REFERENCES plsql101_person;

CREATE INDEX plsql101_purchase_product
ON plsql101_purchase(product_name);

CREATE INDEX plsql101_purchase_salesperson
ON plsql101_purchase(salesperson);

INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'CA', '14-JUL-06', 1);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'BB', '14-JUL-06', 75);
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'GA', '14-JUL-06', 2);
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'GA', '15-JUL-06', 8);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'LB', '15-JUL-06', 20);
INSERT INTO plsql101_purchase VALUES
     ('Round Chrome Snaphoo', 'CA', '16-JUL-06', 5);
INSERT INTO plsql101_purchase VALUES (
     'Small Widget', 'CA', '17-JUL-06', 1)
;

UPDATE plsql101_product
SET    product_price = product_price * .9
WHERE  product_name NOT IN (
       SELECT DISTINCT product_name
```

```
       FROM   plsql101_purchase
       )
;

CREATE TABLE plsql101_old_item (
     item_id   CHAR(20),
     item_desc CHAR(25)
     )
;

INSERT INTO plsql101_old_item VALUES
     ('LA-101', 'Can, Small');
INSERT INTO plsql101_old_item VALUES
     ('LA-102', 'Can, Large');
INSERT INTO plsql101_old_item VALUES
     ('LA-103', 'Bottle, Small');
INSERT INTO plsql101_old_item VALUES
     ('LA-104', 'Bottle, Large');
INSERT INTO plsql101_old_item VALUES
     ('NY-101', 'Box, Small');
INSERT INTO plsql101_old_item VALUES
     ('NY-102', 'Box, Large');
INSERT INTO plsql101_old_item VALUES
     ('NY-103', 'Shipping Carton, Small');
INSERT INTO plsql101_old_item VALUES
     ('NY-104', 'Shipping Carton, Large');


CREATE TABLE plsql101_purchase_archive (
     product_name  VARCHAR2(25),
     salesperson   VARCHAR2(3),
     purchase_date DATE,
     quantity      NUMBER(4,2)
     )
;

INSERT INTO plsql101_purchase_archive VALUES
     ('Round Snaphoo', 'BB', '21-JUN-04', 10);
INSERT INTO plsql101_purchase_archive VALUES
     ('Large Harflinger', 'GA', '22-JUN-04', 50);
INSERT INTO plsql101_purchase_archive VALUES
     ('Medium Wodget', 'LB', '23-JUN-04', 20);
INSERT INTO plsql101_purchase_archive VALUES
     ('Small Widget', 'ZZ', '24-JUN-05', 80);
INSERT INTO plsql101_purchase_archive VALUES
     ('Chrome Phoobar', 'CA', '25-JUN-05', 2);
INSERT INTO plsql101_purchase_archive VALUES
     ('Small Widget', 'JT', '26-JUN-05', 50);
```

Transfer Data Between Tables

Now that you have done all of the basic DML commands, you are ready to put them to use performing a fundamental, and very necessary, function: copying records from one table to another. Being able to do this is important for a number of reasons:

- **Import Data from a Legacy System** A regular part of SQL activities is transferring data from an existing system into a new system. Sometimes the existing system is being replaced by the new system. Other times the data has been purchased from an external source, and needs to be mapped and transferred into your own system. Often, the original data must be modified on its way to the new tables, which can involve using functions such as **UPPER**, **LOWER**, **LTRIM**, **RTRIM**, **SUBSTR**, **INSTR**, **TO_CHAR**, and **DECODE**.
- **Load Summaries into a Data Warehouse** The basic function of a data warehouse is to store precalculated answers to often-asked questions—the kind of questions that can be answered with **SUM**, **COUNT**, **AVG**, **MIN**, and **MAX** functions along with **GROUP BY** clauses. These answers are usually stored in a separate set of tables, and that set of tables is usually populated using SQL queries.
- **Copy Relational Data into Flat Files for Faster Access** Relational databases are the most efficient way to store data, but retrieving data out of relational tables can take longer because the tables need to be joined, and table joins can be time consuming. In some applications, it makes sense to place a copy of related data from multiple tables into a single *flat-file* table where the joins have already been done. The flat-file table consumes more storage space than the relational tables from which it is derived, but it can be accessed more quickly because joins are unnecessary.

Transfer Data Using INSERT

This popular technique utilizes an INSERT command with a subquery that causes the inserted data to come from another table. To give yourself a destination for this technique, enter the following command:

```
CREATE TABLE plsql101_purchase_log (
     purchase_date    DATE,
     product_name     VARCHAR2(25),
     product_price    NUMBER(4,2),
     quantity         NUMBER(4,2),
     first_name VARCHAR2(15),
     last_name  VARCHAR2(20)
     )
```

The PLSQL101_PURCHASE_LOG table is a flat-file representation of the important information from each purchase: date, product name and price, quantity purchased, and full name of salesperson. A table like this serves well as the basis for queries to answer business questions, such as "Who sold the largest and smallest quantities of the Red Snaphoo?" Placing a complete compilation of the information necessary to answer these queries into a single table allows the answers to be produced more quickly, and it helps ensure that access to the tables that store transactions is not slowed down by questions from people who need to analyze those transactions as a group.

Now that you have a flat-file table suitable for storing records to be analyzed, it's time to populate that table with data. You will do that using an INSERT command that joins records from the PERSON, PRODUCT, and PURCHASE tables. The syntax for the command is as follows:

```
INSERT INTO table_name (
   SELECT statement
   )
;
```

The *SELECT statement* portion of the syntax example will be whatever SELECT command will produce the data you want in a structure that matches that of the destination table. To see how this works with your PLSQL101 tables, enter the following command, and check your results with those shown in Figure 7-1:

```
INSERT INTO plsql101_purchase_log (
     SELECT purc.purchase_date,
            prod.product_name,
            prod.product_price,
            purc.quantity,
            pers.first_name,
            pers.last_name
     FROM   plsql101_product  prod,
            plsql101_person   pers,
            plsql101_purchase purc
     WHERE  prod.product_name = purc.product_name
            AND
            pers.person_code = purc.salesperson
     )
;

SELECT * FROM plsql101_purchase_log;
```

As you can see, the PLSQL101_PURCHASE_LOG table contains an easy-to-use collection of information about each transaction in the PLSQL101_PURCHASE table.

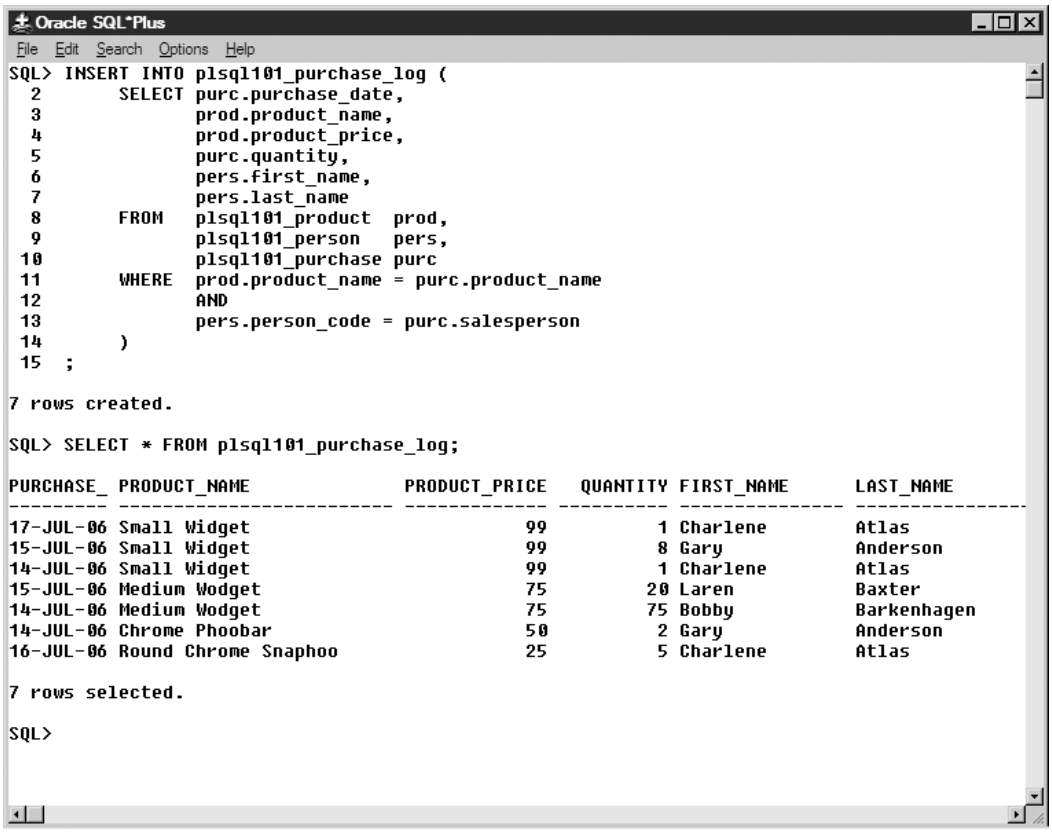


FIGURE 7-1. *Copy records from one table to another*

Insert into Multiple Tables Simultaneously

You may encounter situations where data from one source needs to be placed into two or more destination tables. You can do this with a single *multitable INSERT* statement. There are two variations:

- Unconditional
- Conditional

Unconditional

In this context, the word unconditional simply means that every record in the source table will create a record in every one of the destination tables.

To see this in action, start by deleting all the records in the PLSQL101_PURCHASE_LOG table, and create a second summary table named PLSQL101_SALESPERSON_LOG:

```
DELETE FROM plsql101_purchase_log;

CREATE TABLE plsql101_salesperson_log (
     first_name VARCHAR2(15),
     last_name  VARCHAR2(20),
     purchase_date    DATE,
     product_name     VARCHAR2(25),
     quantity         NUMBER(4,2)
     )
;
```

The syntax for a multitable insert is as follows:

INSERT ALL
INTO *first_table_name* VALUES (*first_column_name, … last_column_name*)
…
INTO *last_table_name* VALUES (*first_column_name, … last_column_name*)
SELECT statement
;

Try this syntax by entering the following code. It reads records from the PLSQL101_PURCHASE table and copies portions of each record into the two log tables. Notice that each destination table gets a different set of columns. Compare your results to Figure 7-2.

```
INSERT ALL
INTO plsql101_purchase_log VALUES (purchase_date, product_name,
                                   product_price, quantity,
                                   first_name, last_name)
INTO plsql101_salesperson_log VALUES (first_name, last_name,
                                   purchase_date, product_name,
                                   quantity)
SELECT purc.purchase_date,
       prod.product_name,
       prod.product_price,
       purc.quantity,
       pers.first_name,
       pers.last_name
FROM   plsql101_product  prod,
       plsql101_person   pers,
       plsql101_purchase purc
```

```
WHERE  prod.product_name = purc.product_name
  AND  pers.person_code = purc.salesperson
;

SELECT * FROM plsql101_purchase_log;
SELECT * FROM plsql101_salesperson_log;
```

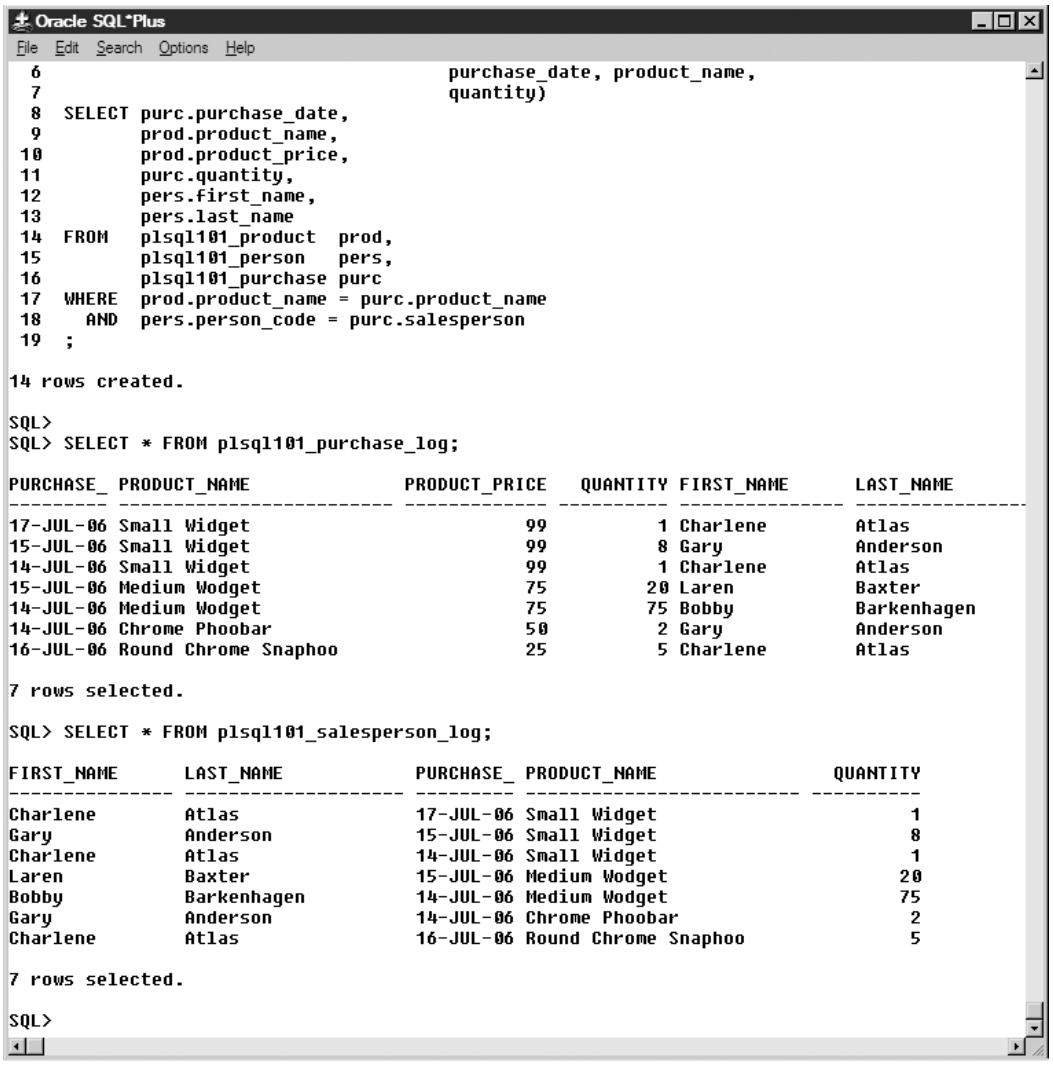


FIGURE 7-2. *Results of an unconditional multitable insert*

This technique enables you to populate many tables using a single INSERT command. In addition, it is faster than executing separate INSERT commands for each destination table, because Oracle only has to parse the command once.

Conditional

The basic multitable insert lets you define which columns from the source will go into each destination table. You can refine the process further by controlling which **rows** will go into each destination table. The syntax for this is as follows:

```
INSERT ALL
WHEN first_condition THEN INTO first_table[VALUES (column_list)]
…
WHEN last_condition THEN INTO last_table[VALUES (column_list)]
SELECT statement
;
```

Notice that the column list is optional. If the columns in your select statement exactly match the columns in all of your destination tables, you do not need to name the columns in the INTO clause.

To see how this works, create two temporary tables using the following commands:

```
CREATE TABLE plsql101_purchase_log_small (
     purchase_date    DATE,
     product_name     VARCHAR2(25),
     quantity         NUMBER(4,2)
     )
;
CREATE TABLE plsql101_purchase_log_large (
     purchase_date    DATE,
     product_name     VARCHAR2(25),
     quantity         NUMBER(4,2)
     )
;
```

Next, enter the following command. It copies purchases for expensive items into one table, and purchases for inexpensive items into the other table. Compare your results with Figure 7-3.

```
INSERT ALL
WHEN product_price < 75 THEN
     INTO plsql101_purchase_log_small
     VALUES (purchase_date, product_name, quantity)
WHEN product_price >= 75 THEN
     INTO plsql101_purchase_log_large
     VALUES (purchase_date, product_name, quantity)
```

```
SELECT purc.purchase_date,
       prod.product_name,
       prod.product_price,
       purc.quantity
FROM   plsql101_product  prod,
       plsql101_purchase purc
WHERE  prod.product_name = purc.product_name
;

SELECT * FROM plsql101_purchase_log_small;
SELECT * FROM plsql101_purchase_log_large;
```

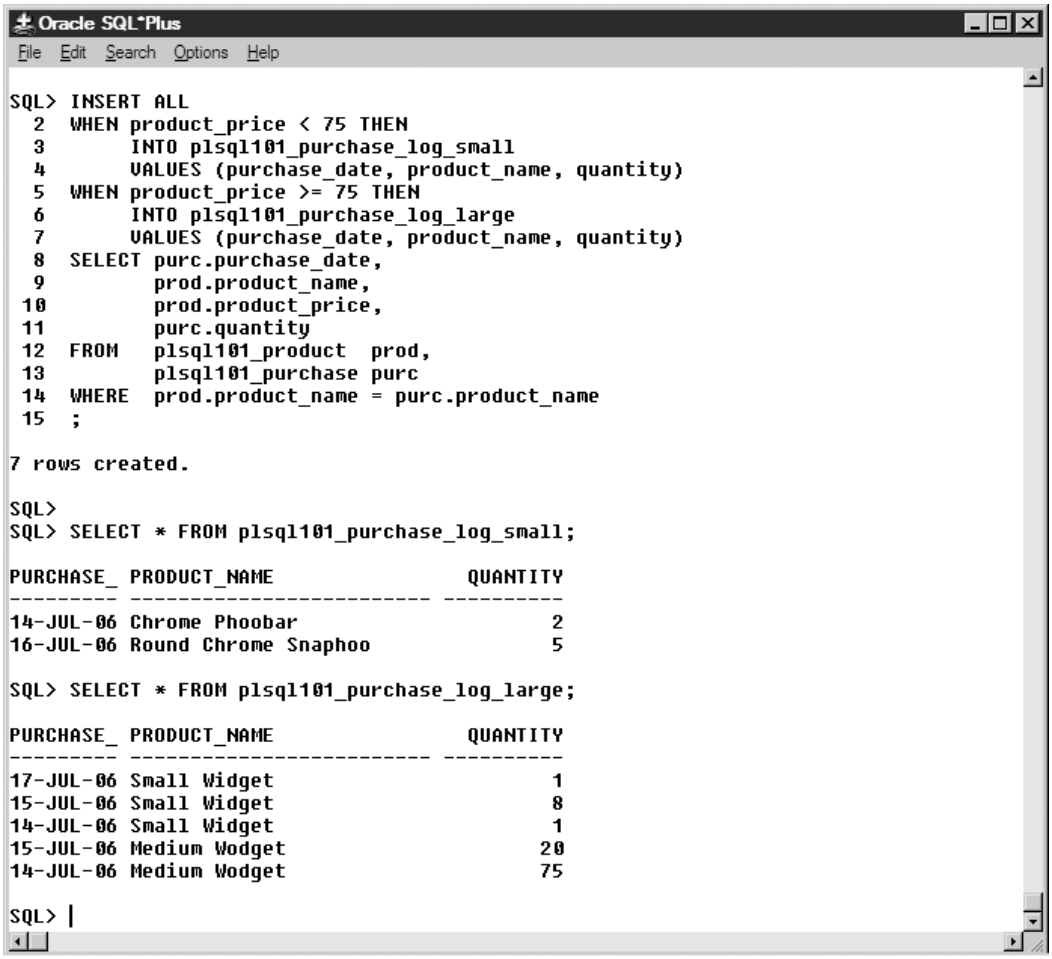


FIGURE 7-3. *Results of a multitable insert with conditions*

Conditional Insert—The MERGE Command

So far, every data copy in this chapter assumes that the data being copied does not conflict with data already in the destination table. You may encounter a situation, however, when you receive a set of data changes from a source system…for instance, changes to the personnel table. The changes could include additions, such as new employees, and also updates, such as a name change when someone gets married. In these situations, you want to add the new records to your destination table, and update existing records without overwriting them completely. This is commonly called an *upsert,* which is a combination of the words "update" and "insert". Oracle's MERGE command gives you this ability. The syntax for the command is the following:

```
MERGE INTO main_table
USING change_table
ON (main_table.primary_key = change_table.primary_key)
WHEN MATCHED THEN
   UPDATE SET main_table.first_column = change_table.first_column
   …
   main_table.last_column = change_table.last_column
WHEN NOT MATCHED THEN
   INSERT (first_column, … last_column)
   VALUES (change_table.first_column, … change_table.last_column)
   ;
```

To see how this works, let's say you have received a table containing two records: one record for a new employee, and the other record for an existing employee whose last name has changed. Enter the following commands to create this table now:

```
CREATE TABLE plsql101_person_change (
     person_code VARCHAR2(3),
     first_name  VARCHAR2(15),
     last_name   VARCHAR2(20),
     hire_date   DATE
     )
;
INSERT INTO plsql101_person_change VALUES
       ('ZA', 'Zelda', 'Armstrong', '28-APR-2006');
INSERT INTO plsql101_person_change VALUES
       ('LN', NULL, 'Norton-Smith', NULL);
```

Now enter the following command to apply the updates to your main personnel table. Compare your results with Figure 7-4.

```
MERGE INTO plsql101_person   p
USING plsql101_person_change pc
ON (p.person_code = pc.person_code)
WHEN MATCHED THEN
     UPDATE SET p.last_name = pc.last_name
WHEN NOT MATCHED THEN
     INSERT (person_code, first_name, last_name, hire_date)
     VALUES (pc.person_code, pc.first_name, pc.last_name, pc.hire_date)
;
```

Create a New Table Based on an Existing One

The methods you have learned for copying data from one table to another assume that the destination table already exists. That's appropriate for day-to-day additions to the destination table—but there's a way to make the initial creation of a destination table easier, too. It's a variation on the CREATE TABLE command. The syntax is as follows:

```
CREATE TABLE new_table_name AS
   SELECT statement
;
```

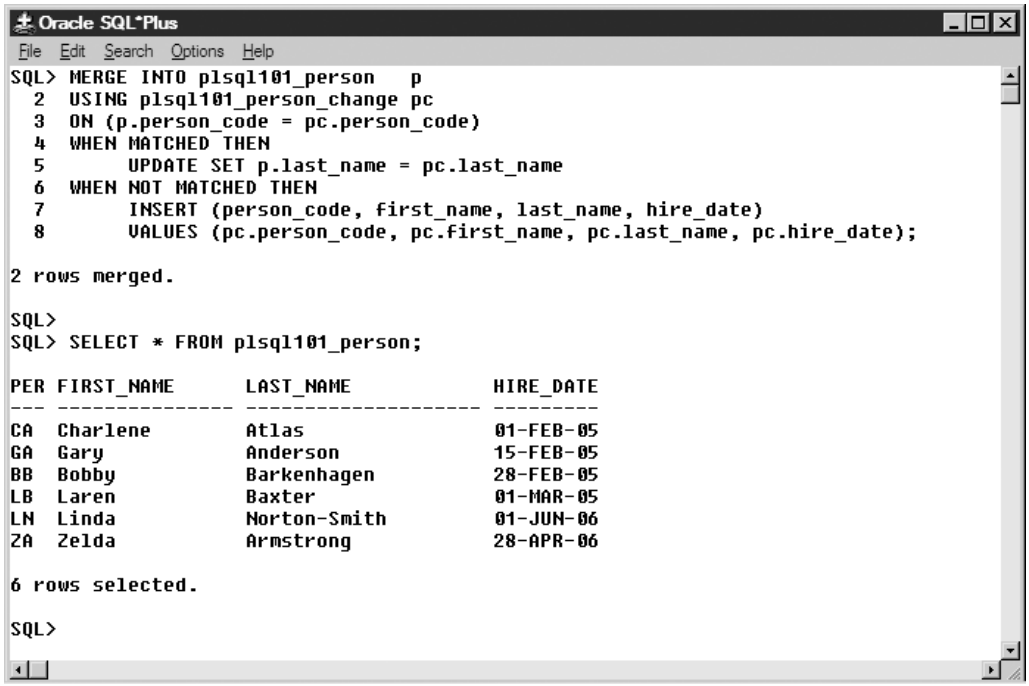


FIGURE 7-4. *Results of using MERGE to update a table*

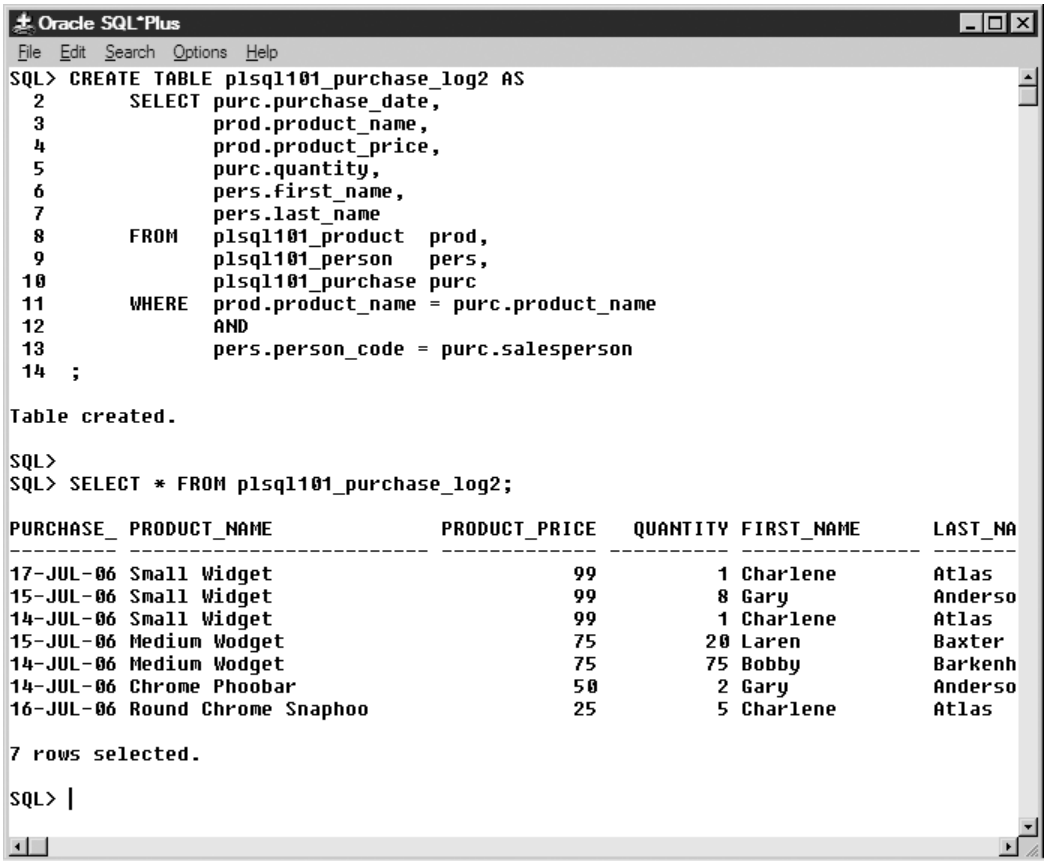


FIGURE 7-5. *Create a new table based on one or more existing tables*

In this case, the *SELECT statement* portion of the command will be the same SELECT statement you used to populate the first destination table a moment ago. Enter the following code to create a second destination table with this technique, and compare your results with those shown in Figure 7-5:

```
CREATE TABLE plsql101_purchase_log2 AS
     SELECT purc.purchase_date,
            prod.product_name,
            prod.product_price,
            purc.quantity,
            pers.first_name,
            pers.last_name
     FROM   plsql101_product  prod,
            plsql101_person   pers,
            plsql101_purchase purc
```

```
      WHERE  prod.product_name = purc.product_name
             AND
             pers.person_code = purc.salesperson
;

SELECT * FROM plsql101_purchase_log2;
```

Rename Tables

From time to time you will be called on to change the names of existing tables. It's very easy to do. The syntax is as follows:

```
RENAME old_table_name TO new_table_name;
```

Apply this to your own tables now by entering the following command:

```
RENAME plsql101_purchase_log2 TO plsql101_log;
```

Alter a Table's Structure

As a database evolves, the business needs that it must satisfy can change. This often creates reasons to change the structure of tables the database already contains. Fortunately, certain types of changes are simple to make: adding and removing columns, changing the datatypes of existing columns, and changing whether (or not) columns allow null values.

Add Columns

You can add columns to a table at any time. New columns are appended to the end of the table's structure after all the existing columns. The syntax to do this is as follows:

```
ALTER TABLE table_name
ADD new_column_name datatype [NOT NULL]
;
```

Try this new command by adding a new column to the PLSQL101_LOG table with the following code. Compare the results you get with those shown in Figure 7-6.

```
DESC plsql101_log

ALTER TABLE plsql101_log
ADD data_load_date VARCHAR2(8);

DESC plsql101_log
```

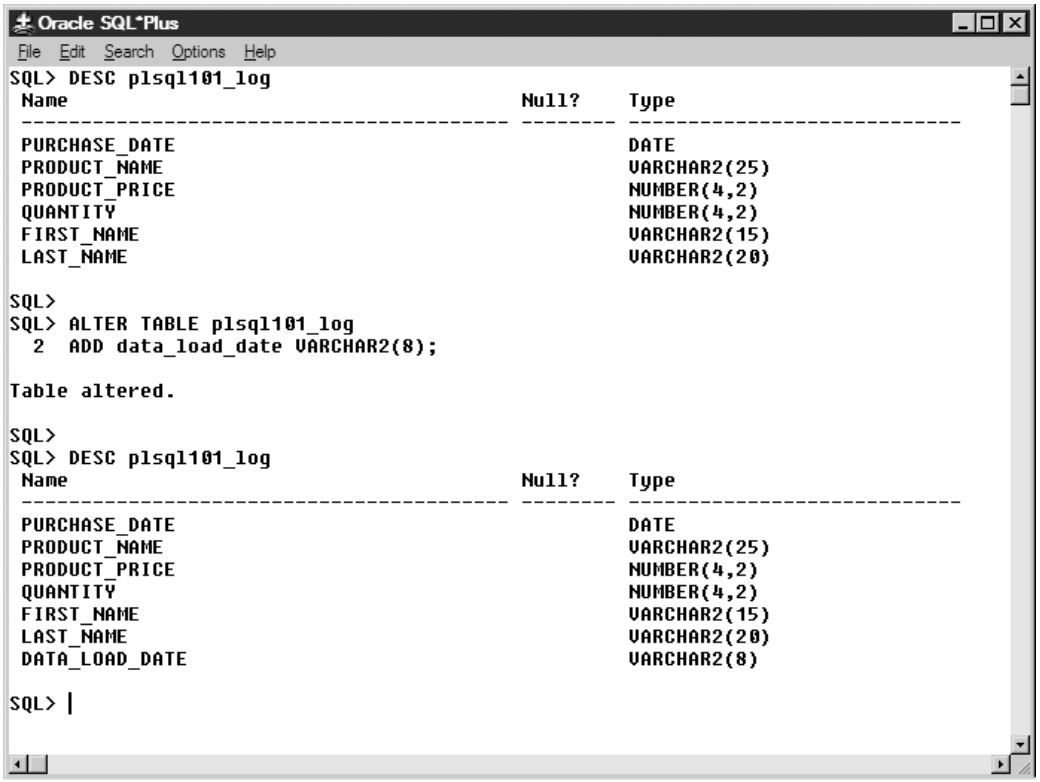


FIGURE 7-6. *Add a column to an existing table*

Rename Columns

If you need to change the name of an existing column, you can do so easily. The syntax is as follows:

ALTER TABLE *table_name*
RENAME COLUMN *old_column_name* TO *new_column_name*;

To see how this works, enter the following commands and compare your results with those shown in Figure 7-7:

```
ALTER TABLE plsql101_log
ADD temp_column CHAR(1);

ALTER TABLE plsql101_log
RENAME COLUMN temp_column TO temp_col;

DESC plsql101_log
```

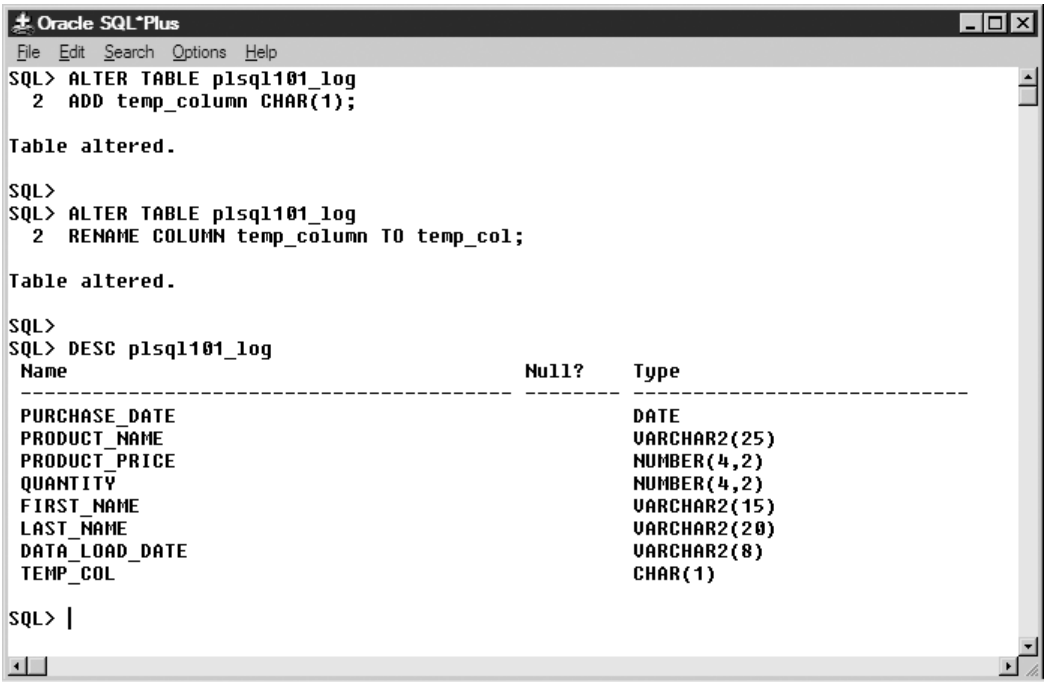


FIGURE 7-7. *Change a column's name*

Remove Columns

It is easier to remove a column from a table than it is to add a column. The syntax is as follows:

ALTER TABLE *table_name* DROP COLUMN *column_name*;

Enter the following code and compare your results with Figure 7-8:

```
ALTER TABLE plsql101_log
DROP COLUMN temp_col;

DESC plsql101_log
```

CAUTION
This technique for removing a column will work even if the column contains data. Use it carefully!

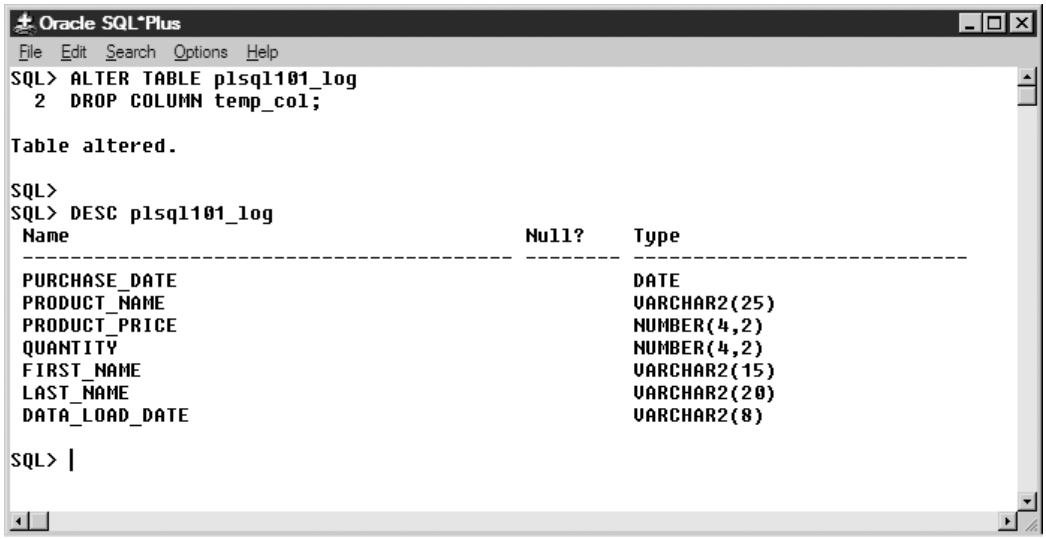


FIGURE 7-8. *Remove a column from a table*

Change Column Datatypes

You may have wondered why the data_load_date column you added earlier is a text column, when its name suggests it is supposed to contain dates. The answer: so you can change the new column's datatype to one that is more appropriate.

The syntax to change the datatype of an existing column is as follows:

```
ALTER TABLE table_name
MODIFY column_name new_datatype
;
```

To apply this to your PLSQL101_LOG table, enter the following code. Compare your results with those shown in Figure 7-9.

```
DESC plsql101_log

ALTER TABLE plsql101_log
MODIFY data_load_date DATE;

DESC plsql101_log
```

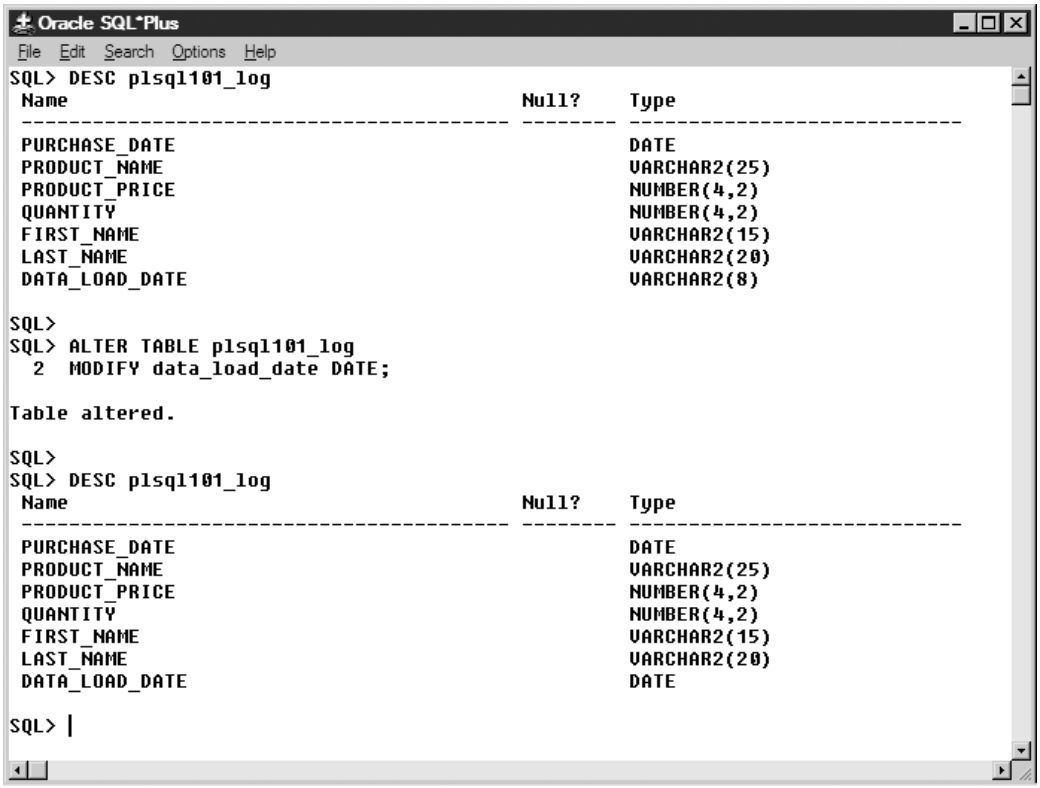


FIGURE 7-9. *Change the datatype of an existing column*

Change Null Options

Often when a database is being designed, the users are not yet sure which columns will be required and which will not. In these instances, it's common to initially create the columns so they allow null values, and then later change them so they do not. (You can change NOT NULL columns to NULL too, of course.) The syntax to do this is as follows:

```
ALTER TABLE table_name
MODIFY column_name NOT NULL
;
```

Before you can modify your new column so it requires data, you must fill that column in the table's existing records. The following set of commands accomplishes

this and then modifies the column so it will no longer accept null values. Enter the commands and compare their results with those shown in Figure 7-10.

```
UPDATE plsql101_log SET data_load_date = '15-DEC-2006';

DESC plsql101_log

ALTER TABLE plsql101_log MODIFY data_load_date NOT NULL;

DESC plsql101_log
```

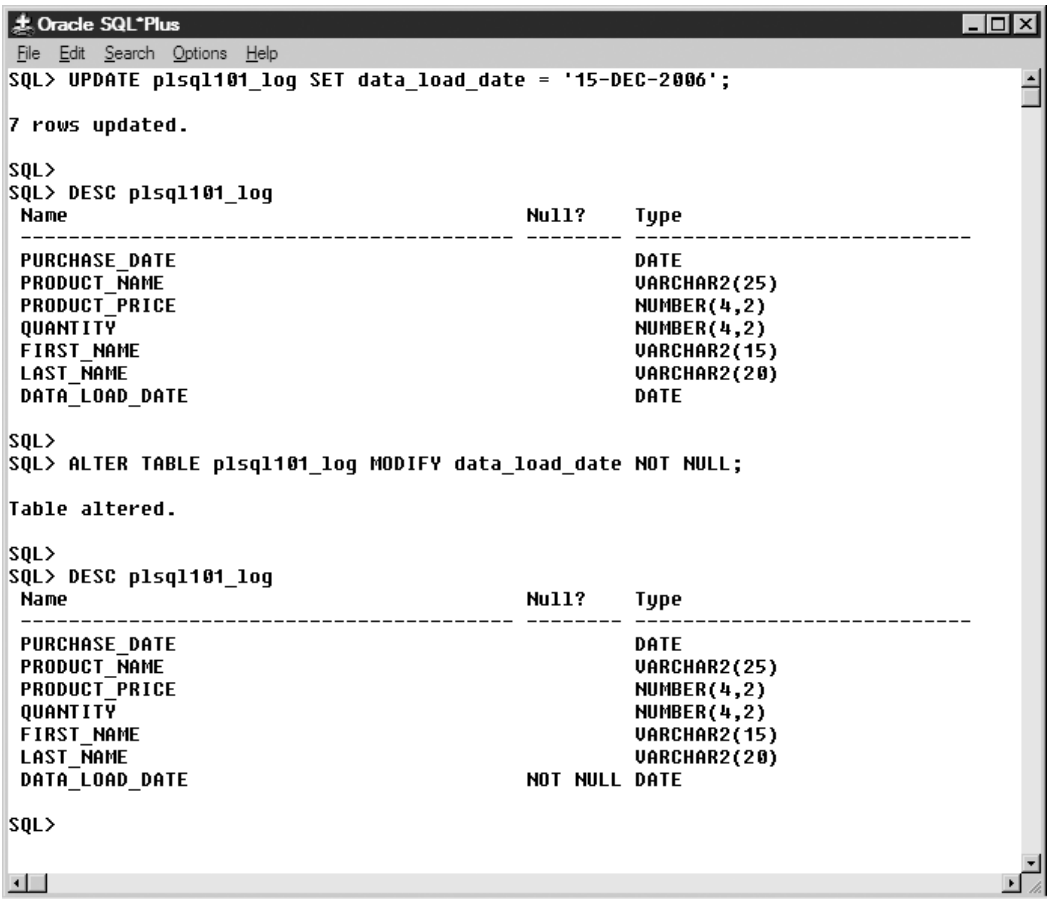


FIGURE 7-10. *Change the null option of an existing column*

Views

The concept of a *view* is simple: Define a query that is going to be used frequently, store it in the Oracle database, and allow users to call it by name, as they would a table. When users select records from the view, Oracle runs the view's stored query, organizes the resulting records in whatever way is specified by the view, and presents them to the user. From the user's point of view, the view looks exactly like a table: data appears to be retrieved from it. In reality, the data is actually coming *through* the view, from one or more other sources.

Why are views useful? For a variety of reasons. One very common use for a view is to join data from two or more tables and present it to users in one easy-to-read list. By simplifying the record-retrieval process so that users don't have to understand how to join tables, you make the data available to a larger number of people.

Views are also useful for enforcing security, because they allow you to limit the columns and rows returned to the user. If you don't want a user to see a personnel table's salary column, just don't include that column when defining the view. As far as the view user is concerned, the column will not exist. The same is true for limiting rows: just include a WHERE clause when defining the view, and the records returned will be filtered in whatever way you want.

Finally, views can provide a convenience factor for you and other users. Certainly you would never design a table whose columns have hard-to-understand names or are in a bizarre order—but other people do, and sooner or later you will have to use their tables. Because a view is just a stored query, you can utilize a query's ability to change the names assigned to columns, as well as change the order in which the columns are displayed. For instance, recently I was given the task of analyzing an existing database with hundreds of columns with names like ID101, ID205, ID3322, and so on. I had a reference guide explaining what each column contained, but continually referring to that reference would have wasted a lot of time, and users who didn't have the reference would have been out of luck. For each table in the database, I created a view that presented that table's columns using clear, easy-to-understand names. As a result, nobody tries retrieving data directly from the tables; everyone retrieves from the views instead, because when they look at the column names they understand what they're getting.

Create a View

The method for creating a view is simplicity itself. Essentially, you specify the name of the view, and then the SELECT statement that the view will execute. The syntax is as follows:

```
CREATE OR REPLACE VIEW view_name AS
SELECT statement
;
```

Note that this command has a new component: OR REPLACE. This addition allows the command to create a new view even if a view with the same name already exists. (The existing view gets overwritten in this case, of course.)

To see a view in action, enter the following commands and compare your results with those shown in Figure 7-11:

```
SELECT * FROM plsql101_purchase;

CREATE OR REPLACE VIEW plsql101_sales_by_atlas_v AS
SELECT *
FROM   plsql101_purchase
WHERE  salesperson = 'CA'
;

SELECT * FROM plsql101_sales_by_atlas_v;
```

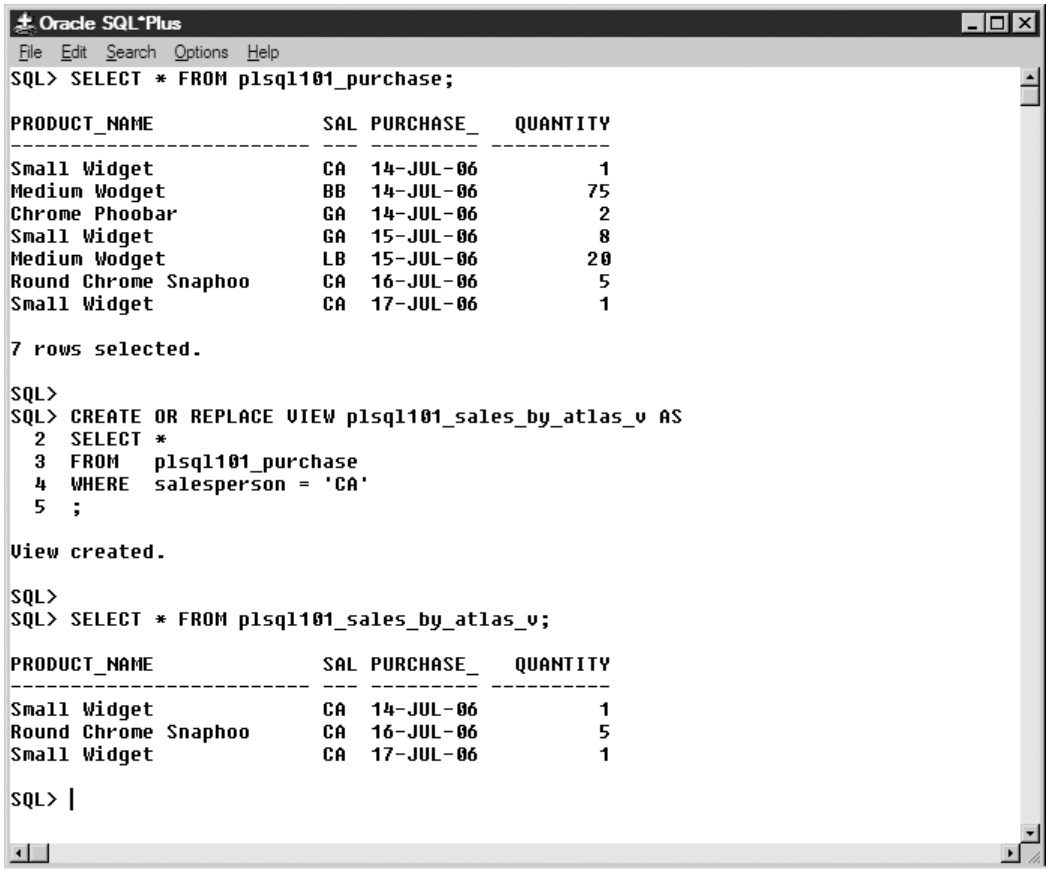


FIGURE 7-11. *Create a simple filtering view*

To see how to create a view that presents data from joined tables, enter the following commands:

```
CREATE OR REPLACE VIEW plsql101_sales_per_person_v AS
SELECT pers.first_name || ' ' || pers.last_name SALESPERSON,
       purc.product_name,
       purc.purchase_date,
       purc.quantity
FROM   plsql101_person   pers,
       plsql101_purchase purc
WHERE  pers.person_code = purc.salesperson (+)
;

SELECT * FROM plsql101_sales_per_person_v
ORDER BY salesperson, product_name, purchase_date;
```

Note that the prior example includes an ORDER BY clause in the SELECT statement that retrieves data from the view, but not in the view itself. Up until Oracle8*i*, views could not include an ORDER BY clause. In Oracle8*i* and subsequent versions, you can cause the view to sort the records it shows by including the ORDER BY clause right after the WHERE clause, just like you would in a standard SELECT statement.

Drop a View

Dropping a view is as easy as dropping a table (but less destructive—since a view doesn't contain any data, the worst that can happen if you accidentally drop a view is having to re-create it). The syntax to drop a view is as follows:

DROP VIEW *view_name*;

Try the syntax now by using it to drop the view you just created. The command to do this is as follows:

```
DROP VIEW plsql101_sales_per_person_v;
```

Alter a View's Definition

Oracle does not provide a way to alter an existing view. The only way to change a view is to drop it and re-create it. For this reason, it's a good idea to store all of your view-creation commands in .sql script files. That way, if you need to change a view, it's easy to open the script file, change the command it contains, and rerun the CREATE VIEW command.

Top N Analysis

Once you see how to make SQL show you the top 1, 10, or 100 records that match whatever criteria and sorting you specify, you may prefer to simply use the technique manually since it is so easy, rather than create a view that encapsulates it. Doing it for other users can score you big points, though, and increased user satisfaction equals increased job security and higher pay. OK, maybe this technique won't get you a raise, but it might get you a free beverage of your choosing.

This technique leverages the fact that Oracle dynamically assigns row numbers to every row returned by each query it processes. This means that no matter where a row resides in its table, if it is the first (or only) row returned by a SELECT statement, it will have a row number of 1 within that query. You can refer to these row numbers in a SELECT statement's WHERE clause. If you write your SELECT statement to sort its results in a way you care about, you can get Oracle to show you the 5, 50, or 500 most important records by including a WHERE clause statement that restricts the row number to the number of records you want.

The syntax to perform this is as follows:

```
SELECT *
FROM   (SELECT column_name_1[, column_name_2...]
         FROM   table_name
        ORDER BY column_with_value_you_care_about
         )
WHERE ROWNUM <= number_of_records_you_want
;
```

Applying this to the small number of records contained in your sample tables for this book won't produce impressive results, but it will demonstrate how the technique works. The following command demonstrates how to create a view that shows the three products whose stock quantities are the highest; try it and compare your results with those shown in Figure 7-12.

NOTE
This view will only work in Oracle8i and subsequent versions, because those versions allow views to include an ORDER BY clause.

```
CREATE OR REPLACE VIEW plsql101_overstocked_items AS
SELECT *
FROM   (SELECT product_name, quantity_on_hand
         FROM   plsql101_product
```

```
        ORDER BY quantity_on_hand DESC
       )
WHERE ROWNUM <= 3
;

SELECT * FROM plsql101_overstocked_items;
```

Other Database Objects

The final section of this chapter covers an assortment of techniques that you could end up using every day. In the pages that follow, you will learn how to use sequences, synonyms, and the Oracle® Data Dictionary.

Sequences

Databases are all about keeping things in order, and one way to keep records in order is to assign them sequential numbers. Oracle allows you to create counters called *sequences* that increment each time they are used. By referring to the sequence when inserting records, you can ensure that a new unique number is assigned to each record inserted.

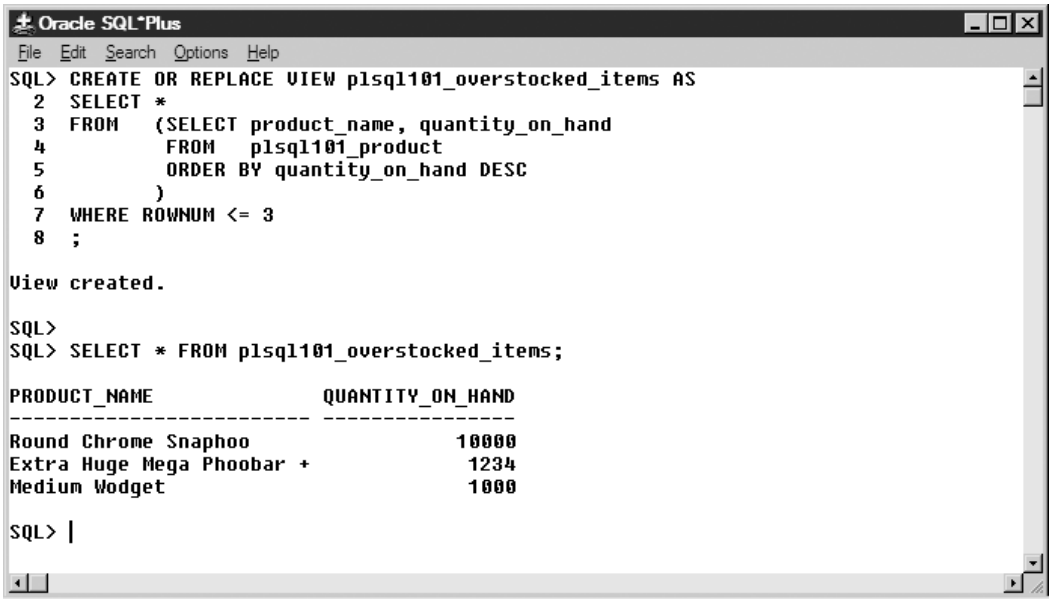


FIGURE 7-12. *Retrieve the top "N" records from a table with a view*

Create a Sequence

The syntax to create a sequence is as follows:

```
CREATE SEQUENCE sequence_name;
```

This simple command creates a sequence that starts at 1 and increments by 1 each time it is used. This is often all you will require from a sequence. However, there are many optional parameters you can use when defining a sequence. Take a look at the following syntax to see some of the more useful parameters:

```
CREATE SEQUENCE sequence_name
[INCREMENT BY increment_quantity]
[START WITH starting_value]
[MAXVALUE highest_value]
[MINVALUE lowest_value]
[CYCLE]
;
```

The INCREMENT BY parameter allows you to create sequences that jump in intervals other than 1. The values for this parameter can have up to 28 digits (although there won't be many opportunities to use an increment like that!). If you specify a negative value here, the sequence will decrement in value each time it is used.

The START WITH parameter enables you to create a sequence whose first value is something other than 1. This can be handy when you are creating a sequence for a table that already contains records: You can tell the sequence to start at the next value after the highest existing record ID.

The MAXVALUE and MINVALUE parameters allow you to define limits for the numbers the sequence generates. If you use these in conjunction with the CYCLE parameter, you can create a sequence that loops repeatedly through a set of values you define.

By far, the most common sequences increment by 1 and have no limit on their values. Execute the following command to create such a sequence, and then proceed to the "Use a Sequence" section to put it to use:

```
CREATE SEQUENCE plsql101_test_seq;
```

Use a Sequence

To get values from a sequence, you must refer to it like a table. Sequences contain two "pseudocolumns," named CURRVAL and NEXTVAL, that return the sequence's current and next value, respectively. Selecting from the NEXTVAL column causes the sequence to automatically increment to its next number.

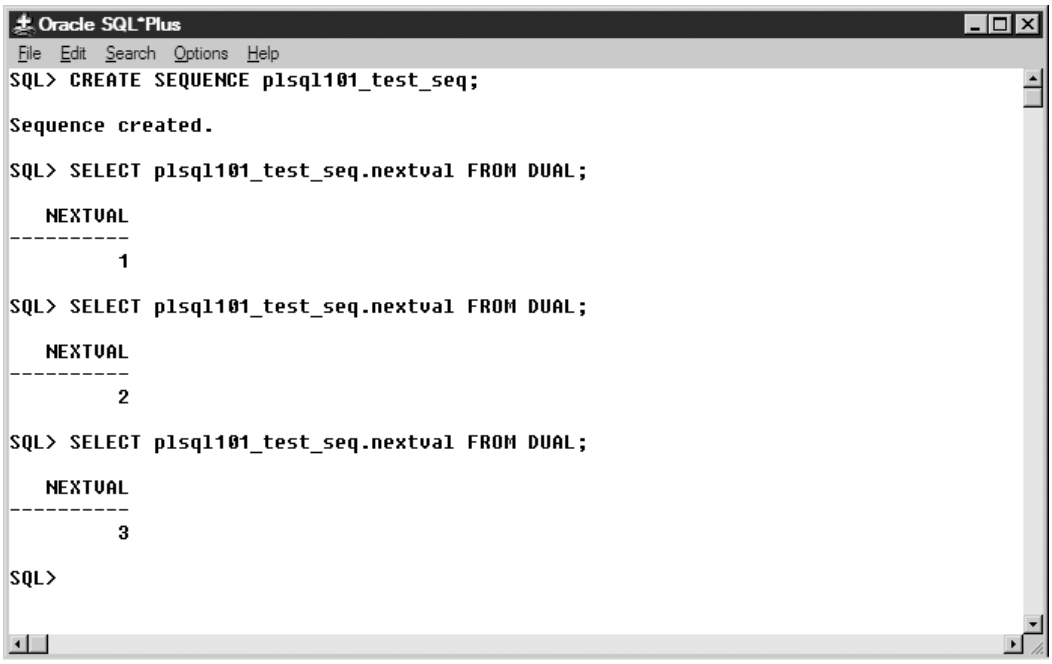


FIGURE 7-13. *Use a sequence from the command line*

To see this in action, enter the following commands and compare your results with those shown in Figure 7-13:

```
SELECT plsql101_test_seq.nextval FROM DUAL;
SELECT plsql101_test_seq.nextval FROM DUAL;
SELECT plsql101_test_seq.nextval FROM DUAL;
```

Now that you have seen how a sequence operates, it is time to learn the method for populating a table's column from a sequence. You can accomplish this by including a reference to the sequence as a value in the INSERT statement. To see how this works, enter the following commands and compare the results you see with those in Figure 7-14:

```
CREATE TABLE plsql101_test (
       record_id   NUMBER(18,0),
       record_text VARCHAR2(10)
);
```

```
INSERT INTO plsql101_test VALUES (
     plsql101_test_seq.nextval, 'Record A'
);

INSERT INTO plsql101_test VALUES (
     plsql101_test_seq.nextval, 'Record B'
);

SELECT * FROM plsql101_test;
```

NOTE
While a sequence is usually designed to be used by one table, there is no restriction in Oracle that requires this. A sequence is an independent object. It can be used by one table, many tables, or no tables at all.

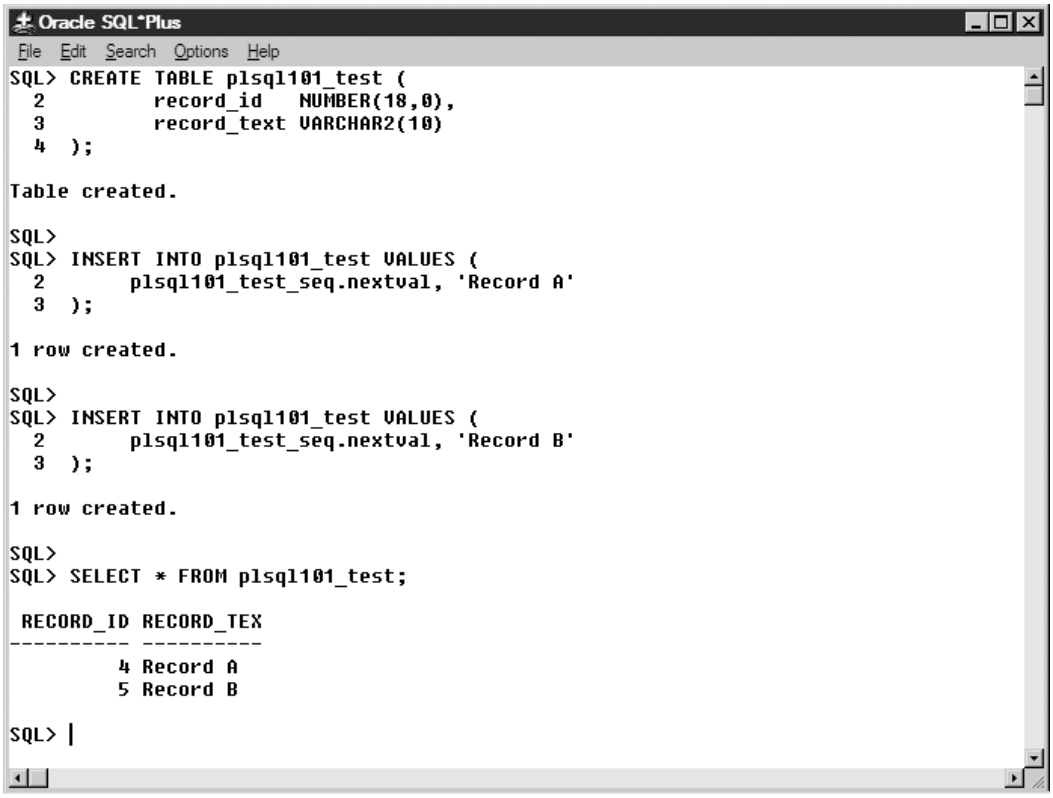


FIGURE 7-14. *Use a sequence to populate a table's column*

The method you just employed demonstrates how to utilize a sequence in an INSERT statement by referring to the sequence explicitly. It is also possible to have the sequence referenced automatically, so it does not have to be referenced in the INSERT statement. The technique for doing this is introduced in Chapter 9.

Modify an Existing Sequence

Once a sequence has been created, you can modify it in a number of ways. You can alter the increment value, adjust or remove minimum and maximum values, or change whether it loops when it reaches its limits, among other things.

The syntax for making these changes to an existing sequence is very similar to what you used to create the sequence in the first place. The syntax is as follows:

```
ALTER SEQUENCE sequence_name
[INCREMENT BY increment_quantity]
[MAXVALUE highest_value | NOMAXVALUE]
[MINVALUE lowest_value | NOMINVALUE]
[CYCLE | NOCYCLE]
;
```

To see this in action, compare Figure 7-15 with the results you get from entering the following commands:

```
ALTER SEQUENCE plsql101_test_seq
MAXVALUE 8
;

SELECT plsql101_test_seq.nextval FROM DUAL;
SELECT plsql101_test_seq.nextval FROM DUAL;
SELECT plsql101_test_seq.nextval FROM DUAL;
SELECT plsql101_test_seq.nextval FROM DUAL;
```

Synonyms

A *synonym* allows you to refer to an Oracle object by a name other than its actual name. You can apply synonyms to a table, view, or sequence, as well as to objects you will learn about in Chapters 8 and 9, such as functions, procedures, and packages. The rest of this discussion will talk about synonyms as they relate to tables, but the information also applies to synonyms assigned to other objects.

Why would you want to create a synonym for something? The main reason is convenience: If you frequently refer to a table that has a long name, you might appreciate being able to refer to it with a shorter name without having to rename the table and alter code referring to that table.

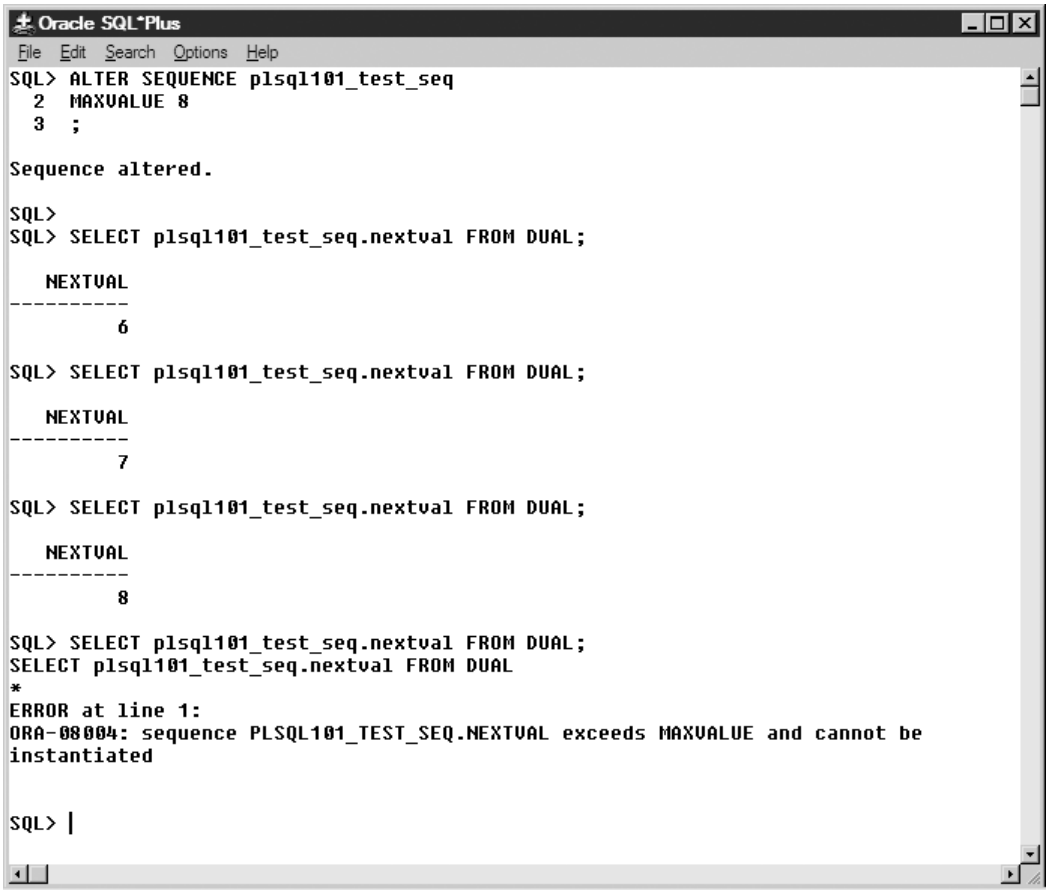


FIGURE 7-15. *Alter an existing sequence*

Synonyms can also increase convenience by making it easier for other people to access your data. Tables are organized by the Oracle user ID of the person who created them, and if another user wants to reference a table you have created, they generally have to place your username in front of the table name, as demonstrated here:

```
SELECT * FROM your_user_name.your_table_name;
```

This can get tedious, and if the table is moved to a different user, then any existing code referencing the table must be changed. Synonyms have an option enabling the table to be "visible" to anyone even if its owner's name is not specified. This allows you to write SQL statements that will continue to work even if the tables they refer to move to another user.

Create a Synonym

The syntax to create a synonym is as follows:

```
CREATE [PUBLIC] SYNONYM synonym_name
FOR object_name
;
```

To see how a synonym works, issue the following commands. Figure 7-16 shows the results you should see.

```
SELECT * FROM prod;

CREATE SYNONYM prod FOR plsql101_product;

SELECT * FROM prod;
```

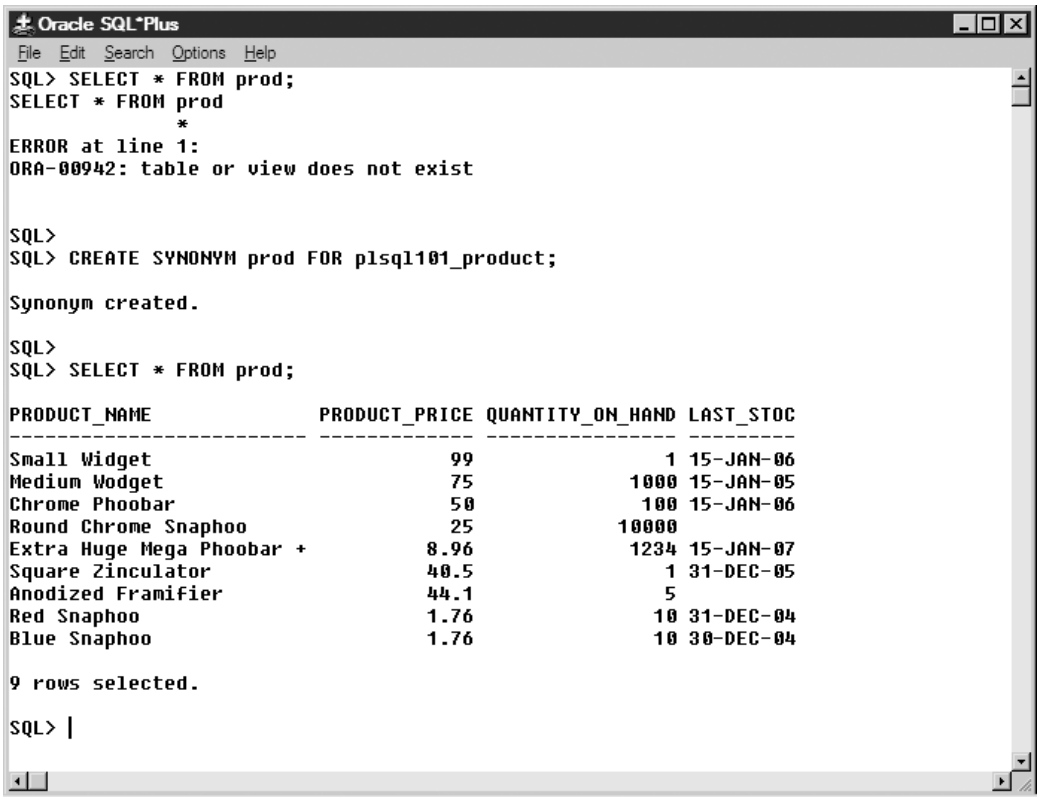


FIGURE 7-16. *Create a synonym for a table*

If you simply want to make a table available to other users, you can create a synonym that has the same name as the table. An example of this type of command follows:

CREATE PUBLIC SYNONYM plsql101_product FOR plsql101_product;

Modify an Existing Synonym

Because a synonym is so simple, Oracle does not offer any means of altering one. Instead, you simply drop the old synonym and create a new one. The syntax for this is the following:

DROP [PUBLIC] SYNONYM *synonym_name*;

Execute this command to drop the first synonym you created enabling the PLSQL101_PRODUCT table to be referred to as PROD:

```
DROP SYNONYM prod;
```

To drop the public synonym you created, issue the following command:

```
DROP PUBLIC SYNONYM plsql101_product;
```

Oracle® Data Dictionary

You probably recognize by now that an Oracle database is made up of many different objects: tables, columns, views, relationships, constraints, sequences, and so on. Oracle keeps track of all these objects by storing information about them in its *data dictionary*. The Oracle® Data Dictionary is a collection of tables and views that are maintained by Oracle so they always have up-to-date information about every object and user in the database. The Oracle® Data Dictionary contains every characteristic you specified when creating an object, as well as behind-the-scenes information such as the amount of space allocated to the object, the amount of that space currently in use, and the rights users have related to that object.

Query the Oracle® Data Dictionary to Acquire User and Database Information

The complete list of Oracle® Data Dictionary objects is available by querying a view named DICT. Using the following command, you can see the list of Oracle® Data Dictionary objects containing useful information. (The list includes information about synonyms that is not relevant to this discussion, so the following command includes a WHERE clause to omit synonyms from the list.) The list may be longer than your screen can show, so the end of the list will look like what you see in Figure 7-17.

```
SELECT table_name, SUBSTR(comments, 1, 45)
FROM   dict
WHERE  SUBSTR(comments, 1, 7) <> 'Synonym'
;
```

FIGURE 7-17. *See the objects in the Oracle® Data Dictionary*

Use Different Oracle® Data Dictionary Views

Because Oracle has so many different data dictionary views, an entire book could be written on how to use them all (in fact, many books written for database administrators devote a substantial amount of time to some of Oracle's more intricate data dictionary views related to system parameters). Within the scope of this book, the two most useful Oracle® Data Dictionary views are those that will show you lists of the tables and views you own. The following command will show you a list of all of your tables:

```
SELECT table_name FROM user_tables;
```

This command produces a list of all the views you have created:

```
SELECT view_name FROM user_views;
```

These commands are handy when you don't remember exactly what you named a table or view, as well as when you want to determine whether a table or view has already been created. While going through this chapter, you created a number of tables that will not be used in the chapters that follow. It's good practice to get rid of temporary tables quickly—if you don't, it is easy to forget what they were for. Take a moment now to drop those tables using the following commands:

```
DROP TABLE plsql101_purchase_log;
DROP TABLE plsql101_salesperson_log;
DROP TABLE plsql101_purchase_log_small;
DROP TABLE plsql101_purchase_log_large;
DROP TABLE plsql101_person_change;
```

Chapter Summary

This chapter introduced a variety of tips and tools that make your knowledge of SQL more complete. It began by showing you how to transfer data between tables using an INSERT statement that has a SELECT statement where you would normally place the values to be inserted. You can also transfer data by executing a CREATE TABLE statement whose column definitions are replaced by a SELECT statement. If you need to put data into multiple tables simultaneously, you can do so with the INSERT ALL INTO command. For situations where you need to add new records and update existing ones, you can use the MERGE command.

After learning how to rename tables using the simple syntax RENAME *old_table_name* TO *new_table_name*, you saw how to alter a table's structure to add new columns, change the datatypes of existing columns, and change whether columns accept null values. Next, you learned about views, which are essentially stored queries. Views allow you to write the command to create a customized result from one or

more tables and store that command so it can easily be used over and over. As an example, you created a view that showed products with the highest numbers of items in stock.

Next, you learned about sequences, which are Oracle's mechanism for generating sequential numbers for use as record IDs and other counting operations. The CREATE SEQUENCE command allows you to specify parameters such as the starting value, lowest and highest values, increment quantity, and whether the sequence loops back to its beginning value once it reaches its limit. You can incorporate a sequence's value into an INSERT statement by including a reference to *sequence_name*.nextval in the values to be inserted.

Next, you learned about synonyms, which allow you to refer to an Oracle object by a name other than its actual name. Synonyms also enable you to make a table or other object available to all users of a database without them needing to know who owns the table.

The final topic in this chapter was the Oracle® Data Dictionary, which is Oracle's internal method for keeping track of users, database objects, and other information needed to keep the database up and running. In this topic, you learned how to get a list of all Oracle® Data Dictionary views. You also saw how to get a list of your tables and views by selecting from data dictionary views named USER_TABLES and USER_VIEWS.

The information in this chapter, and preceding ones, forms a strong base of knowledge about how to use SQL in powerful and efficient ways. Now you are ready to learn how to write sophisticated programs using Oracle's superset of SQL—PL/SQL. In today's job market, knowing how to write PL/SQL programs is like money in the bank.

Chapter Questions

1. **Which of the following commands would transfer data from a table named PRODUCT to a table named PRODUCT_ARCHIVE?**

   A. INSERT INTO product (
   SELECT *
   FROM product_archive
)
   ;

   B. COPY * FROM product TO product_archive;

   C. CREATE TABLE product_archive AS
   SELECT * FROM product;

   D. INSERT INTO product_archive (SELECT * FROM product);

2. **Which of the following commands will rename a table?**

   A. RENAME *table_name new_table_name*;

   B. RENAME *table_name* TO *new_table_name*;

   C. RENAME TABLE *table_name new_table_name*;

   D. RENAME TABLE *table_name* TO *new_table_name*;

3. **Which of the following commands will add a required text column named NEW_COLUMN to a table named TAB1?**

   A. ALTER TABLE tab1
   ADD new_column VARCHAR2(10) NOT NULL;

   B. ADD new_column VARCHAR2(10) NOT NULL
   TO tab1;

   C. ALTER tab1
   ADD new_column VARCHAR2(10) NOT NULL;

   D. ADD new_column VARCHAR2(10) NOT NULL
   TO TABLE tab1;

4. **Which of the following is *not* a benefit offered by views?**

   A. Can rename columns to more readable names than those used in the underlying table

   B. Can join information from multiple tables

   C. Can filter data so only certain rows or columns are displayed

   D. Can speed up data access by referring directly to the columns needed

5. **Which of the following commands would *not* result in the creation of a sequence?**

   A. CREATE SEQUENCE new_seq1 NOMAXVALUE;

   B. CREATE SEQUENCE 2new_seq START WITH 2;

   C. CREATE SEQUENCE new3_seq MIN 1 MAX 100 CYCLE;

   D. CREATE SEQUENCE new_4seq INCREMENT BY -1;

6. **Which of the following are benefits of using table synonyms?**
   - **A.** Can increase data throughput speed
   - **B.** Allows column to be referred to by a different name
   - **C.** Allows table to be referred to by a different name
   - **D.** Enables other users to reference a table without knowing its owner

7. **Which command lets you put data into more than one table using a single command?**
   - **A.** MERGE
   - **B.** INSERT INTO MANY
   - **C.** MULTIADD
   - **D.** INSERT ALL INTO

8. **Which command performs an "upsert"?**
   - **A.** MERGE
   - **B.** INSERT INTO MANY
   - **C.** MULTIUPDATE
   - **D.** INSERT ALL INTO

9. **Select the correct syntax for renaming an existing column.**
   - **A.** ALTER TABLE *table_name* RENAME COLUMN *old_column_name* TO *new_column_name*;
   - **B.** RENAME COLUMN *old_column_name* TO *new_column_name*;
   - **C.** ALTER COLUMN RENAME *old_column_name* TO *new_column_name*;

10. **Select the correct syntax for deleting an existing column.**
    - **A.** ALTER TABLE *table_name* DELETE COLUMN *column_name*;
    - **B.** ALTER TABLE *table_name* DROP COLUMN *column_name*;
    - **C.** DELETE COLUMN *column_name*;
    - **D.** ALTER COLUMN DROP *column_name*;

Answers to Chapter Questions

1. C, D. CREATE TABLE product_archive AS
SELECT * FROM product;
INSERT INTO product_archive (SELECT * FROM product);

Explanation Choice A has the correct syntax, but it has the source and destination tables reversed. Choice B is not valid syntax. Choices C and D are both valid ways of copying data from PRODUCT to PRODUCT_ARCHIVE.

2. B. RENAME *table_name* TO *new_table_name*;

Explanation This is one of the few SQL commands that does not require you to identify the type of object being acted upon. You do, however, have to include the word TO between the original table name and the new one.

3. A. ALTER TABLE tab1
ADD new_column VARCHAR2(10) NOT NULL;

Explanation For a refresher on the ALTER TABLE syntax, review the section titled "Add Columns."

4. D. Can speed up data access by referring directly to the columns needed

Explanation The explanation of choice D sounds somewhat like a benefit offered by indexes. It is not, however, relevant to views. A view does not substantially affect the amount of time it takes to access data.

5. B, C. CREATE SEQUENCE 2new_seq START WITH 2;
CREATE SEQUENCE new3_seq MIN 1 MAX 100 CYCLE;

Explanation Choice B will fail because the sequence name begins with a number (remember the guideline on naming objects?). Choice C will fail because the parameters to set a sequence's limits are MINVALUE and MAXVALUE, not MIN and MAX. If you thought that choice D would fail because its increment value is a negative number, remember that that's the way to create a sequence that decrements in value instead of increments.

6. C, D. Allows table to be referred to by a different name
Enables other users to reference a table without knowing its owner

Explanation For a refresher on this subject, refer to the section titled "Synonyms."

7. D. INSERT ALL INTO

Explanation For a refresher on this subject, refer to the section titled "Insert into Multiple Tables Simultaneously."

8. A. MERGE

Explanation For a refresher on this subject, refer to the section titled "Conditional Insert—The MERGE Command."

9. A. ALTER TABLE *table_name* RENAME COLUMN *old_column_name* TO *new_column_name*;

Explanation Choices B and C do not identify which table the column is in.

10. B. ALTER TABLE *table_name* DROP COLUMN *column_name*;

Explanation Choices C and D do not identify which table the column is in. Choice A uses "delete," which is a DML command that affects data, not a DDL command that affects structure.

PART III

Create Programs Using PL/SQL

CHAPTER 8

Introduction to PL/SQL

Storing and retrieving information is just one part of any real-life application. Even the simplest applications need to do some processing that is difficult or impossible using SQL alone. Just think of how complex the computations are when the government's share of your earnings needs to be computed every year! OK, maybe you want to think of another example instead. In any case, SQL alone isn't up to the task.

What Is PL/SQL?

You may ask why SQL doesn't have features that allow you to do more sophisticated computations on data. The reason is partly historical: SQL came into existence as a database query language (Structured Query Language) and has evolved and been optimized for doing exactly that: querying databases. Different providers of database software have agreed to certain SQL standards, but they did not agree on how to give users more sophisticated SQL-oriented programming capabilities. Thus, each database software provider has come up with proprietary or semi-proprietary products. Oracle calls its solution *PL/SQL*. You can think of this as standing for "Programming Language for SQL."

In this chapter, you will be introduced to the basics of PL/SQL. You will learn the difference between SQL, SQL*Plus, and PL/SQL. You will also start writing simple PL/SQL procedures, as well as functions using basic PL/SQL constructs like variables, loops, and cursors. Then, you will learn about the important art of handling errors in a way the user can easily understand.

If you just started reading in this chapter and have not done any of the exercises in the preceding chapters, you will need to create the sample tables built in prior chapters before you can do the exercises in this chapter. To accomplish this, enter the following SQL commands:

```
DROP TABLE plsql101_purchase;
DROP TABLE plsql101_product;
DROP TABLE plsql101_person;
DROP TABLE plsql101_old_item;
DROP TABLE plsql101_purchase_archive;

CREATE TABLE plsql101_person (
     person_code VARCHAR2(3) PRIMARY KEY,
     first_name  VARCHAR2(15),
     last_name   VARCHAR2(20),
     hire_date   DATE
     )
;
```

```
CREATE INDEX plsql101_person_name_index
ON plsql101_person(last_name, first_name);

ALTER TABLE plsql101_person
ADD CONSTRAINT plsql101_person_unique UNIQUE (
     first_name,
     last_name,
     hire_date
     )
;

INSERT INTO plsql101_person VALUES
     ('CA', 'Charlene', 'Atlas', '01-FEB-05');
INSERT INTO plsql101_person VALUES
     ('GA', 'Gary', 'Anderson', '15-FEB-05');
INSERT INTO plsql101_person VALUES
     ('BB', 'Bobby', 'Barkenhagen', '28-FEB-05');
INSERT INTO plsql101_person VALUES
     ('LB', 'Laren', 'Baxter', '01-MAR-05');
INSERT INTO plsql101_person VALUES
     ('LN', 'Linda', 'Norton', '01-JUN-06');

CREATE TABLE plsql101_product (
     product_name     VARCHAR2(25) PRIMARY KEY,
     product_price    NUMBER(4,2),
     quantity_on_hand NUMBER(5,0),
     last_stock_date  DATE
     )
;

ALTER TABLE plsql101_product ADD CONSTRAINT positive_quantity CHECK(
     quantity_on_hand IS NOT NULL
     AND
     quantity_on_hand >=0
     )
;

INSERT INTO plsql101_product VALUES
     ('Small Widget', 99, 1, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Medium Wodget', 75, 1000, '15-JAN-05');
INSERT INTO plsql101_product VALUES
     ('Chrome Phoobar', 50, 100, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Round Chrome Snaphoo', 25, 10000, null);
```

```
INSERT INTO plsql101_product VALUES
     ('Extra Huge Mega Phoobar +',9.95,1234,'15-JAN-07');
INSERT INTO plsql101_product VALUES ('Square Zinculator',
     45, 1, TO_DATE('December 31, 2005, 11:30 P.M.',
                    'Month dd, YYYY, HH:MI P.M.')
     )
;
INSERT INTO plsql101_product VALUES (
     'Anodized Framifier', 49, 5, NULL);
INSERT INTO plsql101_product VALUES (
     'Red Snaphoo', 1.95, 10, '31-DEC-04');
INSERT INTO plsql101_product VALUES (
     'Blue Snaphoo', 1.95, 10, '30-DEC-04')
;

CREATE TABLE plsql101_purchase (
     product_name  VARCHAR2(25),
     salesperson   VARCHAR2(3),
     purchase_date DATE,
     quantity      NUMBER(4,2)
     )
;

ALTER TABLE plsql101_purchase
ADD PRIMARY KEY (product_name,
                 salesperson,
                 purchase_date
                 )
;

ALTER TABLE plsql101_purchase
ADD CONSTRAINT reasonable_date CHECK(
     purchase_date IS NOT NULL
     AND
     TO_CHAR(purchase_date, 'YYYY-MM-DD') >= '2003-06-30'
     )
;

ALTER TABLE plsql101_purchase
ADD CONSTRAINT plsql101_purchase_fk_product FOREIGN KEY
     (product_name) REFERENCES plsql101_product;

ALTER TABLE plsql101_purchase
ADD CONSTRAINT plsql101_purchase_fk_person FOREIGN KEY
     (salesperson) REFERENCES plsql101_person;

CREATE INDEX plsql101_purchase_product
ON plsql101_purchase(product_name);
```

```
CREATE INDEX plsql101_purchase_salesperson
ON plsql101_purchase(salesperson);

INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'CA', '14-JUL-06', 1);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'BB', '14-JUL-06', 75);
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'GA', '14-JUL-06', 2);
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'GA', '15-JUL-06', 8);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'LB', '15-JUL-06', 20);
INSERT INTO plsql101_purchase VALUES
     ('Round Chrome Snaphoo', 'CA', '16-JUL-06', 5);
INSERT INTO plsql101_purchase VALUES (
     'Small Widget', 'CA', '17-JUL-06', 1)
;

UPDATE plsql101_product
SET    product_price = product_price * .9
WHERE  product_name NOT IN (
       SELECT DISTINCT product_name
       FROM   plsql101_purchase
       )
;

CREATE TABLE plsql101_purchase_archive (
     product_name  VARCHAR2(25),
     salesperson   VARCHAR2(3),
     purchase_date DATE,
     quantity      NUMBER(4,2)
     )
;

INSERT INTO plsql101_purchase_archive VALUES
     ('Round Snaphoo', 'BB', '21-JUN-04', 10);
INSERT INTO plsql101_purchase_archive VALUES
     ('Large Harflinger', 'GA', '22-JUN-04', 50);
INSERT INTO plsql101_purchase_archive VALUES
     ('Medium Wodget', 'LB', '23-JUN-04', 20);
INSERT INTO plsql101_purchase_archive VALUES
     ('Small Widget', 'ZZ', '24-JUN-05', 80);
INSERT INTO plsql101_purchase_archive VALUES
     ('Chrome Phoobar', 'CA', '25-JUN-05', 2);
INSERT INTO plsql101_purchase_archive VALUES
     ('Small Widget', 'JT', '26-JUN-05', 50);
```

Describe PL/SQL

PL/SQL provides the features that allow you to do sophisticated information processing. Let's say that every night you want to transfer the day's business summary into a day's summary table—*PL/SQL packages* can help you do this. Or, you want to know whether you need to arrange for extra supplies for purchase orders that are really large—PL/SQL provides *triggers* that will notify you as soon as any order placed is found to be larger than certain limits decided by you. In addition, you can use *PL/SQL stored procedures* to compute your employees' performance to help you decide about bonuses. Plus, a nice *PL/SQL function* can calculate the tax withholdings for an employee.

PL/SQL lets you use all the SQL data manipulation, cursor control, and transaction control commands, as well as all the SQL functions and operators. So, you can manipulate Oracle data flexibly and safely. Also, PL/SQL fully supports SQL datatypes. This reduces the need to convert data passed between your applications and the database. PL/SQL also supports dynamic SQL, an advanced programming technique that makes your applications more flexible and versatile. Your programs can build and process SQL data definition, data control, and session control statements "on the fly" at run time.

Before we proceed to learn more about some of these power tools, I will give you some idea about how SQL, SQL*Plus, and PL/SQL relate to each other.

Who's Who in SQL, SQL*Plus, and PL/SQL

Think of a restaurant. You go in and hopefully a well-trained waiter or waitress waits on you. You look through the menu and place an order. The waiter writes down your order and takes it into the kitchen. The kitchen is huge—there are many chefs and assistants. You can see a lot of food—cooked, partially cooked, and uncooked—stored in the kitchen. You can also see people with various jobs: they take the food in and out of storage, prepare a particular type of food (just soups or just salads, for instance), and so forth. Depending on what menu items you ordered, the waiter takes the order to different chefs. Some simple orders are completed by one chef, while more complex orders may require help from assistants, or even multiple chefs. In addition, some orders are standard items—a waiter can just tell a chef "mushroom pizza"—while other orders are custom creations requiring a detailed list of exactly what ingredients you want.

Now alter this scenario a little. Think of an Oracle database as the restaurant's kitchen, with SQL*Plus serving as the waiter taking our orders—scripts, commands, or programs—to the kitchen, or database. Inside the kitchen are two main chefs: SQL and PL/SQL. Like a waiter, SQL*Plus knows what orders it can process on its own, as well as what orders to take to specific chefs. In the same way that a waiter can bring you a glass of water without having to get it from a chef, SQL*Plus can adjust the width of the lines shown on its screen without needing to go to the database.

The commands or programs you enter and execute at the SQL*Plus prompt are somewhat like your special-order pizza. For custom orders the chefs have to do some thinking each time. Just like the chef has the recipe for cheese pizza stored in his or her brain, you can have PL/SQL store "recipes" for your favorite orders. These stored PL/SQL elements are called triggers, stored functions, stored procedures, and packages. You will learn more about them soon.

As I mentioned earlier, some orders require more than one chef to prepare them. Most of the interesting and useful database applications you create will have SQL and PL/SQL working together, passing information back and forth between them to process a script or program. In a restaurant, after an order is prepared it goes to a waiter to be taken to your table. Similarly, when SQL and PL/SQL process commands, the results go to SQL*Plus (or a custom front-end form) to be displayed to the user.

Stored Procedures, Stored Functions, and Triggers

PL/SQL procedures, functions, and triggers all help you build complex business logic easily and in a *modular* fashion (meaning piece by piece, with the pieces being reusable by other pieces). Storing these in the Oracle server provides two immediate benefits: they can be used over and over with predictable results, and they execute very rapidly because server operations involve little or no network traffic.

Stored Procedures

A *stored procedure* is a defined set of actions written using the PL/SQL language. When a procedure is called, it performs the actions it contains. The procedure is stored in the database, which is the reason it is called a stored procedure.

A stored procedure can execute SQL statements and manipulate data in tables. It can be called to do its job from within another PL/SQL stored procedure, stored function, or trigger. A stored procedure can also be called directly from an SQL*Plus prompt. As you read through the pages that follow, you will learn how to employ each of these methods for calling a stored procedure.

A procedure consists of two main parts: the specification and the body. The *procedure specification* contains the procedure's name and a description of its inputs and outputs. The inputs and outputs we are talking about are called the procedure's *formal parameters* or *formal arguments*. If a call to a procedure includes command-line parameters or other inputs, those values are called *actual parameters* or *actual arguments*.

Now let's take a look at some samples of procedure specifications. (Remember, the specification doesn't contain any code; it just names the procedure and defines any inputs and outputs the procedure can use.)


run_ytd_reports

This simple specification contains only the procedure's name. It has no parameters.

```
increase_prices (percent_increase NUMBER)
```

A value can be passed to this procedure when it is called. Within the procedure, the value will be addressed as PERCENT_INCREASE. Note that the value's datatype has been specified: NUMBER.

```
increase_salary_find_tax (increase_percent IN     NUMBER := 7,
                          sal              IN OUT NUMBER,
                          tax                 OUT NUMBER
                          )
```

Here we have a procedure with three formal parameters. The word IN after a parameter's name indicates that the procedure can read an incoming value from that parameter when the procedure is called. The word OUT after a parameter's name indicates that the procedure can use that parameter to send a value back to whatever called it. Having IN OUT after a parameter's name says that the parameter can bring a value into the procedure and also be used to send a value back out.

The INCREASE_PERCENT parameter in this example gets assigned a *default value* of 7 by including **:= 7** after the datatype. Because of this, if the procedure is called without specifying any increase percentage, it will increase the salary given by 7 percent and calculate the tax based on the new salary.

NOTE
Datatypes in a procedure cannot have size specifications. For instance, you can specify that a parameter is a NUMBER datatype, but not a NUMBER(10,2) datatype.

The *procedure body* is a block of PL/SQL code, which you will learn about in the section entitled "Structure of a PL/SQL Block."

Stored Functions

A PL/SQL function is similar to a PL/SQL procedure: It has function specification and a function body. The main difference between a procedure and a function is that a function is designed to return a value that can be used within a larger SQL statement.

For instance, think for a moment about a function designed to calculate the percentage difference between two numbers. Ignoring the code that would perform this calculation, the function specification would look like this:

```
calc_percent(value_1 NUMBER,
             value_2 NUMBER) return NUMBER
```

This function accepts two numbers as input, referring to them internally as VALUE_1 and VALUE_2. Once the body of this function was written, it could be referred to in an SQL statement in the following way:

```
INSERT INTO employee VALUES (3000, CALC_PERCENT(300, 3000));
```

Triggers

A *trigger* is a PL/SQL procedure that gets executed automatically whenever some event defined by the trigger—the *triggering event*—happens. You can write triggers that fire when an INSERT, UPDATE, or DELETE statement is performed on a table; when DDL statements are issued; when a user logs on or off; or when the database starts, encounters an error, or shuts down.

Triggers differ from PL/SQL procedures in three ways:

- You cannot call a trigger from within your code. Triggers are called automatically by Oracle in response to a predefined event.
- Triggers do not have a parameter list.
- The specification for a trigger contains different information than a specification for a procedure.

You will learn more about triggers and their uses in Chapter 9.

Stored Procedures and SQL Scripts

While SQL scripts reside on your computer's hard disk, stored procedures reside within your Oracle database. An SQL script contains a series of SQL commands that are executed, one by one, when you invoke the script. In contrast, a stored procedure can contain flow-control commands allowing it to iterate through a particular section of code over and over; branch to another code section when particular situations occur; and respond to error conditions in a way you specify.

Structure of a PL/SQL Block

In this section, you will learn about the PL/SQL *basic block*. Everything in PL/SQL that actually does work is made up of basic blocks. After learning about the basic blocks, you will see examples of complete procedures, functions, and triggers.

A PL/SQL basic block is made up of four sections: the *header section*, an optional *declaration section*, the *execution section*, and the optional *exception section*.

An *anonymous block* is a PL/SQL block with no header or name section, hence the term anonymous block. Anonymous blocks can be run from SQL*Plus and they can be used within PL/SQL functions, procedures, and triggers. Recall that PL/SQL procedures, functions, and triggers are all made up of basic blocks themselves. What this means is that you can have a basic block within a basic block. Perhaps the best way to begin to understand a basic block is to examine a sample. First,

type the following command so that information printed by programs can be made visible in SQL*Plus:

```
set serveroutput on
```

Now try the following sample code to create an anonymous block. Compare your results with Figure 8-1.

```
DECLARE
        Num_a NUMBER := 6;
        Num_b NUMBER;
BEGIN
        Num_b := 0;
        Num_a := Num_a / Num_b;
        Num_b := 7;
        dbms_output.put_line(' Value of Num_b ' || Num_b);
EXCEPTION
        WHEN ZERO_DIVIDE
THEN
              dbms_output.put_line('Trying to divide by zero');
              dbms_output.put_line(' Value of Num_a ' || Num_a);
              dbms_output.put_line(' Value of Num_b ' || Num_b);
END;
/
```

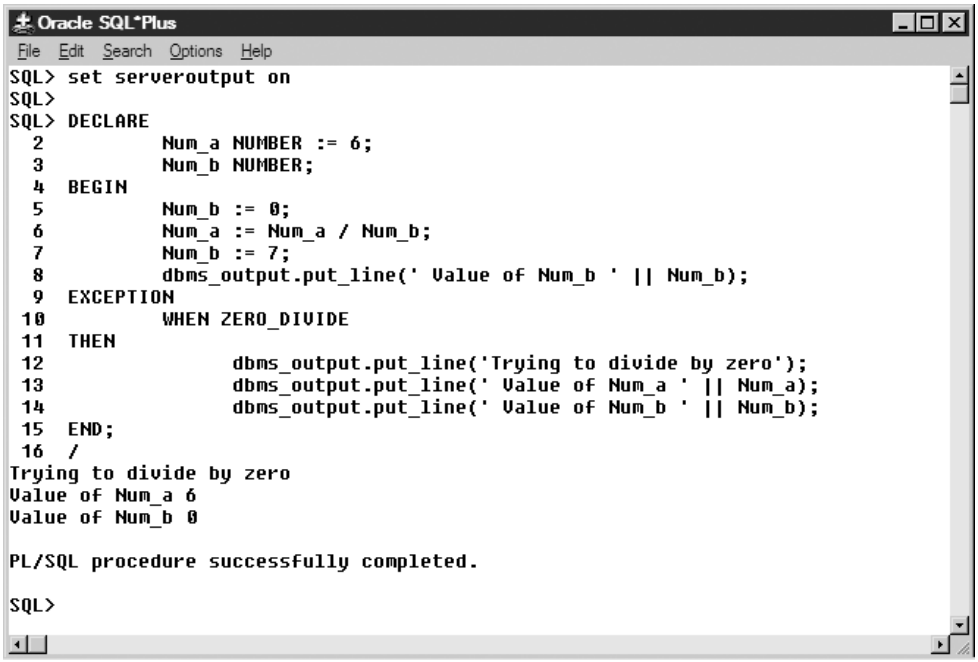


FIGURE 8-1. *Example of an anonymous PL/SQL block*

Header Section

The header section for a block varies based on what the block is part of. Recall that procedures, functions, triggers, and anonymous blocks are made up of basic blocks. In fact, each has one basic block that makes up its body. This body block may contain more basic blocks inside it. The header for this top-level basic block of a function, procedure, or trigger is the specification for that function, procedure, or trigger. For anonymous blocks, the header contains only the keyword DECLARE. For labeled blocks, the header contains the name of the label enclosed between << and >>, followed by the keyword DECLARE, as shown in the following code:

```
<<just_a_label>>
DECLARE
```

Block labels help make it easier to read code. In a procedure using nested blocks (blocks inside other blocks), you can refer to an item in a specific block by preceding the item's name with the name of the block (for example, *block_label.item_label*).

Declaration Section

The declaration section is optional. When used, it begins after the header section and ends at the keyword BEGIN. The declaration section contains the declarations for PL/SQL variables, constants, cursors, exceptions, functions, and procedures that will be used by the execution and exception sections of the block. All variable and constant declarations must come before any function or procedure declarations within the declaration section. You will learn more about PL/SQL variables and constants in the following section of the same name ("PL/SQL Variables and Constants"). A declaration tells PL/SQL to create a variable, constant, cursor, function, or procedure as specified in the declaration.

The declaration section (beginning with the word DECLARE) in the example shown in Figure 8-1 tells PL/SQL to create two number type variables called Num_a and Num_b. It also assigns a value of 6 by default to Num_a.

When a basic block has finished its run, everything declared within the declaration section stops existing. Things declared within the declaration section of a basic block can be used only within the same block. Thus, after running the example block in SQL*Plus there is no way to pass Num_a to another PL/SQL procedure. Num_a and Num_b just go out of existence as soon as the block finishes its run. However, if you call a PL/SQL function or procedure within the execution or exception section of the block, you can pass Num_a and Num_b to them as actual parameters.

The long and short of the story is, whatever is in the declaration section is the private property of the block—to be used by and visible only to itself. Thus, what is in the declaration section of the block only lives as long as the block. In technical terms, Num_a and Num_b are said to have the *scope* of the block in which they are declared. The scope of the block starts at the beginning of the block's declaration section and ends at the end of its exception section.

Execution Section

The execution section starts with the keyword BEGIN and ends in one of two ways. If there is an exception section, the execution section ends with the keyword EXCEPTION. If no exception section is present, the execution section ends with the keyword END, followed optionally by the name of the function or procedure, and a semicolon. The execution section contains one or more PL/SQL statements that are executed when the block is run. The structure for the executable section is shown below:

```
BEGIN
      one or more PL/SQL statements
[exception section]
END [name of function or procedure];
```

The executable section, in the example block of Figure 8-1, contains three PL/SQL assignment statements. The assignment statement is the most commonly seen statement in PL/SQL code. The first statement assigns the value of zero to Num_b. The colon followed by an equal sign (:=) is the assignment operator. The assignment operator tells PL/SQL to compute whatever is on its right-hand side and place the result in whatever is on its left-hand side.

The second statement assigns Num_a the value of Num_a divided by Num_b. Note that after this statement is executed successfully, the value of Num_a will be changed.

The third statement assigns the value of 7 to Num_b.

Exception Section

It is possible that during the execution of PL/SQL statements in the execution section, an error will be encountered that makes it impossible to proceed with the execution. These error conditions are called *exceptions*. The procedure's user should be informed when an exception occurs and told why it has occurred. You may want to issue a useful error to the user or you may want to take some corrective action and retry whatever the procedure was attempting before the error happened. You may want to roll back changes done to the database before the error occurred.

For all these situations, PL/SQL helps you by providing *exception handling* capabilities. Exceptions are so important for good applications that I have a special section at the end of this chapter where you will learn more about them (see "Exceptions" within the "Error Handling" section). As an introduction, the following is the structure for the exception section:

```
EXCEPTION
   WHEN exception_name
   THEN
      actions to take when this exception occurs
   WHEN exception_name
   THEN
      actions to take when this exception occurs
```

The exception section begins at the keyword EXCEPTION and ends at the end of the block. For each exception there is a WHEN *exception_name* statement that specifies what should be done when a specific exception occurs. Our example has three funny-looking statements that have the effect of making text display on your SQL*Plus screen. A little more information is needed to understand what they are doing, but we will leave the details for Chapter 9. The DBMS_OUTPUT package and PUT_LINE procedure are part of the Oracle database; together they cause text to display on your SQL*Plus screen one line at a time.

All the statements between the statement that causes the exception and the exception section will be ignored. So, in the case of the example block in Figure 8-1, the assigning of 7 to Num_b is not executed. You can verify this by looking at the value for Num_b that the example code prints out.

When a statement in the exception section deals with an exception, we refer to that action as *exception handling*.

Detecting that the error occurred and which exception best describes it and then taking appropriate steps to inform PL/SQL about it so as to make it possible for PL/SQL to find the exception section for that exception is called *raising exception*. In the example code in Figure 8-1, the exception is raised by PL/SQL on its own by detecting that there is an attempt at division by zero. PL/SQL has a predefined name for this exception—ZERO_DIVIDE. In many situations, the error must be detected by your code, not by PL/SQL.

Create a Simple PL/SQL Procedure

We have all the ingredients to try writing a complete PL/SQL procedure. You know about the basic block and you have learned about procedure specifications. Now try the following code:

```
CREATE PROCEDURE my_first_proc IS
        greetings VARCHAR2(20);
BEGIN
        greetings := 'Hello World';
        dbms_output.put_line(greetings);
END my_first_proc;
/
```

The syntax for creating a stored procedure is the following:

CREATE PROCEDURE procedure_specification IS procedure_body

In our sample, the procedure specification is just the name of the procedure, and the body is everything after it up to the last semicolon. For functions, you will use the keyword FUNCTION instead of PROCEDURE:

CREATE FUNCTION function_specification IS function_body

The forward slash (/) tells SQL*Plus to go ahead and process the commands in the program. You can re-create the same procedure or function by changing the CREATE command to CREATE OR REPLACE. This will destroy the old definition of the procedure or function and replace it with the new one. If there is no old definition it will simply create a new one.

```
CREATE OR REPLACE PROCEDURE procedure_specification
IS procedure_body
```

Now let us see how this procedure can be called from SQL*Plus:

```
set serveroutput on
EXECUTE my_first_proc;
```

SERVEROUTPUT ON allows you to see the printed output. The EXECUTE command actually executes the procedure. You can call the procedure from within an anonymous block as follows. Compare your results with those shown in Figure 8-2.

```
BEGIN
        my_first_proc;
END;
/
```

Call Procedures and Functions

A procedure or function may or may not have formal parameters with default values. In fact, it may not have any formal parameters at all. For each case, the way the procedure or function is called is different. However, the following applies regardless of the parameters:

- The datatypes for the actual parameters must match or should be convertible by PL/SQL to the datatypes of corresponding formal parameters.
- Actual parameters must be provided for all formal parameters that do not have default values.

When calling a function without any parameters, you can just use the name with or without parentheses, like the following:

```
        procedure_name();
  or    procedure_name;
```

The same syntax is used when dealing with a function, except a semicolon will not be used when the function is called as part of an expression.

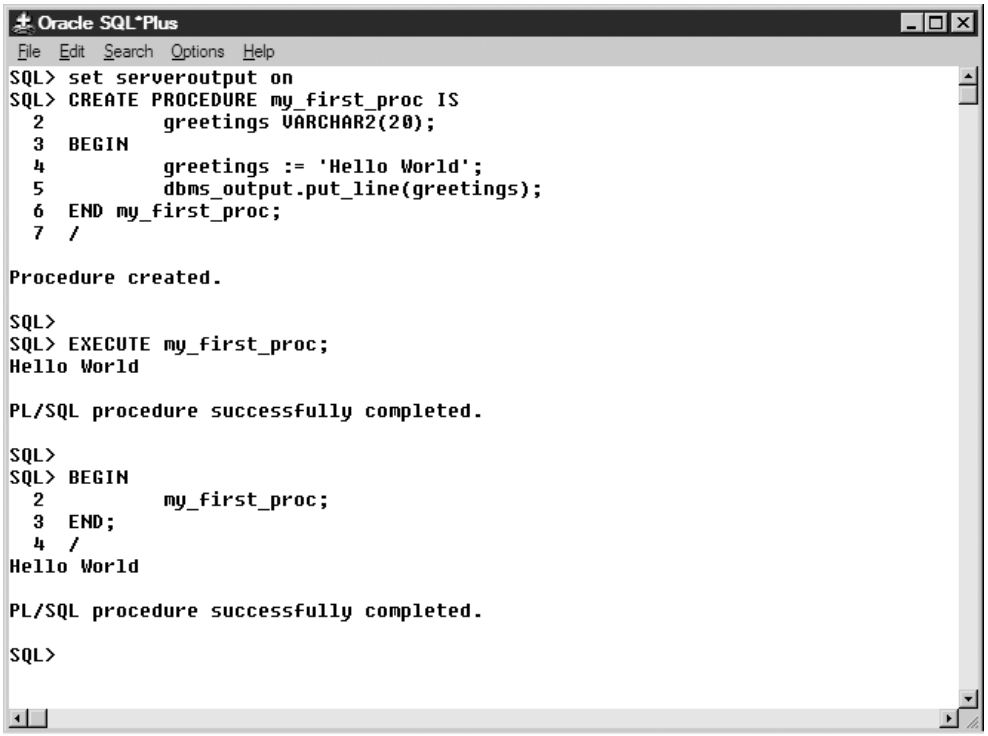


FIGURE 8-2. *Simple "Hello World" PL/SQL procedure*

When a procedure has formal parameters with default values and when they are all at the end of the list of formal parameters in the procedure specification, the procedure may be called without specifying values for the last few formal parameters for which default values exist. However, all the formal parameters for which actual parameters are being supplied at call time must be listed before all of the formal parameters for which no actual parameters are being supplied. The call will then look like the following:

```
procedure_name(actual_param1,
               actual_param2,
               ...
               actual_paramN);
```

N may be less than or equal to the number of formal parameters for the procedure and *N* must be greater than or equal to the number of formal parameters for which default values do not exist.

When the default-valued formal parameters are not the last parameters in the specification, or when you wish to avoid having PL/SQL figure out which actual parameter corresponds to which formal parameter using its order in the list, you can specifically tell PL/SQL which actual parameter is for which formal parameter using the following syntax:

```
procedure_name(formal_param1 => actual_param1,
               formal_param2 => actual_param2,
               ...
               )
;
```

This is called *named notation* for calling functions and procedures. The earlier notation is called *positional notation* as the parameters are matched by their position in the list.

The same calling methods apply to functions. Functions, however, can appear within other expressions and may not have any semicolon at the end. You will see an example for named notation in the next section. It is possible to mix two notations, but the positional list must precede the notational list in the call.

PL/SQL Variables and Constants

You have seen some examples of PL/SQL variables in previous sections. Now we will discuss them in greater detail. Variables are essentially containers with name tags. They can contain or hold information or data of different kinds. Based on the kind of data they can hold, they have different datatypes and to distinguish them from one another they have names. Just as oil comes in a bottle and flour in a paper bag, PL/SQL will store numbers in variables of the NUMBER datatype and text in variables of the CHAR or VARCHAR2 datatypes. Taking it a step further, imagine the refrigerator in your company's break room. It's filled with brown paper bags that contain your lunch and the lunches of your coworkers. How will you find your noontime feast amongst all the other bags? Right! You'd put your name on the bag. Variables are given names, too, in order to avoid confusion. Further, if your lunch consisted of only bananas you may eat them and put the peels back into the brown paper bag. Now the contents of the bag have changed. Similarly, the contents of variables can be changed during the execution of PL/SQL statements.

Declare PL/SQL Variables

The syntax for declaring a variable in PL/SQL is either of the following:

```
variable_name data_type  [ [NOT NULL]  := default_value_expression];
variable_name data_type [ [NOT NULL] DEFAULT default_value_expression];
```

variable_name is any valid *PL/SQL identifier*. A valid PL/SQL identifier has the following properties:

- Up to 30 characters long and has no white space of any form in it (as space or tabs).
- Made up of letters, digits 0 to 9, underscore (_), dollar ($), and pound (#) signs.
- Starts with a letter.
- Is not the same as a *PL/SQL* or an *SQL reserved word,* which has special meaning for PL/SQL or SQL. For example, a variable name cannot be BEGIN. BEGIN has a special meaning telling PL/SQL that here starts the beginning of a basic block execution section.

The use of NOT NULL requires that the variable have a value and, if specified, the variable must be given a default value.

When a variable is created it can be made to have a value specified by the default value expression. It is just a shorthand way to assign values to variables.

You already know about SQL datatypes—NUMBER, VARCHAR2, and DATE. PL/SQL shares them with SQL. PL/SQL has additional datatypes that are not in SQL. For a complete list, please refer to Oracle PL/SQL references.

Declare PL/SQL Constants

The syntax for declaring a constant is the following:

```
variable_name data_type  CONSTANT  := constant_value_expression;
```

Unlike variables, constants must be given a value and that value cannot change during the life or scope of the constant. Constants are very useful for enforcing safe and disciplined code development in large and complex applications. For example, if you want to ensure that the data passed to a PL/SQL procedure is not modified by the procedure, you can make that data a constant. If the procedure tries to modify it, PL/SQL will return with an exception.

Assign Values to Variables

There are three ways a variable can get its value changed. First is the assignment of a valid expression to it using the PL/SQL assignment operator. You have seen a number of examples of this kind. The syntax is the following:

```
variable_name := expression ;
```

Second, a variable can be passed as the actual parameter corresponding to some IN OUT or OUT formal parameter when calling a PL/SQL procedure. After the procedure is finished, the value of the variable may change. The following example shows the named notation for calling procedures. Refer to Figure 8-3 for the expected output.

```
CREATE  PROCEDURE hike_prices (old_price NUMBER,
                               percent_hike NUMBER := 5,
                               new_price OUT NUMBER)
IS
BEGIN
        new_price := old_price + old_price * percent_hike / 100;
END hike_prices;
/
```

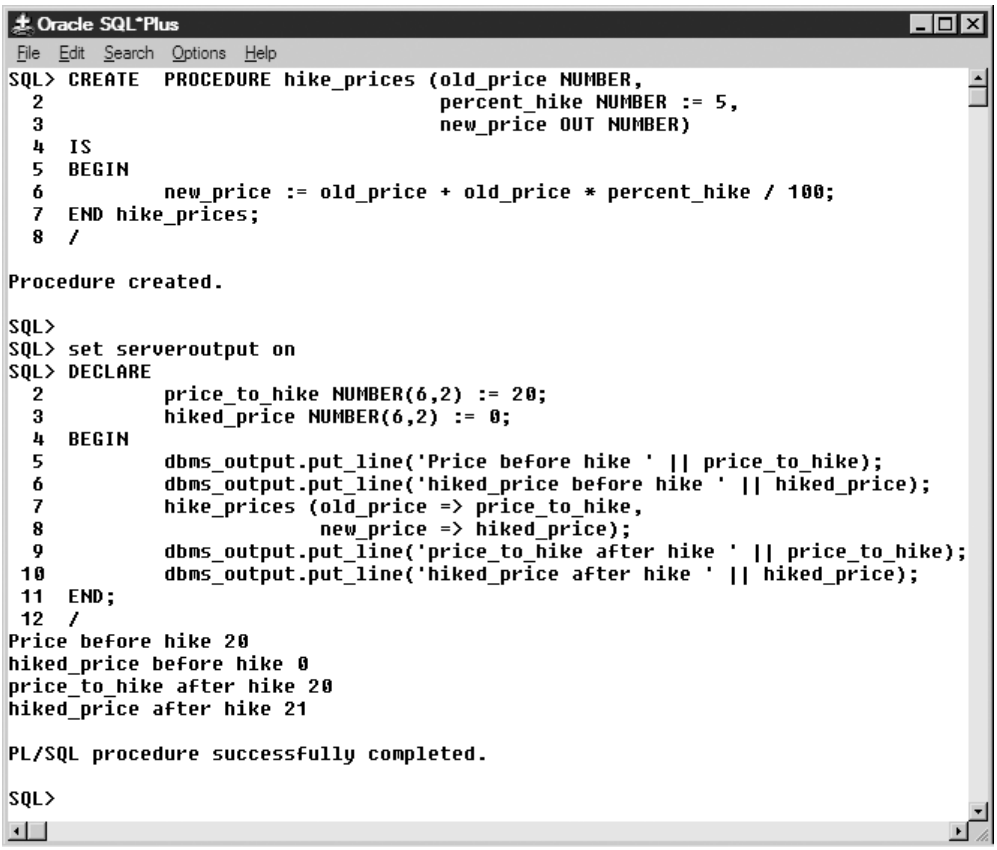


FIGURE 8-3. *Assign values to PL/SQL variables by using them as actual parameters*

The following procedure shows the variables changing their values:

```
set serveroutput on
DECLARE
        price_to_hike NUMBER(6,2) := 20;
        hiked_price NUMBER(6,2) := 0;
BEGIN
        dbms_output.put_line('Price before hike ' || price_to_hike);
        dbms_output.put_line('hiked_price before hike ' || hiked_price);
        hike_prices (old_price => price_to_hike,
                     new_price => hiked_price);
        dbms_output.put_line('price_to_hike after hike ' || price_to_hike);
        dbms_output.put_line('hiked_price after hike ' || hiked_price);
END;
/
```

The following is a quick example with Figure 8-4 showing the results:

```
set serveroutput on
DECLARE
product_quant        NUMBER;
BEGIN
      SELECT  quantity_on_hand
      INTO    product_quant
      FROM    plsql101_product
      WHERE   product_name = 'Small Widget';
dbms_output.put_line ('Small Widget ' || product_quant);
END;
/
```

product_quant is assigned the value equal to the quantity of small widgets.

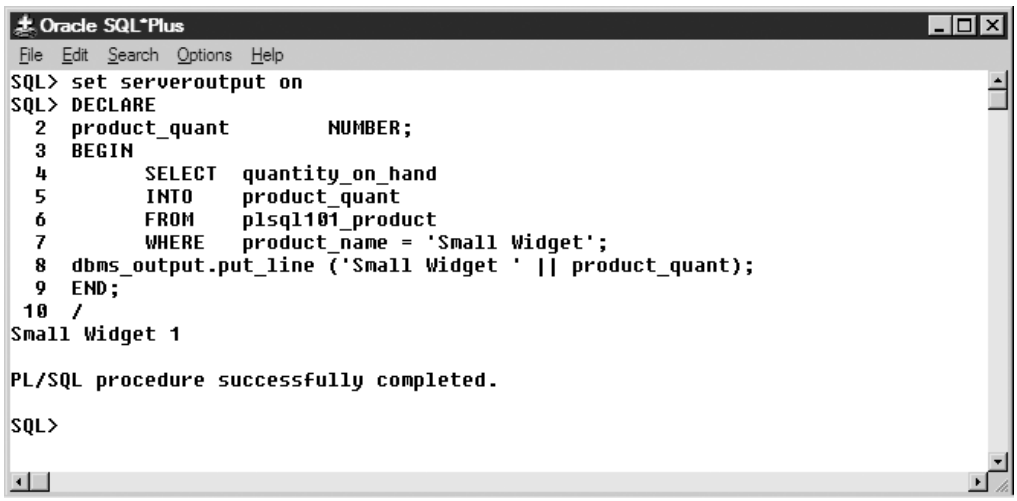


FIGURE 8-4. *Assign values to PL/SQL variables using SQL*

Use Variables

Variables are the very basic units of PL/SQL programs. They are used to hold results of computations, to return values from function calls, as actual parameters for calling functions and procedures, and so on. Variables should be used to make your application clean and easy to read, thereby creating a lower maintenance, more efficient program.

Suppose you want to perform a number of calculations using the current quantity of small widgets—compare it with the quantity from three months ago, or to the quantity of medium widgets. By using the variable to hold the value, you avoid the delay that would come from getting the quantity from the table again and again.

By naming variables in a way that makes sense to you, you can make your code easy to read and understand. The same principle applies when you use variables to hold the results of some very complex expressions instead of repeating the expressions in the code in multiple places.

Control Structures in PL/SQL

Many times you want to do one thing if something is true and something else if it is not true. For example, if a purchase order exceeds a certain dollar amount you would like to take 5 percent off the order, and maybe 10 percent off if the order exceeds some other amount. This kind of logic may be required inside your application that prints out the final invoice for your customers. This is *conditional processing* of data. Based on the condition, different parts of the code need to be executed.

Recall the case where you need to compute income tax for each employee. You need to complete a function for each employee, such as finding the earnings and filing status, and then apply the correct formula to find the tax. The correct formula differs for each employee based on filing status and all of the other factors. This is an example of an *iterative operation*.

PL/SQL provides you with the ability to do conditional and iterative processing. The constructs it provides are said to cause change of *program flow* and so control *the flow of the execution*.

IF Statement

The syntax for an IF statement is as follows:

```
IF condition_1 THEN
      actions_1;
[ELSIF condition_2 THEN
      actions_2;]
...
[ELSE
      actions_last;]
END IF;
```

actions_1 to *actions_last* represent one or more PL/SQL statements. Each set of statements gets executed only if its corresponding condition is true. When one of the IF conditions is determined to be true, the rest of the conditions are not checked.

Enter the following example and see that your results match those of Figure 8-5:

```
-- Compute discounts on orders.
-- Input order amount. Returns discount amount (zero for wrong inputs).
CREATE FUNCTION compute_discounts (order_amt NUMBER)
RETURN NUMBER IS
        small_order_amt NUMBER := 400;
        large_order_amt NUMBER := 1000;
        small_disct NUMBER := 1;
        large_disct NUMBER := 5;
BEGIN
        IF (order_amt < large_order_amt
            AND
            order_amt >= small_order_amt)
        THEN
             RETURN (order_amt * small_disct / 100);
        ELSIF (order_amt >= large_order_amt)
        THEN
              RETURN (order_amt * large_disct / 100);
        ELSE
              RETURN(0);
        END IF;
END compute_discounts;
/
```

This function will give a 1 percent discount for orders between 400 and 1000 and a 5 percent discount on orders above 1000. It will return zero for all other amounts including wrong values. For example, someone may try to use a negative value for *order_amt*, which is meaningless.

Observe at the start how the function is clearly documented. You should always consider all possibilities when writing your code and either clearly state in your documentation what you are going to do about error conditions or, if the conditions are severe enough, give appropriate error messages. Suppose in our case—however unimaginable it is—that this function may be called with a negative value for the *order_amt*, we have documented what the function will do in such a case.

You can test the function by calling it in an anonymous block. Be sure you have serveroutput on. Refer once again to Figure 8-5 for this example.

```
set serveroutput on
DECLARE
        tiny NUMBER := 20;
        med NUMBER := 600;
        big NUMBER := 4550;
        wrong NUMBER := -35;
BEGIN
        dbms_output.put_line (' Order     AND      Discount ');
```

```
        dbms_output.put_line (tiny || ' ' || compute_discounts(tiny));
        dbms_output.put_line (med || ' ' || compute_discounts (med));
        dbms_output.put_line (big || ' ' || compute_discounts (big));
        dbms_output.put_line (wrong || ' ' || compute_discounts (wrong));
END;
/
```

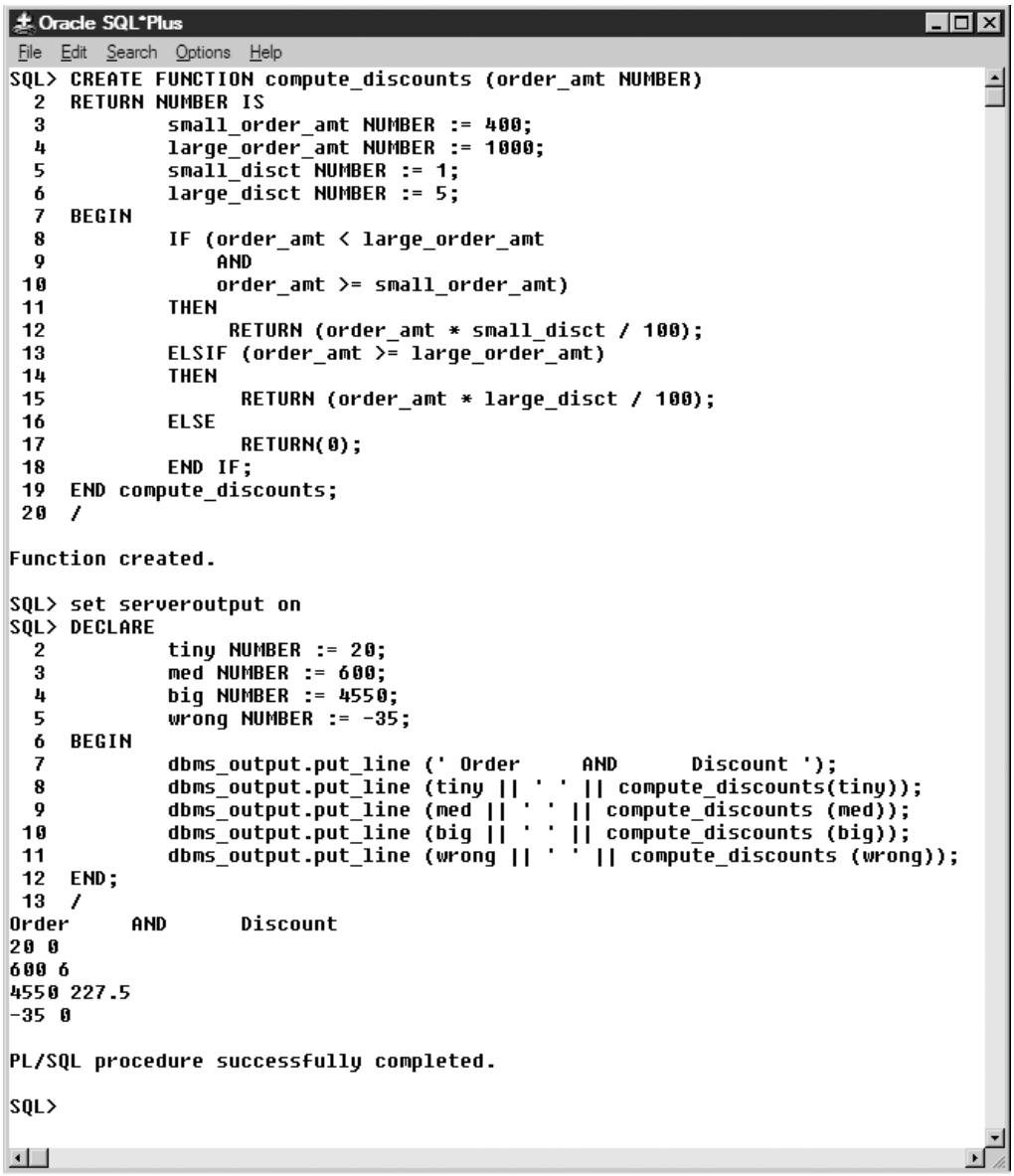


FIGURE 8-5. *Example of an IF statement*

Loops

PL/SQL provides three different iteration constructs. Each allows you to repeatedly execute a set of PL/SQL statements. You stop the repeated executions based on some condition.

LOOP

The syntax for the LOOP construct is as follows:

```
<<loop_name>>
LOOP
      statements;
      EXIT loop_name [WHEN exit_condition_expression];
      statements;
END LOOP ;
```

All the statements within the loop are executed repeatedly. During each repetition or *iteration* of the loop, the exit condition expression is checked for a positive value if the WHEN condition is present. If the expression is true, then the execution skips all statements following the EXIT and jumps to the first statement after END LOOP within the code. No more iterations are done. If the WHEN condition is not present, the effect is to execute statements between LOOP and EXIT only once. You will obviously be doing something illogical if you are not using the WHEN condition. After all, the idea of a loop is to potentially loop through the code.

Try out the following loop example and compare the results with Figure 8-6. It simply prints out the first ten numbers.

As usual, do not forget to set serveroutput on to see the output.

```
set serveroutput on
DECLARE
        just_a_num NUMBER := 1;
BEGIN
        <<just_a_loop>>
        LOOP
                dbms_output.put_line(just_a_num);
        EXIT just_a_loop
        WHEN (just_a_num >= 10);
                just_a_num := just_a_num + 1;
        END LOOP;
END;
/
```

Each iteration increments the variable *just_a_num* by 1. When 10 is reached, the exit condition is satisfied and the loop is exited.

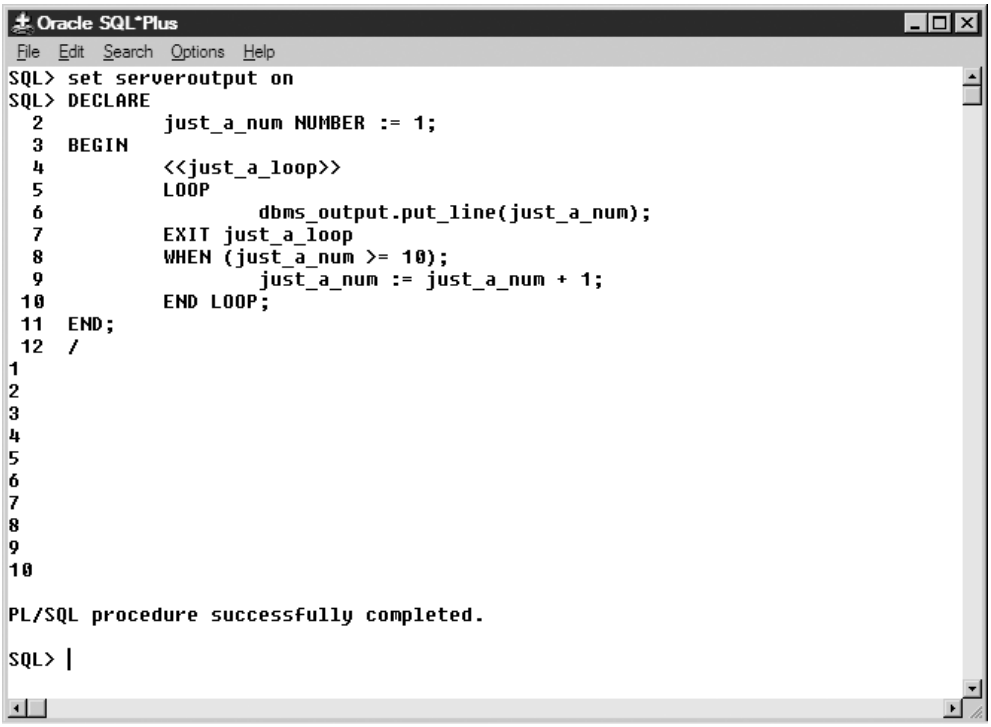


FIGURE 8-6. *Example of a simple LOOP*

WHILE Loop

Another type of loop is the WHILE loop. A WHILE loop is well suited for situations when the number of loop iterations is not known in advance, but rather is determined by some external factor. The syntax for a WHILE loop is as follows:

```
WHILE while_condition_expression
LOOP
      statements;
END LOOP;
```

Practice creating a WHILE loop by entering the following code. Your results should match those of Figure 8-7.

```
set serveroutput on
DECLARE
     just_a_num NUMBER := 1;
```

```
BEGIN
     WHILE (just_a_num <= 10) LOOP
          dbms_output.put_line(just_a_num);
          just_a_num := just_a_num + 1;
     END LOOP;
END;
/
```

NOTE
The condition for the WHILE must be true every time before entering the loop.

FOR Loop

The FOR loop uses a counter variable, also called a *loop index*, to count the number of iterations. The counter is incremented, starting from the lower limit specified, or decremented, starting from the upper limit specified, at the end of each iteration or loop. If it is out of the range, the looping stops. The syntax for the FOR loop is as follows:

FOR *counter* IN [REVERSE] *lower_bound .. upper_bound*
LOOP
    statements;
END LOOP;

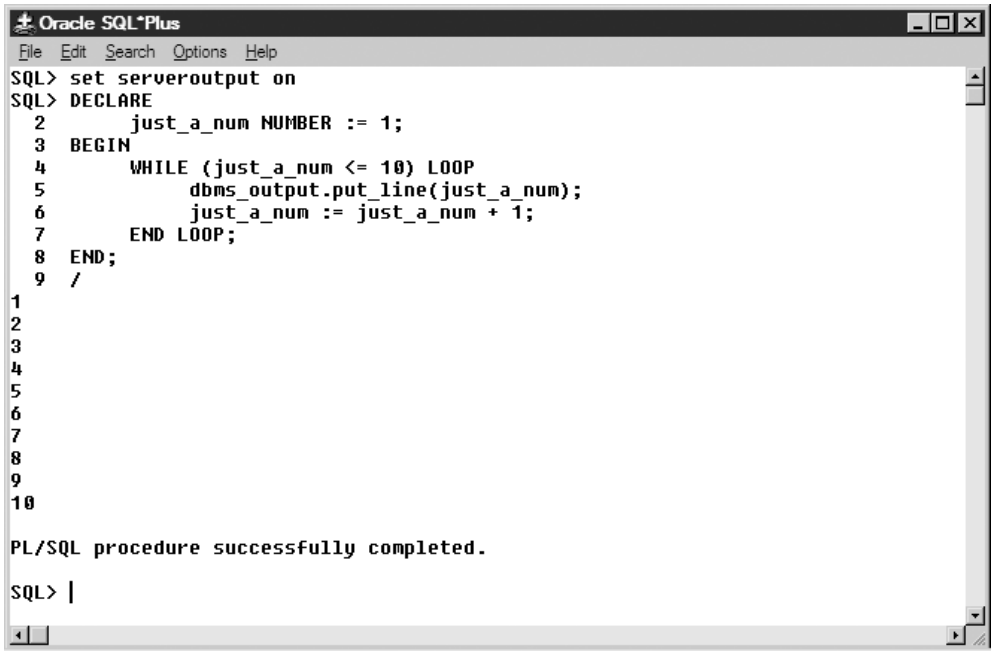


FIGURE 8-7. *Example of a WHILE loop*

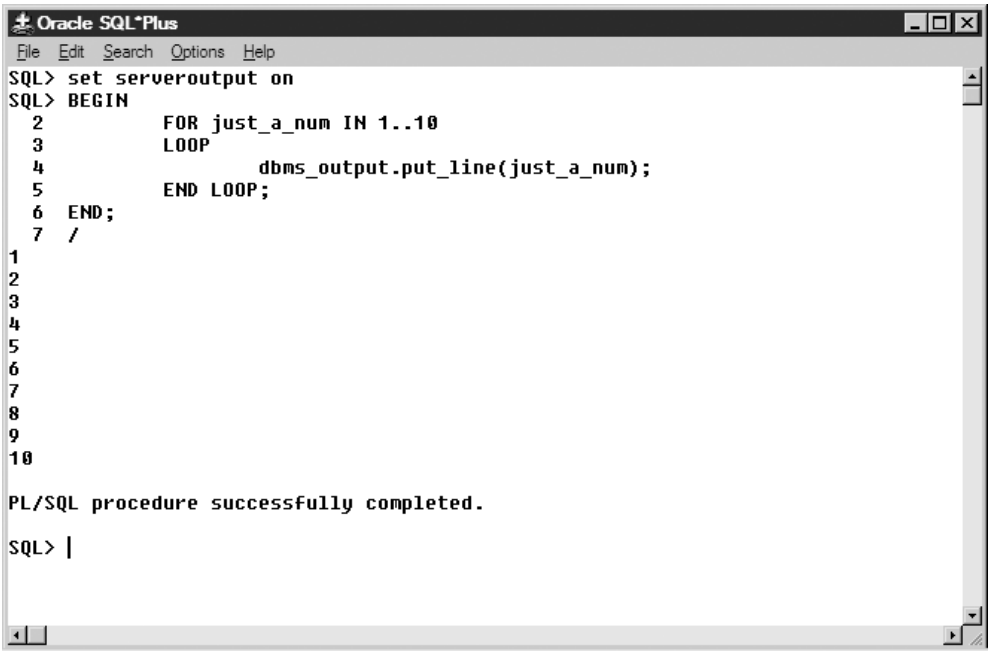


FIGURE 8-8. *Example of a FOR loop*

Now create your first FOR loop using the following code. Your results should match those of Figure 8-8.

```
set serveroutput on
BEGIN
        FOR just_a_num IN 1..10
        LOOP
                dbms_output.put_line(just_a_num);
        END LOOP;
END;
/
```

Now for fun and experience, try using the REVERSE command in your FOR loop. Your results should show the numbers in reverse order from 10 to 1.

Cursors

The cursor is an extremely important PL/SQL construct. It is the heart of PL/SQL and SQL cooperation and stands for "current set of records." A *cursor* is a special PL/SQL element that has an associated SQL SELECT statement. Using a cursor,

each row of the SQL statement associated with the cursor can be processed one at a time. A cursor is declared in the declaration section of a basic block. A cursor is opened using the command OPEN and rows can be fetched using the command FETCH. After all processing is done, the cursor is closed using the CLOSE command. Closing the cursor releases all of the system resources that were used while the cursor was open. You can lock the rows selected by a cursor to prevent other people from modifying them while you are using them. Closing the cursor or executing an explicit COMMIT or ROLLBACK will unlock the rows.

PL/SQL uses hidden or *implicit cursors* for SQL statements within PL/SQL code. We discuss them more in Chapter 9. In this section, we will focus on *explicit cursors*, which simply means cursors that have been assigned a name.

We will write a simple procedure that uses a cursor to compute the commissions for all salespersons. Before we do that, however, take a look at the syntax for an explicit cursor.

Cursor Declaration and Cursor Attributes

A cursor is declared within a PL/SQL procedure in the following manner:

```
CURSOR cursor_name [( [parameter1 [, parameter2 ...])]
[RETURN return_specification]
IS
    select_statement
        [FOR UPDATE
            [OF table_or_col1
                [, table_or_col2 ...]
            ]
        ]
;
```

The parameters are similar to procedure parameters, but they are all IN parameters. They cannot be OUT or IN OUT because the cursor cannot modify them. The parameters are used in the WHERE clause of the cursor SELECT statement. The return specification tells what type of records will be selected by the SELECT statement. You will learn more about PL/SQL records in Chapter 9. The *table_or_col* is a column name you intend to update or a table name from which you intend to delete or update rows; it must be taken from the names of tables and columns used within the cursor SELECT statement. It is used to clearly document what may potentially be modified by the code that uses this cursor. The FOR UPDATE commands lock the rows selected by the SELECT statement when the cursor is opened, and they remain locked until you close the cursor in the ways already discussed.

A cursor has some indicators to show its state and they are called *attributes of the cursor*. The attributes are shown in Table 8-1.

Attribute	Description
cursor_name%ISOPEN	Checks if the cursor is open. It returns TRUE if the cursor *cursor_name* is already open.
cursor_name%ROWCOUNT	The number of table rows returned by the cursor SELECT statement.
cursor_name%FOUND	Checks whether the last attempt to get a record from the cursor succeeded. It returns TRUE if a record was fetched.
cursor_name%NOTFOUND	Opposite of the FOUND attribute. It returns TRUE when no more records are found.

TABLE 8-1. *Cursor Attributes*

PL/SQL Records

Although PL/SQL records will be discussed in greater detail in Chapter 9, you'll need to know a little something about them before we proceed. So let's start with a brief introduction in this chapter.

A PL/SQL record is a collection of basic types of data and can be accessed as a single unit. You access the individual fields of the record using the *record_name.field_name* notation you are already familiar with for use with table columns. Records are of three types and you can declare variables of record types. The three types of records are the following:

- **Table-Based** This record has fields that match the names and types of the table columns. So if a cursor selects the entire row—by using SELECT* from *some_table,* for example—the records it returns can be directly copied into the variable of the table-based record type for *some_table*.
- **Cursor-Based** This record has fields that match in name, datatype, and order to the final list of columns in the cursor's SELECT statement.
- **Programmer-Defined** These are records in which you define a record type.

Use OPEN, FETCH, and CLOSE Cursor

The following is the syntax for opening, fetching from, and closing a cursor:

```
OPEN cursor_name;
FETCH cursor_name INTO record_var_or_list_of_var;
CLOSE cursor_name;
```

When opened, a cursor contains a set of records if the cursor's SELECT statement was successful and resulted in fetching selected rows from the database. Each FETCH then removes a record from the open cursor and moves the record's contents into either a PL/SQL variable—of a record type that matches the record type of the cursor record—or into a different set of PL/SQL variables such that each variable in the list matches in type with the corresponding field in the cursor record.

You will check if there are any more records left in the cursor before trying to fetch one from the cursor using the FOUND and NOTFOUND attributes of the cursor. Fetching from an empty cursor will fetch the last fetched record over and over again and will not give you any error. So make sure you use FOUND or NOTFOUND if you are using FETCH.

The actual processing of records from a cursor usually occurs within a loop. When writing the loop, it's a good idea to start by checking whether a record has been found in the cursor. If so, the code proceeds to perform whatever processing you need; if not, the code exits from the loop. There is a more compact way to do the same where PL/SQL takes care of opening, fetching, and closing without your needing to do it—the cursor FOR loop.

Cursor FOR Loop

The syntax for the cursor FOR loop is the following:

```
FOR cursor_record IN cursor_name LOOP
    statements;
END LOOP;
```

This cursor FOR loop continues fetching records from the cursor into the *cursor_record* record type variable. You can use *cursor_record* fields to access the data within your PL/SQL statements in the loop. When all the records are done, the loop ends. The cursor is automatically opened and closed for your convenience by PL/SQL.

You will receive an *invalid cursor* message if you try to fetch from a cursor that is not open. If you do not close cursors, you may end up eventually running into the maximum number of open cursors that the system allows.

WHERE CURRENT OF

When the cursor is opened in order to update or delete the rows it selects, you can use

```
WHERE CURRENT OF cursor_name
```

to access the table and row corresponding to the most recently fetched record in the WHERE clause of the UPDATE or DELETE statement. For example, to reduce the prices in the PLSQL101_PRODUCT table by 3 percent, type the following code and check your results against those in Figure 8-9.

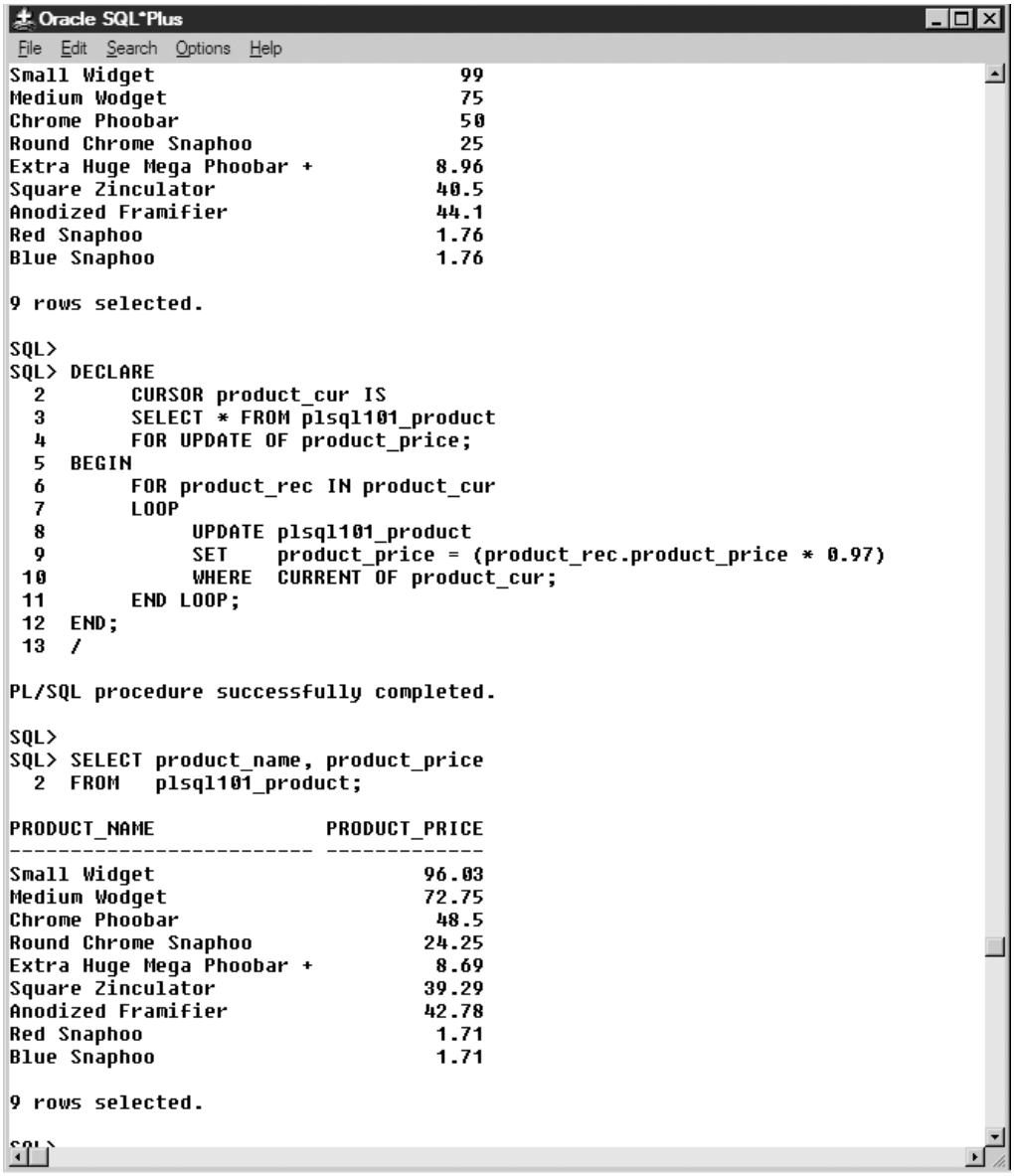


FIGURE 8-9. *Examples of a cursor FOR loop and WHERE CURRENT OF clause*

```
SELECT product_name, product_price
FROM   plsql101_product;

DECLARE
     CURSOR product_cur IS
```

```
     SELECT * FROM plsql101_product
     FOR UPDATE OF product_price;
BEGIN
     FOR product_rec IN product_cur
     LOOP
          UPDATE plsql101_product
          SET    product_price = (product_rec.product_price * 0.97)
          WHERE  CURRENT OF product_cur;
     END LOOP;
END;
/

SELECT product_name, product_price
FROM   plsql101_product;
```

Nested Loops and Cursor Example

The following code demonstrates complete use of cursors and loops within loops or *nested loops*. Enter the following code:

```
-- This procedure computes the commissions for salespersons.
-- It prints out the salesperson's code, his or her total sales,
-- and corresponding commission.
-- No inputs. No errors are reported and no exceptions are raised.
/* Logic: A cursor to create a join between PLSQL101_PRODUCT and
PLSQL101_PURCHASE on PRODUCT_NAME column is done.
The result is ordered by salesperson.
Outer loop starts with a new salesperson and inner loop
processes all rows for one salesperson.
*/
CREATE OR REPLACE PROCEDURE do_commissions IS
     commission_rate NUMBER  := 2   ;
     total_sale      NUMBER  := 0   ;
     current_person  CHAR(3) := ' ' ;
     next_person     CHAR(3)        ;
     quantity_sold   NUMBER  := 0   ;
     item_price      NUMBER  := 0   ;
     CURSOR sales_cur IS
          SELECT purc.salesperson,
                 purc.quantity,
                 prod.product_price
          FROM   plsql101_purchase purc,
                 plsql101_product  prod
          WHERE  purc.product_name = prod.product_name
          ORDER BY salesperson;
BEGIN
     OPEN sales_cur;
```

```
     LOOP
          FETCH sales_cur INTO
                next_person, quantity_sold, item_price;
          WHILE (next_person = current_person
                 AND
                 sales_cur%FOUND)
          LOOP
               total_sale :=
                     total_sale + (quantity_sold * item_price);
                FETCH sales_cur INTO
                     next_person, quantity_sold, item_price;
          END LOOP;
          IF (sales_cur%FOUND)
          THEN
               IF (current_person != next_person)
               THEN
                    IF (current_person != ' ' )
                    THEN
                         dbms_output.put_line
                            (current_person ||
                             ' ' ||
                             total_sale ||
                             ' ' ||
                             total_sale * commission_rate / 100);
                    END IF;
                    total_sale := quantity_sold * item_price;
                    current_person := next_person;
               END IF;
          ELSE IF (current_person != ' ')
          THEN
                 dbms_output.put_line(current_person ||
                              ' ' ||
                              total_sale ||
                              ' ' ||
                              total_sale * commission_rate / 100);
               END IF;
          END IF;
          EXIT WHEN sales_cur%NOTFOUND;
          END LOOP;
          CLOSE sales_cur;
     END do_commissions;
/
```

First, look at the cursor's SELECT statement. It lists, from the PLSQL101_PURCHASE table, the quantities of items sold. It also shows their corresponding prices from the PLSQL101_PRODUCT table. This is achieved by creating a join. The result is ordered by salesperson so that we have all of the records for a particular salesperson together.

Once the cursor is opened and the first row is fetched, the condition for WHILE is checked. The first FETCH command for the current person has a value that cannot match any salesperson code; recall that its default value is a single space ( ). Therefore, the loop is skipped and we jump to the first IF statement. The IF statement checks to see if the last FETCH command returned any records. If records were returned, a check is made to see whether the *current_person* and *next_person* values match. If they don't match, we know that the last FETCH is the start of a new salesperson and it is time to print out the commissions for the current salesperson. Note that the first record for *current_person* is not valid; therefore, the IF check will fail and nothing will print.

The next statement sets the value for *total_sale* to be equal to the cost for the very first product. The statement after that stores the *next_person* value into the *current_person* variable. Now we will be back to the first FETCH in the loop as the loop's EXIT condition is not yet true. This FETCH may result in the same value for *next_person* as the *current_person*, in which case we have more than one entry for the current person in our list of sales. When that is the case, the WHILE loop is entered and the cost for items is added to the total sale amount. This loop will keep adding costs by fetching new records from the cursor until a new salesperson is identified. This process repeats over and over until there are no records left in the cursor. At that point, the validity of the *current_person* is checked. If the *current_person* is valid, then the very last IF statement prints out sales and commissions for that person; the commissions are calculated using the value in the *commission_rate* constant.

To test the procedure, enter the following commands and compare your results with those in Figure 8-10. The first command shows the raw records in the PLSQL101_PURCHASE table, while the second command causes the DO_COMMISSIONS procedure to subtotal the sales in those records and calculate appropriate commissions for each salesperson.

```
SELECT purc.salesperson,
       purc.quantity,
       prod.product_price
FROM   plsql101_purchase purc,
       plsql101_product  prod
WHERE  purc.product_name = prod.product_name
ORDER BY salesperson;

set serveroutput on
EXECUTE do_commissions;
```

Error Handling

It is important to issue user-friendly error messages when error conditions occur. Earlier in this chapter, the section on basic PL/SQL blocks included a mention of exceptions; now it is time to get into more detail.

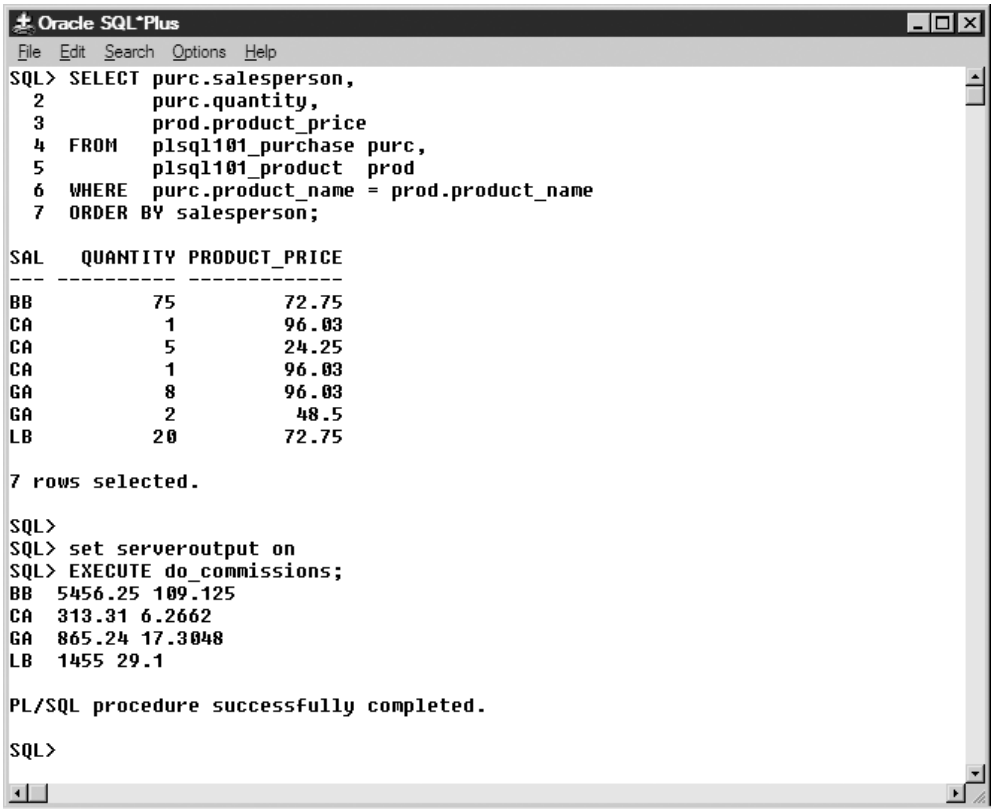


FIGURE 8-10. *Example of nested loops*

Exceptions

An exception is an error state that is activated—or *raised*—when a specific problem occurs. There are many different exceptions, each relating to a different type of problem. When an exception is raised, the code execution stops at the statement that raised the exception, and control is passed to the exception-handling portion of the block. If the block does not contain an executable section, PL/SQL tries to find an executable section in the *enclosing basic block,* which is an outer block of code surrounding the block in which the exception was raised. If the immediate enclosing block does not have an exception handler to accommodate the raised exception, then the search continues to the next enclosing block and so on until a proper exception handler is found or, if not found, execution is halted with an unhandled exception error.

The exception-handling portion of a block is the perfect opportunity to issue meaningful error messages and clean up anything that could cause confusion or trouble later. A typical cleanup could involve issuing the ROLLBACK statement if an exception is raised during a procedure that has inserted rows into a table.

Once control is passed to the exception handler, control is not returned to the statement that caused the exception. Instead, control is passed to the enclosing basic block at the point just after the enclosed block or procedure/function was called.

System-Defined Exceptions

You are familiar with the ZERO_DIVIDE exception predefined by PL/SQL. There are quite a few other system-defined exceptions that are detected and raised by PL/SQL or Oracle. Table 8-2 provides a more complete list of system-defined exceptions.

System-Defined Exception	Description
CURSOR_ALREADY_OPEN	Tried to open an already open cursor.
DUP_VAL_ON_INDEX	Attempted to insert duplicate value in column restricted by unique index to be unique.
INVALID_CURSOR	Tried to FETCH from cursor that was not open or tried to close a cursor that was not open.
NO_DATA_FOUND	Tried to SELECT INTO when the SELECT returns no rows (as well as other conditions that are outside the scope of this book).
PROGRAM_ERROR	Internal error. Usually means you need to contact Oracle support.
STORAGE_ERROR	Program ran out of system memory.
TIME_OUT_ON_RESOURCE	Program waited too long for some resource to be available.
TOO_MANY_ROWS	SELECT INTO in PL/SQL returns more than one row.
VALUE_ERROR	PL/SQL encountered invalid data conversions, truncations, or constraints on data.
ZERO_DIVIDE	Attempt at division by zero.
OTHERS	All other exceptions or internal errors not covered by the exceptions defined in the basic block. Used when you are not sure which named exception you are handling, but you do want to handle whichever exception was raised.

TABLE 8-2. *System-Defined Exceptions*

PL/SQL has two ways of showing information to a user about an error. One option is the use of the command SQLCODE, which returns the error code. An error code is a negative value that usually equals the value of the corresponding ORA error that would be issued if the exception remains unhandled when an application terminates. The other option returns a text message regarding the error. Not surprisingly, this command is SQLERRM. You can use both SQLCODE and SQLERRM in the exception handler. Note: not all system-defined exceptions are named.

Now try the previous example again, but this time use SQLCODE and SQLERRM. Enter the following code and compare your results with those shown in Figure 8-11.

```
set serveroutput on
DECLARE
     Num_a NUMBER := 6;
     Num_b NUMBER;
BEGIN
     Num_b := 0;
     Num_a := Num_a / Num_b;
     Num_b := 7;
     dbms_output.put_line(' Value of Num_b ' || Num_b);
EXCEPTION
     WHEN ZERO_DIVIDE THEN
          DECLARE
               err_num NUMBER        := SQLCODE;
               err_msg VARCHAR2(512) := SQLERRM;
          BEGIN
               dbms_output.put_line('ORA Error Number '  || err_num );
               dbms_output.put_line('ORA Error message ' || err_msg);
               dbms_output.put_line(' Value of Num_a is '   || Num_a);
               dbms_output.put_line(' Value of Num_b is '   || Num_b);
          END;
END;
/
```

Programmer-Defined Exceptions

One handy feature of PL/SQL is that it allows you to create your own exception conditions and names. When raising and handling your own exceptions, they must be named and declared just like any other PL/SQL entity.

Here is a complete example of how to name and define your own exception. Enter the following code and compare your results with those shown in Figure 8-12:

```
set serveroutput on
DECLARE
     quantity1 NUMBER := -2;
     quantity2 NUMBER := 3;
     total NUMBER := 0;
     quantity_must_positive EXCEPTION;
     FUNCTION find_cost (quant NUMBER) RETURN NUMBER IS
```

```
     BEGIN
          IF (quant > 0)
          THEN
               RETURN(quant * 20);
          ELSE
               RAISE quantity_must_positive;
          END IF;
     END find_cost;
BEGIN
     total := find_cost (quantity2);
     total := total + find_cost(quantity1);
EXCEPTION
     WHEN quantity_must_positive
     THEN
          dbms_output.put_line('Total until now: ' || total);
          dbms_output.put_line('Tried to use negative quantity ');
END;
/
```

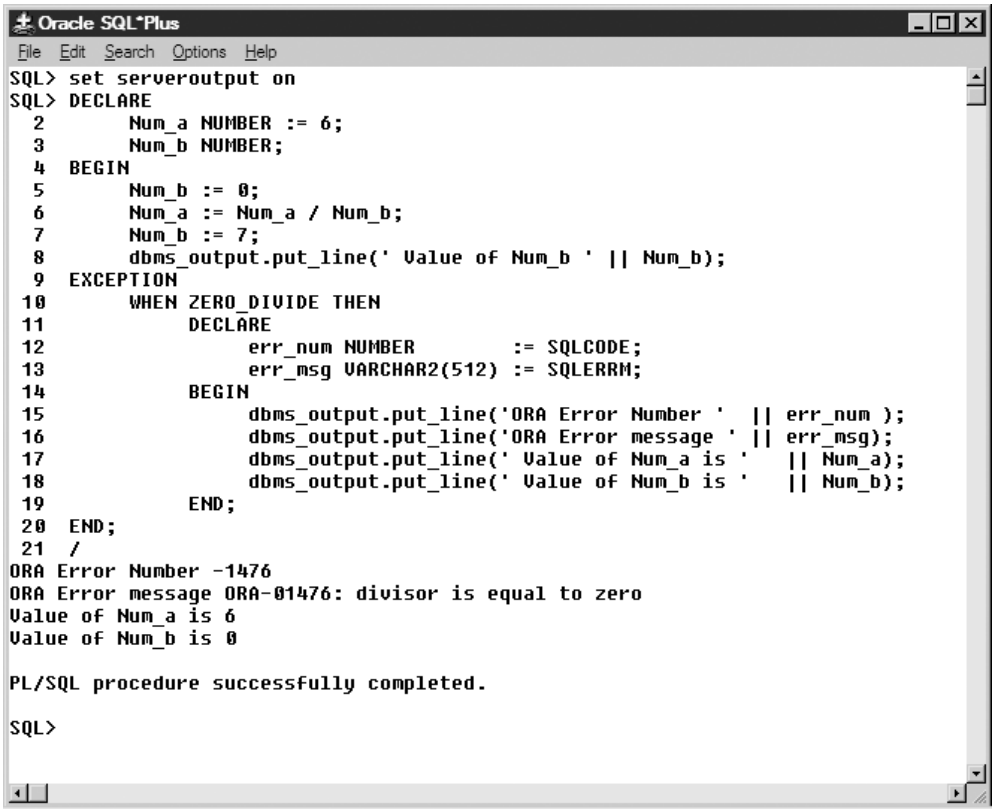


FIGURE 8-11. *Using SQLCODE and SQLERRM for system-defined exceptions*

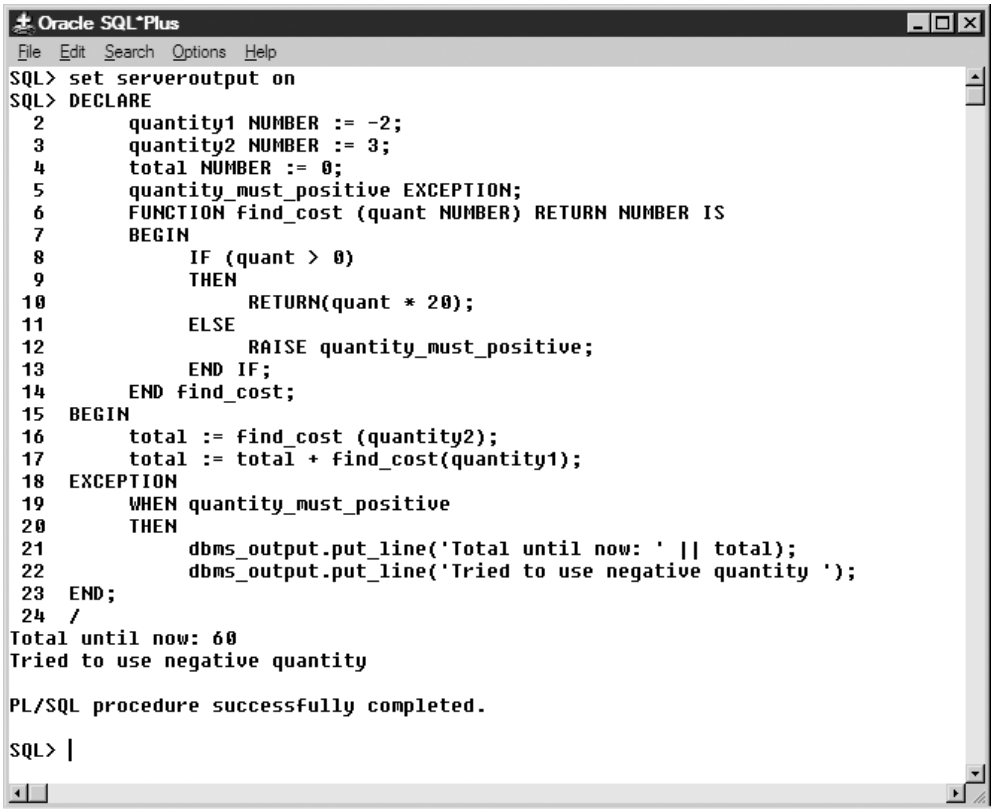


FIGURE 8-12. *Programmer-defined exception*

The exception is declared in the declaration section. Just like any other PL/SQL variable declared there, the life of the exception is valid only for this block. Since *find_cost* is also in this block, or is enclosed by this block, it can use the exception name. If the same function was defined as, say, a stored function, then you could not use the same exception name.

You can use your own exceptions for application-specific exception conditions that otherwise cannot be detected by the system or have no meaning for the system. For example, the system does not know that quantities ordered must be positive integer values. Your application should know this, however, and you can enforce it by catching values that are not positive integers as an exception while doing computations based on quantities. This is a very simple example, but you can imagine and will certainly come across more complex cases in real-life applications.

Chapter Summary

This chapter served as an introduction to the wonderful world of PL/SQL—a powerful programming language that works hand in hand with SQL. We explored PL/SQL variables. PL/SQL variables are used to hold the results of computations and to carry those results from one computation task to another.

We discussed the aspects of the PL/SQL basic block. All PL/SQL program units are made up of one or more basic blocks. A basic block is made up of header, declaration, execution, and exception sections. The header section contains identifying information for the block. For anonymous blocks, the header section is empty. The declaration section contains declarations for variables, constants, exceptions, cursors, functions, and procedures to be used within the block's execution and exception sections; if none of these are used, the declaration section will be empty. The execution section contains PL/SQL executable statements. The execution section is not optional and must be present to form a block. The exception section is used to handle error, or exception, conditions occurring within the execution section. This includes exceptions that may not be handled within any enclosed or nested blocks and within functions or procedures called.

We discussed how to create and call functions and procedures. You learned the meaning and use of formal and actual parameters.

Recall that PL/SQL program flow control constructs allow you to conditionally execute a piece of code once or repeatedly. The IF statement allows conditional execution once. The LOOP, WHILE loop, and FOR loop allow for repeated execution of the same set of statements. Cursors are the means for PL/SQL to communicate with SQL and hence the database. The cursor FOR loop allows you to process rows of tables one at a time.

Finally, you learned how to define your own exceptions and to raise or handle them by issuing friendly error messages. Another option is to remove what's causing the error and try again to create a successful program.

We have covered a lot of ground in this chapter, which is the foundation for Chapter 9. You are probably eager to play with PL/SQL's powerful features. Have some fun, and then jump right into the next chapter.

Chapter Questions

1. **Which of the following are true about PL/SQL procedures and functions?**

   A. There is no difference between the two.

   B. A function has a return type in its specification and must return a value specified in that type. A procedure does not have a return type in its specification and should not return any value, but it can have a return statement that simply stops its execution and returns to the caller.

C. Both may have formal parameters of OUT or IN OUT modes, but a function should not have OUT or IN OUT mode parameters.

D. Both can be used in a WHERE clause of a SQL SELECT statement.

2. Which is the correct output for a run of the following code sample?

```
<<outer_block>>
DECLARE
    scope_num NUMBER := 3;
BEGIN
    DECLARE
        scope_num NUMBER := 6;
        Num_a     NUMBER := outer_block.scope_num;
    BEGIN
        dbms_output.put_line(scope_num);
        dbms_output.put_line(Num_a);
    END;
    dbms_output.put_line(scope_num);
END;
```

A. 6 3 3

B. Gives error saying duplicate declaration and aborts execution

C. 3 3 3

D. 6 3 6

3. Which of the following is true about IF statements?

A. At most, one set of executable statements gets executed corresponding to the condition that is TRUE. All other statements are not executed.

B. It depends. Sometimes more than one set of statements gets executed as multiple conditions may be TRUE and then statements for each of them should get executed.

4. Which of the following LOOPs will be entered at least once?

A. Simple LOOP

B. WHILE loop

C. FOR loop

D. Cursor FOR loop

5. **Which one of the following is not true about exceptions?**

   A. Exceptions raised within the declaration section are to be handled in the enclosing block, if you want to handle them.

   B. Statements in the execution section just after the statement responsible for raising exceptions are executed once the exception handler has finished execution.

   C. When the system raises exceptions and they are not handled by the programmer, all the committed changes made to database objects—like tables by the execution section within which the exception occurred—are not automatically rolled back by the system.

   D. Exceptions raised within a called procedure not handled by the procedure will roll back the changes done to IN OUT or OUT parameters by the procedure before the exception occurred.

Answers to Chapter Questions

1. B, C. A function has a return type in its specification and must return a value specified in that type. A procedure does not have a return type in its specification and should not return any value, but it can have a return statement that simply stops its execution and returns to the caller.
   Both may have formal parameters of OUT or IN OUT modes, but a function should not have OUT or IN OUT mode parameters.

Explanation A is certainly not true. D is false because procedures do not return values whereas functions do by utilizing the WHERE clause. Functions compute and return a single value, but do not modify its inputs so C is true. B is true as a matter of PL/SQL legal syntax.

2. A. 6 3 3

Explanation This is an example of scope. The outer block *scope_num* is overridden inside the inner block by its own *scope_num*. Thus the value for *scope_num* inside the inner block is 6. This inner *scope_num* is not visible to the outer block, so once the inner block has run, the *scope_num* used is the outer *scope_num* resulting in the last value of 3. To get at the outer *scope_num,* we use the label name inside the inner block while assigning value to Num_a.

3. A. At most, one set of executable statements gets executed corresponding to the condition that is TRUE. All other statements are not executed.

Explanation The IF, ELSE, and ELSIF constrain the execution so that the conditions are mutually exclusive. Only one statement can be true. When no statements are true, no statements are executed.

4. A. Simple LOOP

Explanation The simple LOOP checks the condition for exiting the loop inside the loop body so it must get inside at least once. All other loops check the condition before entering the loop.

5. B. Statements in the execution section just after the statement responsible for raising exceptions are executed once the exception handler has finished execution.

Explanation If not handled, exceptions will abort the execution of the execution section and return control to the enclosing block. Therefore, the statements in the culprit execution section after the statement that raises exception will not be executed. All other choices are true.

CHAPTER 9

More PL/SQL Tools

The previous chapter covered many of the PL/SQL basics. You can now write complete PL/SQL procedures and functions. You can also use cursors to interact with the database. This chapter focuses on implicit cursors and triggers and further explores functions and procedures. This chapter introduces PL/SQL packages as well as demonstrates how to interact with Oracle using non-Oracle products. Specifically, you will see how to transfer data between an Oracle database and Microsoft's Access and Excel products. You will also learn how to measure program execution speed and determine the amount of time a process takes to complete. Then it will be time to get down and dirty—time to write interesting, useful projects. We'll begin the chapter by discussing what it takes to turn ordinary code into truly stellar programming by covering code-writing conventions.

Take a minute or two now for a self-check. You need to be well versed in the content of Chapter 8 before continuing with Chapter 9. Are you ready? If you feel you need to review, by all means, take the time now to reread Chapter 8 before delving into this fun- and fact-filled chapter. Also, if you haven't created the tables and other database objects that were in Chapter 8, you'll need to do that now. You can use the following SQL script to create those objects.

```
DROP TABLE plsql101_purchase;
DROP TABLE plsql101_product;
DROP TABLE plsql101_person CASCADE CONSTRAINTS;
DROP TABLE plsql101_old_item;
DROP TABLE plsql101_purchase_archive;
DROP TABLE plsql101_audit;

CREATE TABLE plsql101_person (
     person_code VARCHAR2(3) PRIMARY KEY,
     first_name  VARCHAR2(15),
     last_name   VARCHAR2(20),
     hire_date   DATE
     )
;

CREATE INDEX plsql101_person_name_index
ON plsql101_person(last_name, first_name);

ALTER TABLE plsql101_person
ADD CONSTRAINT plsql101_person_unique UNIQUE (
     first_name,
     last_name,
     hire_date
     )
;
```

```
INSERT INTO plsql101_person VALUES
     ('CA', 'Charlene', 'Atlas', '01-FEB-05');
INSERT INTO plsql101_person VALUES
     ('GA', 'Gary', 'Anderson', '15-FEB-05');
INSERT INTO plsql101_person VALUES
     ('BB', 'Bobby', 'Barkenhagen', '28-FEB-05');
INSERT INTO plsql101_person VALUES
     ('LB', 'Laren', 'Baxter', '01-MAR-05');
INSERT INTO plsql101_person VALUES
     ('LN', 'Linda', 'Norton', '01-JUN-06');

CREATE TABLE plsql101_product (
     product_name     VARCHAR2(25) PRIMARY KEY,
     product_price    NUMBER(4,2),
     quantity_on_hand NUMBER(5,0),
     last_stock_date  DATE
     )
;

ALTER TABLE plsql101_product ADD CONSTRAINT positive_quantity CHECK(
     quantity_on_hand IS NOT NULL
     AND
     quantity_on_hand >=0
     )
;

INSERT INTO plsql101_product VALUES
     ('Small Widget', 99, 1, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Medium Wodget', 75, 1000, '15-JAN-05');
INSERT INTO plsql101_product VALUES
     ('Chrome Phoobar', 50, 100, '15-JAN-06');
INSERT INTO plsql101_product VALUES
     ('Round Chrome Snaphoo', 25, 10000, null);
INSERT INTO plsql101_product VALUES
     ('Extra Huge Mega Phoobar +',9.95,1234,'15-JAN-07');
INSERT INTO plsql101_product VALUES ('Square Zinculator',
     45, 1, TO_DATE('December 31, 2005, 11:30 P.M.',
                    'Month dd, YYYY, HH:MI P.M.')
     )
;
INSERT INTO plsql101_product VALUES (
     'Anodized Framifier', 49, 5, NULL);
INSERT INTO plsql101_product VALUES (
     'Red Snaphoo', 1.95, 10, '31-DEC-04');
INSERT INTO plsql101_product VALUES (
     'Blue Snaphoo', 1.95, 10, '30-DEC-04')
;
```

```
CREATE TABLE plsql101_purchase (
     product_name  VARCHAR2(25),
     salesperson   VARCHAR2(3),
     purchase_date DATE,
     quantity      NUMBER(4,2)
     )
;

ALTER TABLE plsql101_purchase
ADD PRIMARY KEY (product_name,
                 salesperson,
                 purchase_date
                 )
;

ALTER TABLE plsql101_purchase
ADD CONSTRAINT reasonable_date CHECK(
     purchase_date IS NOT NULL
     AND
     TO_CHAR(purchase_date, 'YYYY-MM-DD') >= '2006-06-30'
     )
;

ALTER TABLE plsql101_purchase
ADD CONSTRAINT plsql101_purchase_fk_product FOREIGN KEY
     (product_name) REFERENCES plsql101_product;

ALTER TABLE plsql101_purchase
ADD CONSTRAINT plsql101_purchase_fk_person FOREIGN KEY
     (salesperson) REFERENCES plsql101_person;

CREATE INDEX plsql101_purchase_product
ON plsql101_purchase(product_name);

CREATE INDEX plsql101_purchase_salesperson
ON plsql101_purchase(salesperson);

INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'CA', '14-JUL-06', 1);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'BB', '14-JUL-06', 75);
INSERT INTO plsql101_purchase VALUES
     ('Chrome Phoobar', 'GA', '14-JUL-06', 2);
INSERT INTO plsql101_purchase VALUES
     ('Small Widget', 'GA', '15-JUL-06', 8);
INSERT INTO plsql101_purchase VALUES
     ('Medium Wodget', 'LB', '15-JUL-06', 20);
```

```
INSERT INTO plsql101_purchase VALUES
     ('Round Chrome Snaphoo', 'CA', '16-JUL-06', 5);
INSERT INTO plsql101_purchase VALUES (
     'Small Widget', 'CA', '17-JUL-06', 1)
;

UPDATE plsql101_product
SET    product_price = product_price * .9
WHERE  product_name NOT IN (
       SELECT DISTINCT product_name
       FROM   plsql101_purchase
       )
;

CREATE TABLE plsql101_purchase_archive (
     product_name  VARCHAR2(25),
     salesperson   VARCHAR2(3),
     purchase_date DATE,
     quantity      NUMBER(4,2)
     )
;

INSERT INTO plsql101_purchase_archive VALUES
     ('Round Snaphoo', 'BB', '21-JUN-04', 10);
INSERT INTO plsql101_purchase_archive VALUES
     ('Large Harflinger', 'GA', '22-JUN-04', 50);
INSERT INTO plsql101_purchase_archive VALUES
     ('Medium Wodget', 'LB', '23-JUN-04', 20);
INSERT INTO plsql101_purchase_archive VALUES
     ('Small Widget', 'ZZ', '24-JUN-05', 80);
INSERT INTO plsql101_purchase_archive VALUES
     ('Chrome Phoobar', 'CA', '25-JUN-05', 2);
INSERT INTO plsql101_purchase_archive VALUES
     ('Small Widget', 'JT', '26-JUN-05', 50);
```

Coding Conventions

Throughout this book, you have seen a systematic choice of fonts, distance between the lines and words, the way pages are numbered, and the way figures are shown. A specific font size has been used for all the chapter headings. Font sizes have not changed arbitrarily from chapter to chapter. These formatting choices were made, of course, to create an organized, easy-to-read body of text. When writing code, a good programmer will use standard formatting practices—or *conventions*—in order for his or her program to be easily understood. Table, index, function, and procedure names were chosen carefully throughout this book. Attempts were made to be as descriptive

as possible when choosing names so that those names would reflect the purpose of the entity. For example, the purpose of the function named COMPUTE_DISCOUNTS in Chapter 8 was to—you got it—compute discounts.

Most real-life applications are made up of hundreds and thousands of program pieces or modules and can easily run into a few hundred thousand lines of code and many times even millions of lines of code. Usually, several developers work on a piece of code together. The code keeps changing as time goes by. Developers come and go and new developers need to be able to understand and modify old code without disabling an existing application. Such a disruption could cause a critical activity, such as the day-to-day activities of a major financial institution, to come to a screeching halt. If each developer wrote code in a style of his or her whims, that type of shutdown is exactly the sort of thing that could happen because the varying styles of code would become difficult—if not impossible—to read. Utilizing coding conventions helps standardize the code. In fact, conventions are so vitally important for successful long-term development that many organizations have special departments and committees devoted only to developing and enforcing a set of conventions.

Even if you're the only person who reads your code, you'll regret not using standard conventions once you've been away from the program long enough to forget its finer (and sometimes not-so-fine) points.

Some of the conventions you've seen in this book so far are the following:

- All SQL and PL/SQL commands are in uppercase.
- All names are in lowercase.
- For SQL, each logical piece of the statement starts on a separate line. For example, the list of columns in a SELECT statement starts with the SELECT command on a line of its own, each column name is on a line of its own, and so on.
- Similar rules are followed in PL/SQL. Function and procedure specifications stand out from the body. The indentation for nested blocks clearly indicates block boundaries.
- A space is always placed after the comma.

When writing code, keep in mind the conventions outlined in this chapter as well as other factors, such as clear, self-explanatory object names, the 30-character limit on object names, and the maximum screen width (if your code lines are longer than the screen width they will either get chopped off or wrap around in an ugly, hard-to-read fashion on the screen). Take a few minutes to look at the previous chapters, and you will notice how coding conventions such as these were used.

More on PL/SQL and Oracle Server Interaction

You've already learned to use explicit cursors to fetch and modify data in the database. In this section, we'll further explore PL/SQL records and how they are used with cursors. Then you'll read about using implicit cursors within PL/SQL. Finally, we will consider which type of cursor—implicit or explicit—is better to use in a given situation.

Allow me to return to the restaurant analogy for a moment. Imagine a kitchen with two chefs. One chef is tasked with getting raw food items out of the refrigerator and placing them on a tray in an arrangement that makes sense for the dish being prepared. The second chef takes the items from the tray, submits those items to cooking steps such as peeling, chopping, boiling, and spicing, and then places the prepared items back on the tray. At this point, the first chef takes the prepared items from the tray and gives them to a food server.

This analogy actually matches what goes on inside a PL/SQL procedure. (I realize this may seem like a stretch, but stay with me.) The first chef's actions—taking raw items out of storage, making them available for processing, and moving the processed items to the person who will serve them—match those taken by SQL in a procedure when it retrieves data from a table, filters and sorts it, and makes it available to PL/SQL. The second chef's actions—processing the raw food into desired results—match what PL/SQL does. The tray that the two chefs use to move food back and forth between each other is analogous to cursors.

Whenever PL/SQL and SQL interact, they do so via a cursor. When we give the cursor a name by declaring it, it is an *explicit cursor*. When PL/SQL creates a cursor on its own to handle an operation, it is called an *implicit cursor*. (You'll read more about implicit cursors soon.)

Declare Variable Types Dynamically and PL/SQL Records

In Chapter 8, you fetched data from a cursor into PL/SQL variables. In this chapter, PL/SQL records will be put to work to do some cool stuff. As you have seen, PL/SQL records allow you to gather different pieces of data into a single unit, hiding the complexity of the data. It's also less convenient to pass several PL/SQL variables than it is to use one record whose fields can contain the information from all of your variables.

The concept is similar to that of the large crates that revolutionized the shipping industry. Each crate can hold a myriad of goods that can be transported all at once. When you want to add or remove something from the inventory, all you do is open

the crate and put the object in or take the object out. The crane that moves the crate from one place to another doesn't need to do anything differently. Similarly, a PL/SQL program unit specification doesn't necessarily need to change if the structure of a record it uses changes. If the changes to the record do not affect the data being used by your program, then the program does not need to change. For example, if a function takes a record but only uses the first two fields of it, the function does not need to change if you add a third field to the record. The function does need to change, however, if you remove the record's first field. This is very convenient and important in real applications.

PL/SQL has another very powerful feature: the dynamic type—or *anchored variable type*—declaration for PL/SQL variables that automates finding out which stored PL/SQL program units need to change if the database objects they depend on have changed. PL/SQL will try to compile all those program units automatically and the ones that fail to compile will be put in an unusable or invalid state. If you try to use an invalid program unit you will get an error. You can then modify that unit to make it conform to the changes to the database objects. For example, if a stored function used a record based on a table and you removed a column from the table that the function was using, you will need to rewrite the function body.

Imagine you want to create a record that has the same fields as the columns in a single row of a table, or you want to create a variable that has the same type as a column in a table, or you want a record that has the same fields as the columns selected by a cursor. Well, lucky for you, PL/SQL has ways of allowing you to do all of those things:

- Syntax to declare a PL/SQL variable of a column type:

  1. *variable_name table_name.column_name*%TYPE ;

- Syntax to declare a record with fields that are the same as a row in a table:

  1. *record_name table_name*%ROWTYPE ;

- Syntax to declare a record with fields that are the same as columns in a cursor:

  1. *record_name cursor_name*%ROWTYPE ;

In a cursor FOR loop, we use a cursor-based record that is automatically created by PL/SQL for us. All we do is give it a name. The example record given in Chapter 8 that reduces prices uses the name product_rec. It has fields that match the order, name, and type of the columns selected by the cursor.

To create your own record, you need to first tell PL/SQL what the name of the record is going to be, followed by what the structure will be for the record. To do this, use the following syntax in the declaration section:

TYPE *record_type_name IS*
(field_1_name field_1_type,
field_2_name field_2_type,
...
);

The actual declaration of the record follows:

record_variable record_type_name;

The following example puts all the pieces together. Create the following SQL script and run it in SQL*Plus®, then compare your results with Figure 9-1.

```
/* Performance is current average per order amount as a percentage of
   the  historical average per order sale amount for a salesperson.
   Status returns the status of errors if any.
*/
SET SERVEROUTPUT ON
DECLARE
    TYPE performance_type IS RECORD
        (person_code      plsql101_person.person_code%TYPE,
         person_name      plsql101_person.last_name%TYPE,
         current_sales    NUMBER(8,2),
         perform_percent  NUMBER(8,1),
         status           varchar2(30)
        );

    one_perform performance_type;

    CURSOR person_cur IS
        SELECT *
        FROM   plsql101_person;

    /* This procedure computes the performance and current total sales
     by one salesperson. The information for the salesperson is
     passed in as a record named a_person. If there are no sales for
     the day by the person then current_sales is set to zero. If the
     person has no history, for example, the person just joined today,
     then the perform_percent is set to zero.
     */
```

```
PROCEDURE current_performance
    (a_person plsql101_person%ROWTYPE,
     a_perform OUT performance_type)
IS
    CURSOR history_cur (person varchar2) IS
        SELECT   AVG(tab2.product_price * tab1.quantity) avg_order
        FROM     plsql101_purchase_archive tab1,
                 plsql101_product tab2
        WHERE    tab1.product_name = tab2.product_name
        GROUP BY tab1.salesperson
        HAVING   tab1.salesperson = person;

    hist_rec history_cur%ROWTYPE;
    current_avg_sales NUMBER(8,2) := 0;

BEGIN
    a_perform.person_code := a_person.person_code;
    a_perform.person_name := a_person.last_name;
    a_perform.status := NULL;

    BEGIN
        SELECT   SUM(tbl2.product_price * tbl1.quantity),
                 AVG(tbl2.product_price * tbl1.quantity)
        INTO     a_perform.current_sales,
                 current_avg_sales
        FROM     plsql101_purchase tbl1,
                 plsql101_product tbl2
        WHERE    tbl1.product_name = tbl2.product_name
        GROUP BY tbl1.salesperson
        HAVING   tbl1.salesperson = a_person.person_code;
    EXCEPTION
        WHEN NO_DATA_FOUND
        THEN
            a_perform.status := 'Current purchases exception';
            a_perform.current_sales := 0;
    END;

    OPEN history_cur (a_person.person_code);
    FETCH history_cur INTO hist_rec;
    IF (history_cur%NOTFOUND)
    THEN
        a_perform.perform_percent := 0;
        IF (a_perform.status IS NULL)
        THEN
            a_perform.status := 'Erroneous or no history';
        END IF;
```

```
        ELSE
            a_perform.perform_percent :=
                 100 * (current_avg_sales - hist_rec.avg_order)/
                                                  hist_rec.avg_order;
            a_perform.status := 'All fine';
        END IF;
        CLOSE history_cur;
    EXCEPTION
        WHEN NO_DATA_FOUND
        THEN
            a_perform.status := 'Exceptions found';
    END current_performance;

BEGIN
    FOR person_rec IN person_cur
    LOOP
        current_performance(person_rec, one_perform);

        dbms_output.put_line(one_perform.person_code ||
                             ' ' ||
                             one_perform.person_name ||
                             ' ' ||
                             one_perform.current_sales ||
                             ' ' ||
                             one_perform.perform_percent ||
                             ' ' ||
                             one_perform.status);
    END LOOP;
END;
/
```

Let's review what you just did here. First, you declared a record type called PERFORMANCE_TYPE. Because the declaration employs %TYPE on the fields being drawn from the PLSQL101_PERSON table, you guaranteed that the datatypes in the table and in the procedure will always match, even if those in the table are changed in the future! Next, you declared a record variable called ONE_PERFORM, followed by a simple cursor that selects all rows from the PLSQL101_PERSON table.

The procedure CURRENT_PERFORMANCE takes two parameters. One parameter is the person record, which has exactly the same type as a row of the PLSQL101_PERSON table and which is also the same as the type of records fetched by the PERSON_CUR cursor declared earlier. So it is safe to pass records from PERSON_CUR cursor to this procedure.

The second parameter is OUT, which means the parameter will be written into by the procedure. The procedure will fill up the a_perform parameter. The procedure has HISTORY_CUR as an explicit cursor. This cursor joins the PLSQL101_PRODUCT and

PLSQL_101_PURCHASE_ARCHIVE tables to find the average amount per order for a given salesperson. This is the archived or historical data, hence the name HISTORY_CUR. This value will be used to find out how well the salesperson has done with his current sales. hist_rec is a record variable based on the HISTORY_CUR cursor. CURRENT_AVG_SALES is the average of all current orders for a salesperson.

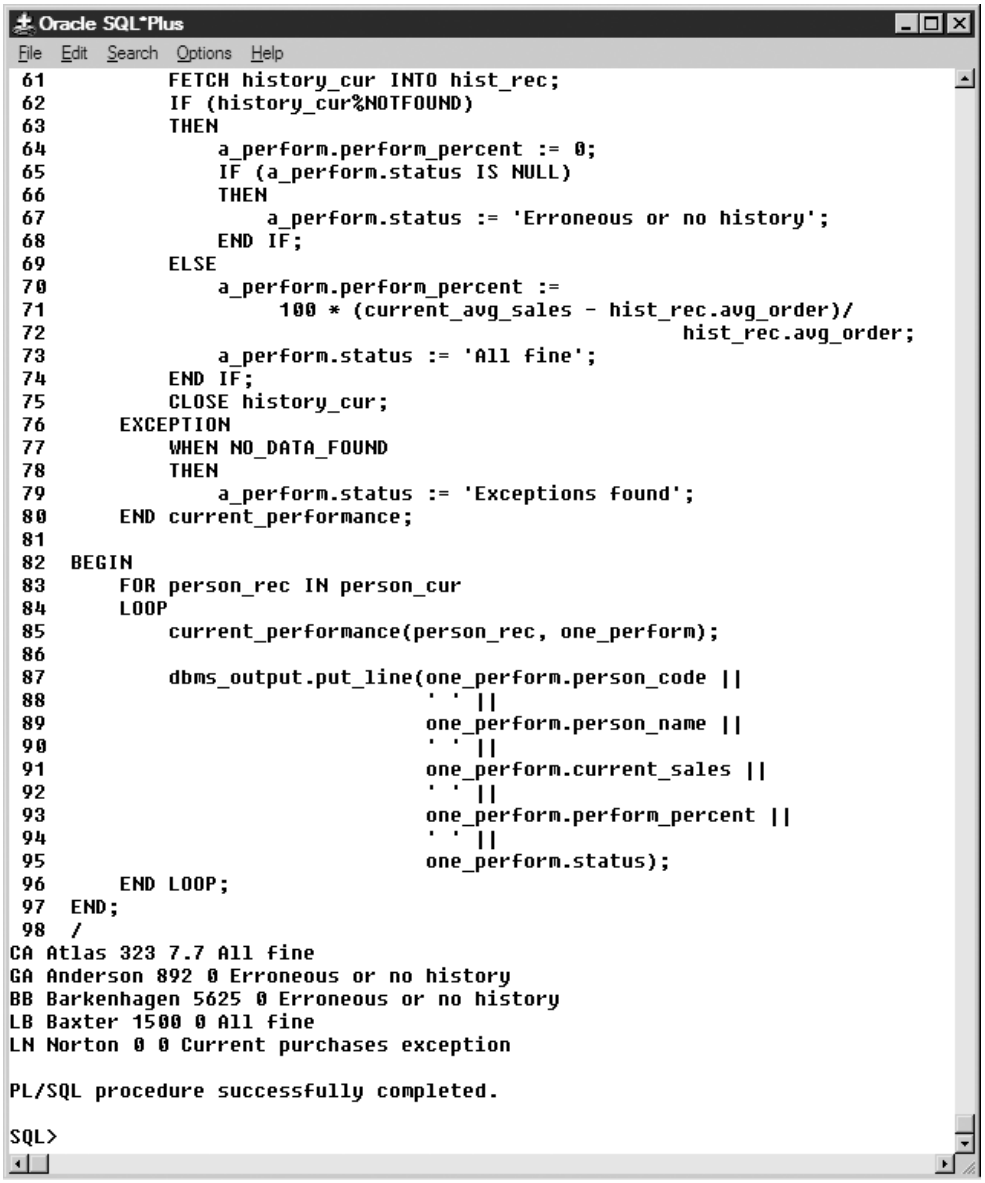


FIGURE 9-1. *An example of anchored or dynamic types*

In the execution section of the procedure, you wrote code that copied the salesperson's last name and code into the OUT parameter A_PERFORM. You also set the initial status to NULL.

Next, you created the implicit cursor, which we will discuss at greater length in the next section. In this case, the implicit cursor computed the total current sales and the current average sales per order for the salesperson that we obtained from the A_PERSON IN parameter. We have enclosed this portion of the code in its own basic block so that we can catch exceptions raised only by this portion. As you can see, there is indeed an exception for Linda Norton. She has no current sales, so no data is found for her.

Next, you opened the HISTORY_CUR cursor and fetched from it. Note that a single fetch was done, as there can be no more than one summary for a single salesperson. Also note the use of the column alias AVG_ORDER. The cursor here takes the salesperson's name as a parameter. So the cursor code can be reused for different salespeople. It is possible that there may be no data for a salesperson in archives because he or she is a new hire. It is also possible that there are other errors that cause the cursor to return no records. In this case, the two items Large Harflinger and Round Snaphoo have no data in the PLSQL101_PRODUCT table. That is why we set the status to "erroneous or no history," not just "no history." If we do find valid historical data, we compute the percentage that the current average amount per order is from its historical value and put this into the a_perform.perform_percent field.

Finally, you closed the HISTORY_CUR cursor. The exception section is for capturing unforeseen NO_DATA_FOUND exceptions not captured before.

The execution section of the main anonymous block simply looped through the PERSON_CUR and called the procedure for each person record and printed the results.

You executed the final SELECT statements in order to verify that the program did what it was supposed to and to see what error conditions occurred.

This is a complete example that covers a lot of new information. The same example with modifications will be used later to demonstrate some other topics covered in this chapter. If you're not completely comfortable with what was done here, go back now and review so that you'll be ready for the rest of the chapter.

DML in PL/SQL or Implicit Cursors

In this section, we will study the implicit cursors we used and talked about. Take a look at the last code example. The SELECT statement that finds the current average amount per order is a simple SELECT statement with the added keyword INTO. The INTO part of the statement is required in order to put the values returned by the SELECT statement into the corresponding PL/SQL variables. In our example, the PL/SQL variables are CURRENT_AVG_SALES and the A_PERFORM.CURRENT_SALES. We can use this SELECT only if it returns a maximum of one record. If it returns more than one record, the TOO_MANY_ROWS exception will be raised. PL/SQL uses

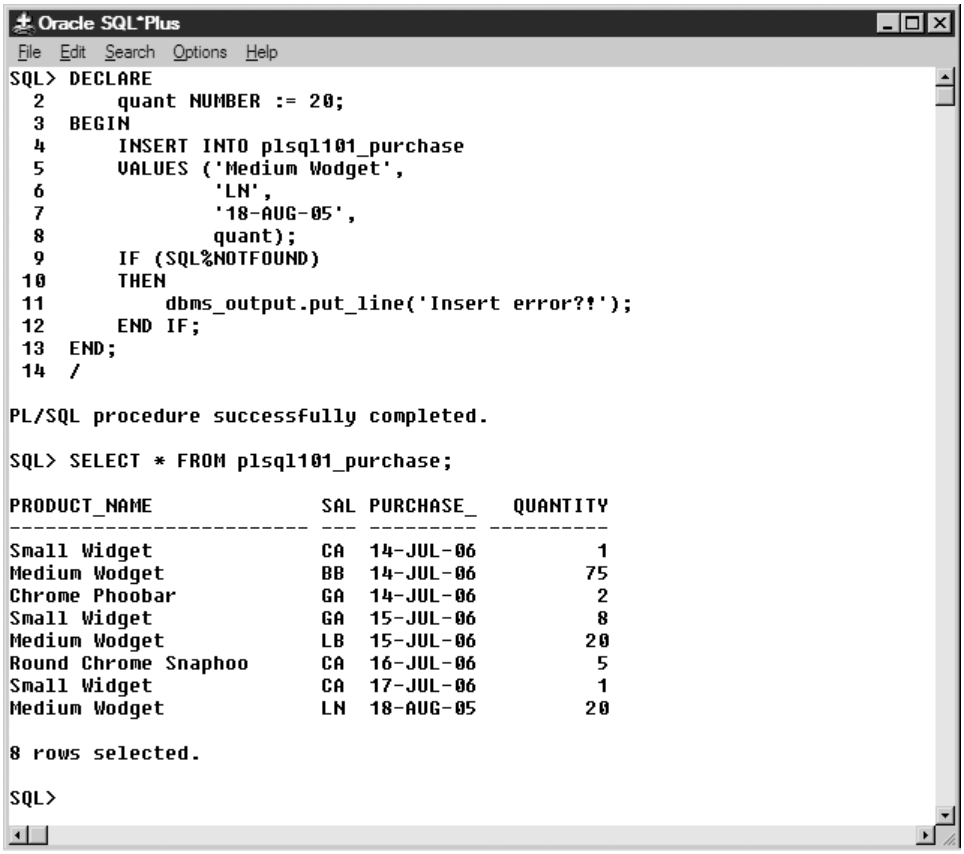


FIGURE 9-2. *Insert a record using PL/SQL*

an implicit cursor that it calls "SQL" for this SELECT statement. This cursor has attributes that you can reference to learn information about the most recently performed SQL action. For instance, if you query the state of SQL%FOUND it will tell you whether or not the latest SELECT statement fetched any records at all. When there are two consecutive SELECT statements, SQL%FOUND only gives the status for the second one.

Let's correct the exceptions that were raised in the previous example by inserting some purchase data for Linda using an INSERT from within PL/SQL. Compare your results with Figure 9-2.

```
DECLARE
    quant NUMBER := 20;
BEGIN
    INSERT INTO plsql101_purchase
```

```
    VALUES ('Medium Wodget',
            'LN',
            '18-AUG-05',
            quant);
    IF (SQL%NOTFOUND)
    THEN
        dbms_output.put_line('Insert error?!');
    END IF;
END;
/
SELECT * FROM plsql101_purchase;
```

You can use a PL/SQL variable to insert a value. However, the column destined to hold the value must be of the same type as the PL/SQL variable or must be convertible from the PL/SQL variable to the column type. Remember, in SQL and PL/SQL, data items can interact only if their types match.

Now, using an SQL statement, insert two rows into the PLSQL101_PRODUCT table. See Figure 9-3 for results.

```
INSERT INTO plsql101_product
VALUES ('Large Harflinger',
        21,
        100,
        '29-AUG-04');

INSERT INTO plsql101_product
VALUES ('Round Snaphoo',
        12,
        144,
        '21-JUL-04');
SELECT * FROM plsql101_product;
```

Now enter the following code to update from within PL/SQL. See Figure 9-4 for results.

```
CREATE OR REPLACE PROCEDURE update_prod (
     prod_rec plsql101_product%ROWTYPE
     ) IS
BEGIN
     UPDATE plsql101_product
     SET    last_stock_date = prod_rec.last_stock_date,
            quantity_on_hand = quantity_on_hand
                               +
                               prod_rec.quantity_on_hand
     WHERE product_name = prod_rec.product_name;
END update_prod;
/
DECLARE
     a plsql101_product%ROWTYPE;
```

```
BEGIN
     a.product_name := 'Small Widget';
     a.product_price := 87;
     a.quantity_on_hand := 31;
     a.last_stock_date := TO_DATE('23-NOV-04');
     update_prod(a);
END;
/
SELECT * FROM plsql101_product;
```

That was simple enough! You will always need to be aware of all possible exceptions when using SQL DML within PL/SQL. This is especially true for implicit

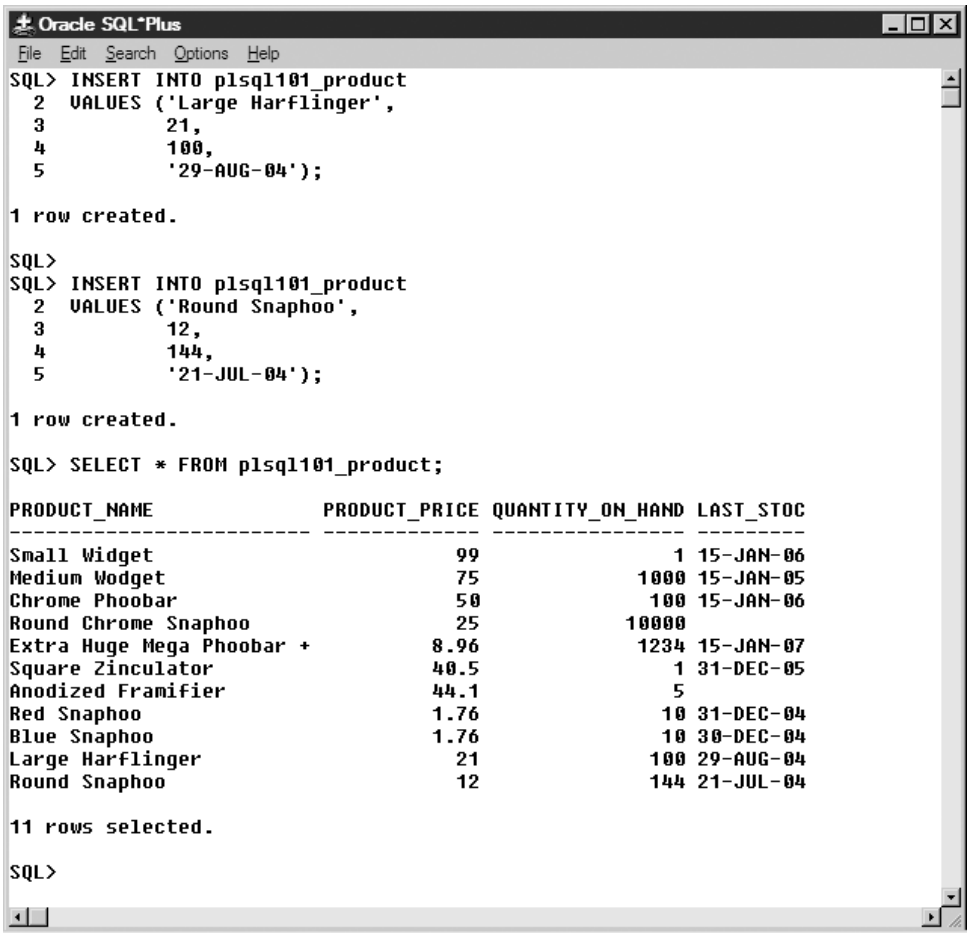


FIGURE 9-3. *New rows in the PLSQL101_PRODUCT table*

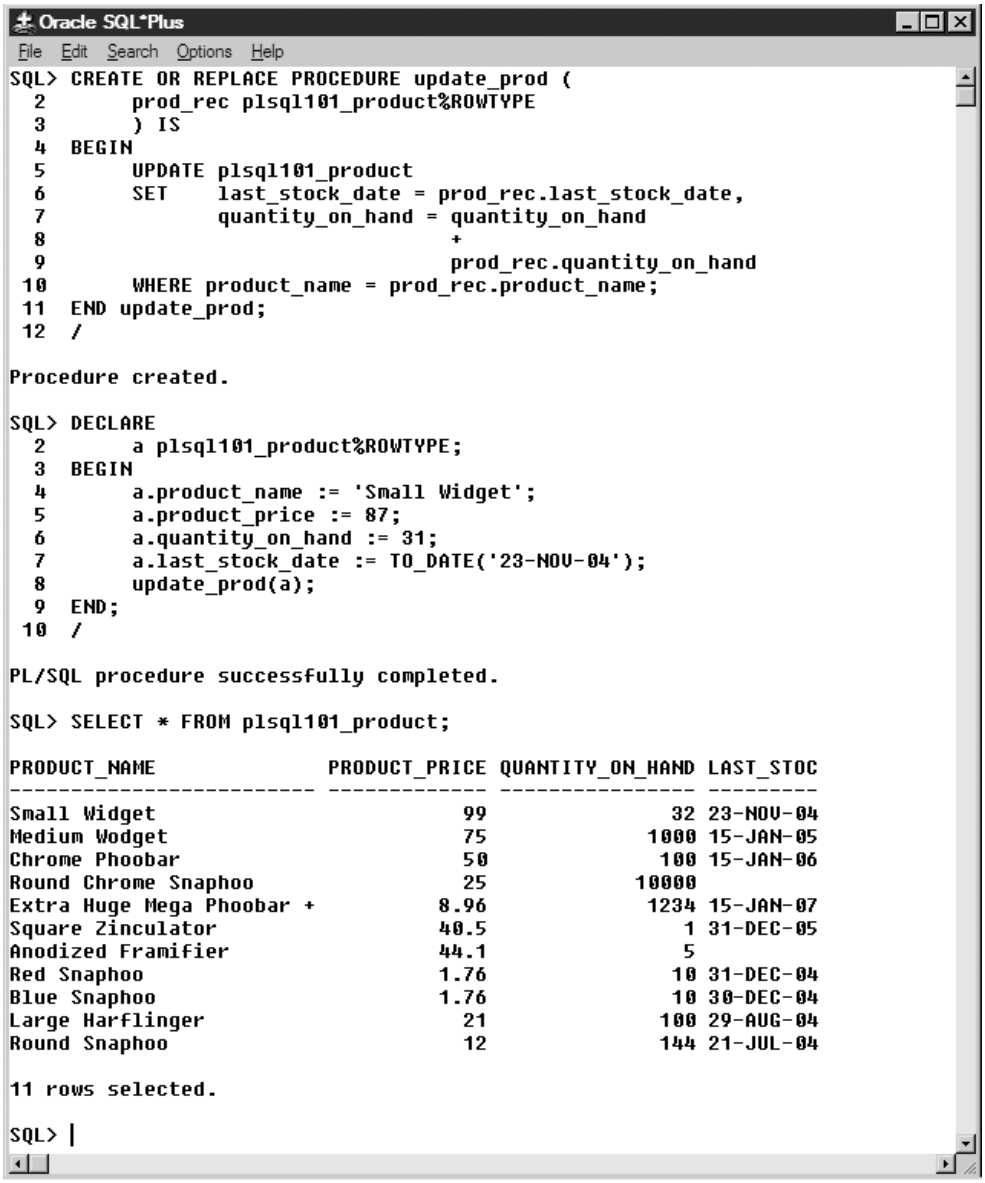


FIGURE 9-4. *Update from PL/SQL procedure using an implicit cursor*

cursors, as you do not have as much control as you get with explicit cursors. The delete works similarly. Let us try to delete something that violates a constraint and see the results using SQL attributes. Refer to Figure 9-5 for results.

```
set serveroutput on

BEGIN
  DELETE FROM plsql101_product
  WHERE       product_name = 'junk';
  IF (SQL%NOTFOUND)
  THEN
      dbms_output.put_line('No such product');
  END IF;
END;
/
```

Implicit Versus Explicit Cursors

Because an implicit cursor can only deal with a single row of data, you should use an explicit cursor whenever the statement filling the cursor can generate more than one row of results. In addition, explicit cursors remain in the database's memory for a while after you have executed them, and if you (or another user) issue the same cursor SELECT statement while the prior one is still in the database's memory, you will get your results much more quickly.

Note that the HISTORY_CUR cursor in our earlier example can be easily replaced by an implicit cursor, because grouping the records by salesperson guarantees that only one row of results will be produced. Later in this chapter, when I show you how to put functions and procedures into packages, I will also demonstrate how to change the cursor to one that is implicit.

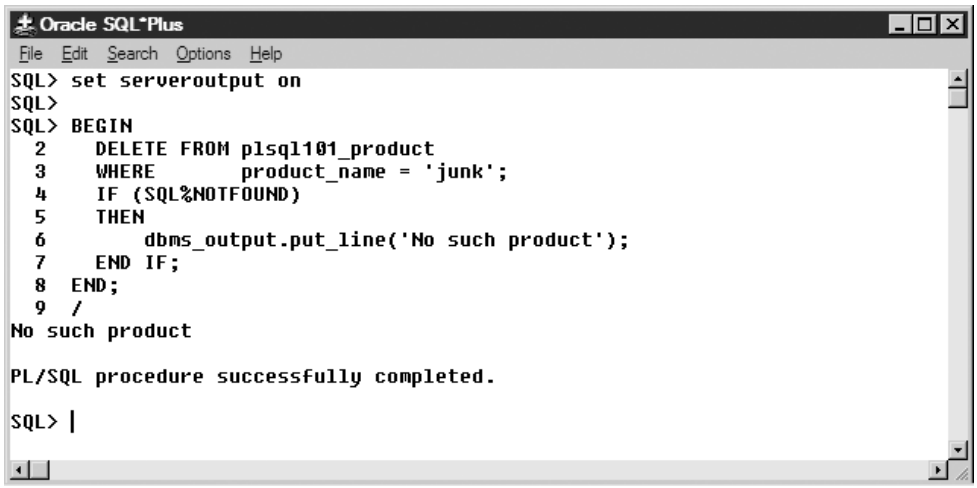


FIGURE 9-5. *Procedure to delete from a table using PL/SQL*

Timing Operations

This section describes how to calculate the amount of time it takes a process to execute. This is useful to find out how good your code is. After all, speed is key when running database applications. A responsible programmer will utilize the information in this section on a regular basis.

Use a Program to Measure Time

One way to measure how long a procedure takes to run is to have the procedure keep track of time itself. The following code demonstrates this. It employs SYSDATE to find the start time and end time for a loop that inserts 5000 records into a table. It then calculates how long one record insertion takes by dividing the total elapsed time by 5000. The following is the SQL script to do this. See Figure 9-6 for results.

NOTE
You will see different results based on various factors, like load on the database server, actual speed of the database computer, and so on. Usually, you will run the same code again and again and then take the average to estimate the performance. Also, remember that the date shown in Figure 9-6 will be different from the date shown in your work because the code is using SYSDATE.

```
DROP TABLE plsql101_timetab CASCADE CONSTRAINTS;
CREATE TABLE plsql101_timetab (
     c1     NUMBER NOT NULL,
     c2     VARCHAR2(30) NULL,
     c3     DATE NULL
     )
;
CREATE OR REPLACE PROCEDURE test_time IS
     maxloops NUMBER := 5000;
     loopcount NUMBER(6,0) := 0;
     starttime CHAR(5) ;
     endtime CHAR(5) ;
     /* Note that since the start and end times are defined in terms
     of the number of seconds since midnight, this routine will not
     work if the run time crosses over midnight.
     */
     runtime NUMBER;
     processrate NUMBER(20,10);
BEGIN
     starttime := TO_CHAR(SYSDATE,'SSSSS');
```

```
     LOOP
          loopcount := loopcount +1;
          INSERT INTO plsql101_timetab (C1, C2,C3)
          VALUES (loopcount, 'TEST ENTRY', SYSDATE);
          COMMIT;
          IF loopcount >= maxloops THEN
               EXIT;
          END IF;
     END LOOP;
     COMMIT;
     endtime := TO_CHAR(SYSDATE,'SSSSS');
     runtime := TO_NUMBER(endtime)-TO_NUMBER(starttime);
     dbms_output.put_line(runtime || ' seconds' );
     processrate := maxloops / runtime;
     INSERT INTO plsql101_timetab (C1, C2, C3) VALUES
          (loopcount+1,
          TO_CHAR(processrate, '9999999999')||' records per second',
          SYSDATE
          );
END test_time;
/
EXECUTE test_time;
SELECT * FROM plsql101_timetab
WHERE  c1 > 5000;
```

The following is a test loop that will show time measurements for ten iterations of the same code. See Figure 9-7 for results.

```
TRUNCATE TABLE plsql101_timetab;
COMMIT;
SET SERVEROUTPUT ON
BEGIN
    FOR trial_count IN 1..10
    LOOP
        test_time;
        COMMIT;
    END LOOP;
END;
/
SELECT   *
FROM     plsql101_timetab
WHERE    c1 > 5000
ORDER BY c3;
```

Use the TIMING Command to Count Real Time

When you want to do more accurate measurements, you can do so using the TIMING command. We will modify the above example slightly to show you how. Figure 9-8

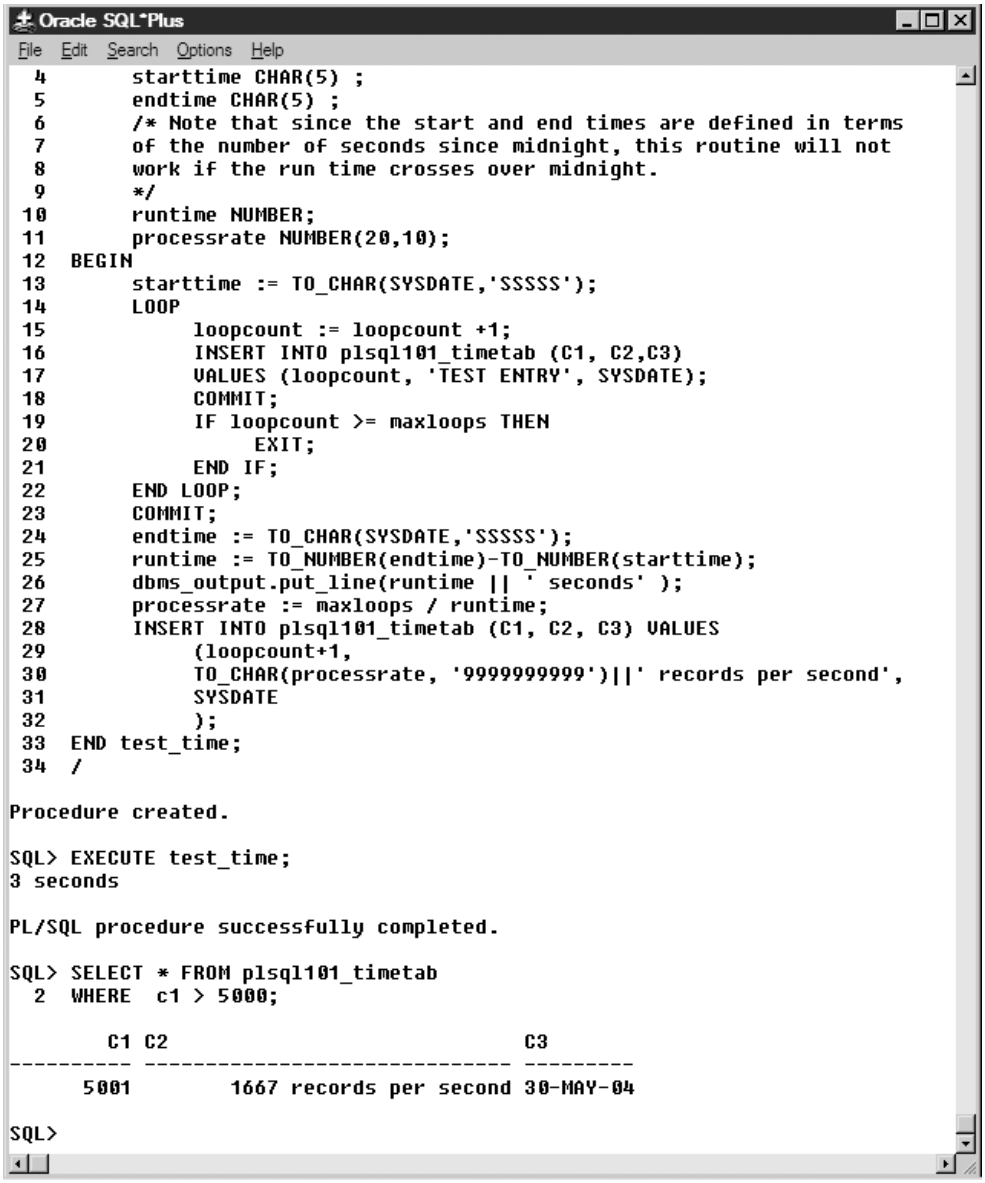


FIGURE 9-6. *Measure performance of inserts with a PL/SQL program*

shows the results. In this example, the elapsed time is represented with the value 1.67. This value means that 1.67 seconds elapsed between the TIMING START command and the TIMING STOP command.

```
TIMING START;
EXECUTE test_time;
COMMIT;
TIMING STOP;
```

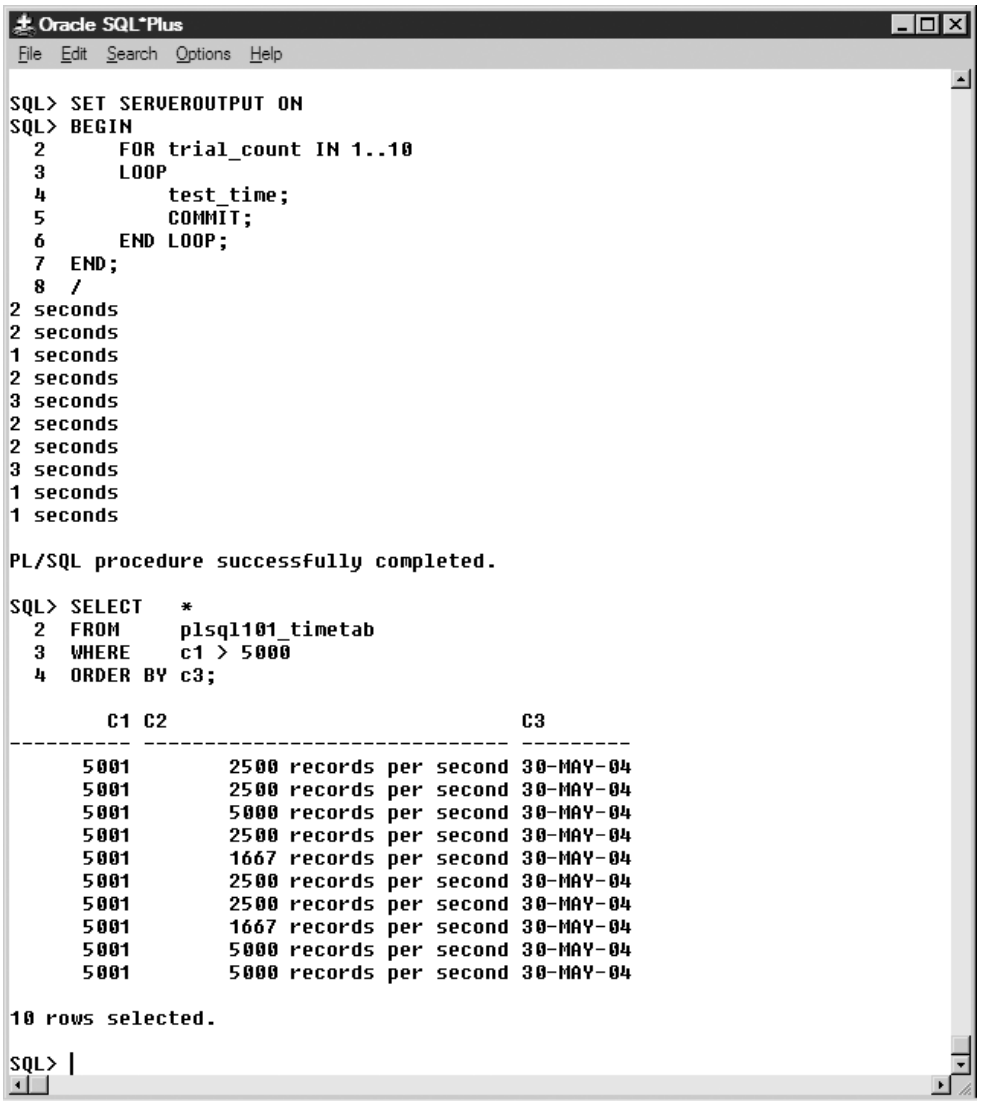


FIGURE 9-7. *Results of a ten-iteration speed test*

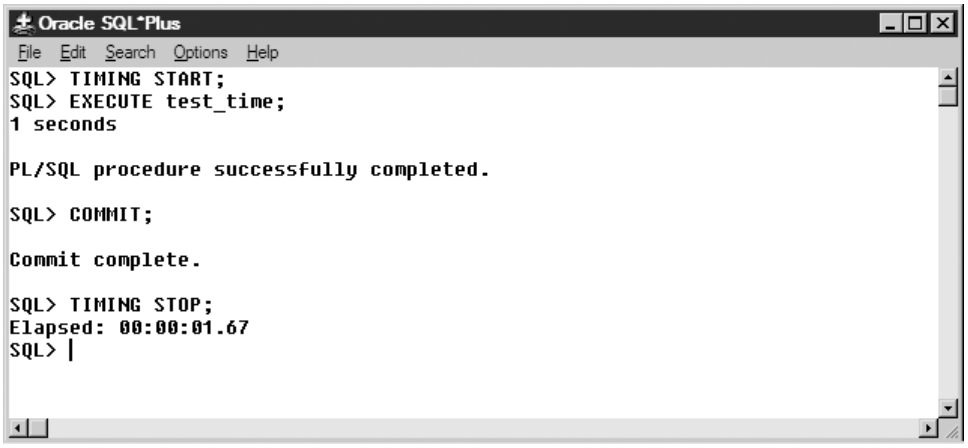


FIGURE 9-8. *Measure INSERT performance with the TIMING command*

PL/SQL Packages

What makes using a PC so easy? One of the reasons is that it combines many useful functions into one easy-to-use package. The software displays screens and you do not need to know how a mouse click communicates with the computer in order to achieve your desired result. The complexity of the behind-the-scenes activities is hidden from you; all you need to know is that when you take a particular action, a predictable result occurs. PL/SQL offers a similar efficiency in software development by providing *packages* for bundling together useful functions, procedures, record types, and cursors.

A package has a specification just like a procedure or function. It has a body just like a procedure or function. What makes a package different is that you can create the specification and body separately. You can even replace a package body with a different body that conforms to the existing specifications, and the package will continue to work.

Now, why would you want to keep the body separate from the specification? The answer is really quite simple. Package users don't need to be exposed to all of the details of package implementation, so those details are hidden inside the body. The body is stored, compiled, and processed from within the database and is invisible to users of the package. Users of the package should simply use the specification for their programming purposes and be done with it. This is very important when you want your proprietary code to be secure and not accessible to hackers or competitors.

The syntax for a package specification is as follows:

```
CREATE PACKAGE package_name IS
    [variable_and_type declarations]
    [cursor specifications]
    [function_and_procedure specifications]
END [package_name] ;
```

To create a package body, you would use the following syntax:

```
CREATE OR REPLACE PACKAGE BODY package_name IS
    [local declarations]
    [full_cursors in package specification]
    [full_function_and_procedures in package specification]END [package_name] ;
```

All variables and types declared in the package specification are accessible by users of the package. The package specification contains only enough information to identify what a package contains, as well as what variables those contents expect as input and output. The package specification's declaration section contains declarations for functions, procedures, exceptions, cursors, variables, and constants that are available for use within the package's body. The executable section of the package body contains the full definitions—without the CREATE OR REPLACE command—for all the cursors, functions, and procedures declared in its specification.

The variables that are present in the package specification are called *package variables*. They are initialized only once: when the package is first accessed. When a call is made to any of the package's contents, Oracle loads the package into memory, where it stays for as long as the user is connected to the database. When there are multiple sessions, the package variables and their values are shared; the packaged objects can also be accessed more quickly in subsequent sessions.

The use of the execution section of the package is usually for the initialization of package local variables or package variables. The execution section of a package is executed once when the package is loaded, so there is not much scope for using the execution section to do things repeatedly, since it cannot be called more than once.

Users access the package's procedures, variables, and functions using the same *container.contained* notation—in this case that means *package_name.packaged_object*. You have already used one example of a packaged function, the dbms_output.put_line function from the dbms_output package supplied by Oracle. When referring to functions from within their own package, you do not need to place the *package_name* qualification before the function name.

Ready to create a package? You bet you are. You'll just pull some of the previous examples and turn them into a package. Run the following SQL script to see the creation and use of a package. Figure 9-9 shows the SQL*Plus® outputs.

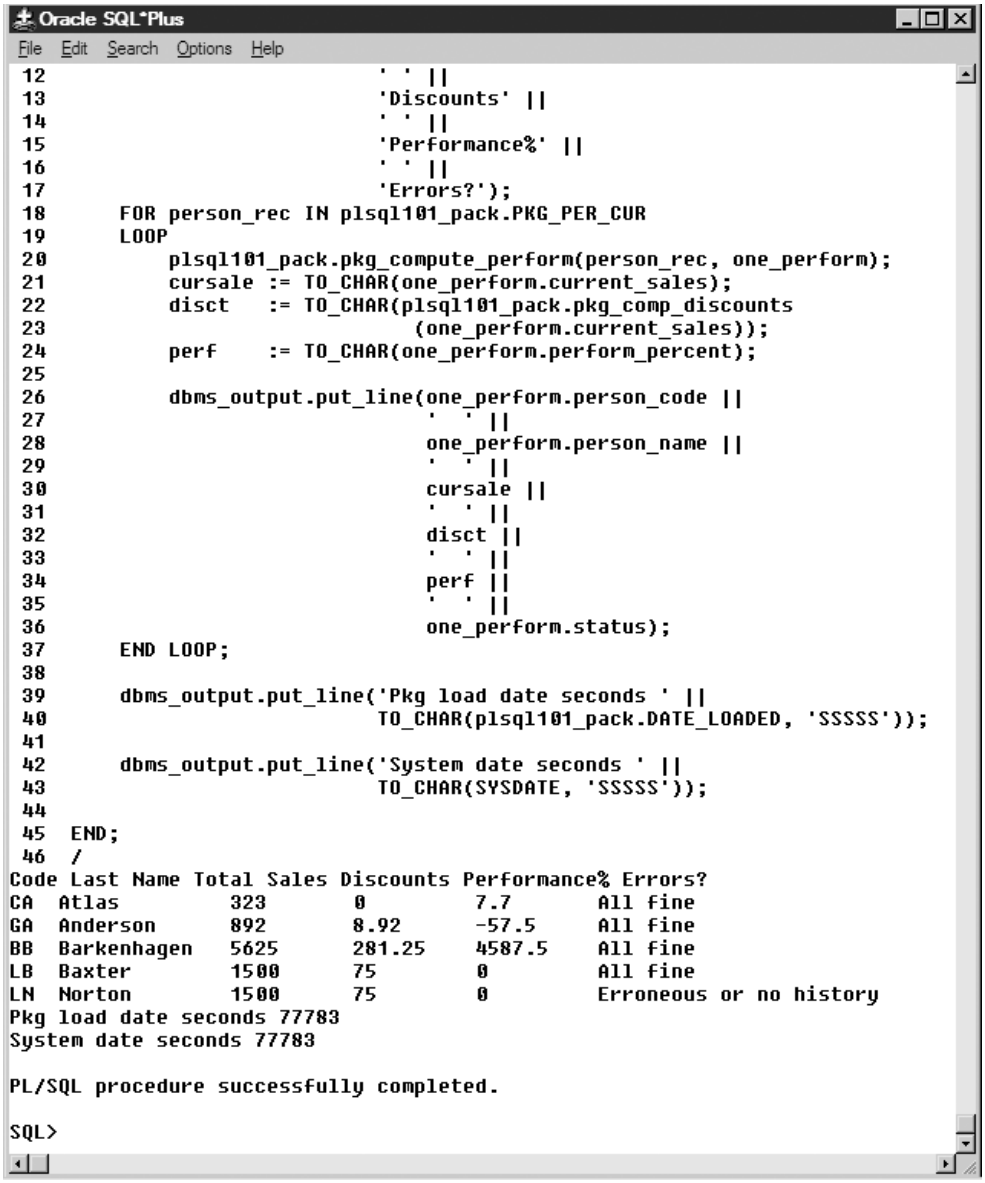


FIGURE 9-9. *Example of a package and its usage*

```
CREATE OR REPLACE PACKAGE plsql101_pack IS
    DATE_LOADED DATE;
    /* Performance is current average per order amount as a percentage
       of the historical average per order sale amount for a
       salesperson. Status returns the status of errors if any.
     */
```

```
    TYPE pkg_perform_type IS RECORD
        (person_code      plsql101_person.person_code%TYPE,
         person_name      char(12),
         current_sales    NUMBER(8,2),
         perform_percent  NUMBER(8,1),
         status           char(30)
        );
    CURSOR PKG_PER_CUR RETURN plsql101_person%ROWTYPE;
    /* Compute discounts on orders.
       Input order amount.
       Returns discount amount (zero for wrong inputs).
     */
    FUNCTION pkg_comp_discounts (order_amt NUMBER) RETURN NUMBER;

    /* This procedure computes the performance and current total sales
       BY a salesperson. The information for the salesperson is passed
       in as a record a_person. If there are no sales for the day BY
       the person the current_sales is set to zero. If the person has
       no history, for example, the person just joined today, then
       the perform_percent is set to zero.
     */
    PROCEDURE pkg_compute_perform
        (a_person plsql101_person%ROWTYPE,
         a_perform OUT pkg_perform_type);
END plsql101_pack;
/

CREATE OR REPLACE PACKAGE BODY plsql101_pack IS
    small_order_amt NUMBER(8,2) := 400;
    large_order_amt NUMBER(8,2) := 1000;
    small_disct NUMBER(4,2)     := 1;
    large_disct NUMBER(4,2)     := 5;

    CURSOR PKG_PER_CUR
    RETURN plsql101_person%ROWTYPE
    IS
        SELECT *
        FROM plsql101_person;

    FUNCTION pkg_comp_discounts (order_amt NUMBER)
    RETURN NUMBER IS
    BEGIN
        IF (order_amt < large_order_amt
             AND
             order_amt >= small_order_amt)
        THEN
                RETURN (order_amt * small_disct / 100);
        ELSIF (order_amt >= large_order_amt)
        THEN
                RETURN (order_amt * large_disct / 100);
```

```
    ELSE
            RETURN(0);
    END IF;
END pkg_comp_discounts;

PROCEDURE pkg_compute_perform
    (a_person plsql101_person%ROWTYPE,
     a_perform OUT pkg_perform_type)
IS
    hist_ord_avg NUMBER(8,2) := 0;
    current_avg_sales NUMBER(8,2) := 0;

BEGIN
    a_perform.person_code := a_person.person_code;
    a_perform.person_name := a_person.last_name;
    a_perform.status := NULL;

    BEGIN
        SELECT   SUM(tbl2.product_price * tbl1.quantity),
                 AVG(tbl2.product_price * tbl1.quantity)
        INTO     a_perform.current_sales,
                 current_avg_sales
        FROM     plsql101_purchase tbl1,
                 plsql101_product tbl2
        WHERE    tbl1.product_name = tbl2.product_name
        GROUP BY tbl1.salesperson
        HAVING   tbl1.salesperson = a_person.person_code;
    EXCEPTION
        WHEN NO_DATA_FOUND
        THEN
            a_perform.status := 'Current purchses exception';
            a_perform.current_sales := 0;
    END;

    BEGIN
    SELECT   AVG(tab2.product_price * tab1.quantity) avg_order
    INTO     hist_ord_avg
    FROM     plsql101_purchase_archive tab1,
             plsql101_product tab2
    WHERE    tab1.product_name = tab2.product_name
    GROUP BY tab1.salesperson
    HAVING   tab1.salesperson = a_person.person_code;

        a_perform.perform_percent :=
           100 * (current_avg_sales - hist_ord_avg)/hist_ord_avg;
        a_perform.status := 'All fine';

    EXCEPTION
        WHEN NO_DATA_FOUND
        THEN
            a_perform.perform_percent := 0;
```

```
                IF (a_perform.status IS NULL)
                THEN
                    a_perform.status := 'Erroneous or no history';
                END IF;
        END;
    EXCEPTION
        WHEN NO_DATA_FOUND
        THEN
            a_perform.status := 'Exceptions found';
    END pkg_compute_perform;

BEGIN
    /* The date the package was first loaded */
    DATE_LOADED := SYSDATE;
END plsql101_pack;
/

DECLARE
   one_perform plsql101_pack.pkg_perform_type;
   cursale char(8);
   disct   char(8);
   perf    char(8);
BEGIN
    dbms_output.put_line('Code' ||
                         ' ' ||
                         'Last Name' ||
                         ' ' ||
                         'Total Sales' ||
                         ' ' ||
                         'Discounts' ||
                         ' ' ||
                         'Performance%' ||
                         ' ' ||
                         'Errors?');
    FOR person_rec IN plsql101_pack.PKG_PER_CUR
    LOOP
        plsql101_pack.pkg_compute_perform(person_rec, one_perform);
        cursale := TO_CHAR(one_perform.current_sales);
        disct   := TO_CHAR(plsql101_pack.pkg_comp_discounts
                           (one_perform.current_sales));
        perf    := TO_CHAR(one_perform.perform_percent);

        dbms_output.put_line(one_perform.person_code ||
                             '  ' ||
                             one_perform.person_name ||
                             '  ' ||
                             cursale ||
                             '  ' ||
                             disct ||
                             '  ' ||
                             perf ||
```

```
                                ' ' ||
                                one_perform.status);
    END LOOP;

    dbms_output.put_line('Pkg load date seconds ' ||
                         TO_CHAR(plsql101_pack.DATE_LOADED, 'SSSSS'));

    dbms_output.put_line('System date seconds ' ||
                         TO_CHAR(SYSDATE, 'SSSSS'));

END;
/
```

Notice that the cursor PKG_PER_CUR is required to have a return type. The use of the CHAR variable is purely for cosmetic purposes: it makes the printout look better.

The discount rates are hidden inside the package so that the users of the package cannot modify them. DATE_LOADED is a package variable. On some computers the code executes so fast there is no difference between system time and the package-loaded time. You will, however, see a difference if the execution becomes slow or the database's host computer is slow.

Triggers

Triggers were briefly introduced in Chapter 8. This section offers a short review of that material and then goes into the nitty-gritty of triggers.

A trigger is best described as a procedure that is executed automatically whenever some event defined by the trigger—the *triggering event*—happens.

You can write triggers that fire whenever one of the following operations occurs:

- DML statements on a particular schema object.
- DDL statements issued within a schema or database.
- User logon or logoff events, server errors, database startup, or instance shutdown.

Triggers differ from PL/SQL procedures in three ways:

- Triggers are called automatically by Oracle when the event defined for that trigger happens. You cannot call a trigger from within your code.
- Triggers do not have a parameter list.
- The syntax for a trigger specification is slightly different than a specification for a procedure.

Triggers are similar to procedures in the following ways:

- The body of a trigger looks like the body of a procedure—both are PL/SQL basic blocks.
- A trigger does not return any values.
- Triggers can be used to perform a variety of tasks.
- Triggers automatically generate derived column values. For example, every time a new order is processed the commission for the sales agent may be automatically calculated and entered into the appropriate table.
- Triggers can prevent invalid transactions. For example, a trigger can stop someone from increasing the salary of an employee by more than the budget allows. Note that this cannot be done using check constraints, because a check constraint only refers to values in the current row—and therefore cannot determine an overall budget amount.
- Triggers can be used to enforce complex security authorizations. For example, only supervisors can change the salary value, and only for the people they supervise.
- Triggers can be used to enforce complex business rules. For example, a trigger can be used to verify that an item on a purchase order is available on the shipping date and if it isn't, the trigger will automatically place a restocking order such that enough quantities arrive before the shipping date.
- Triggers can provide transparent event logging. For example, a trigger can track how many times a particular salesperson accesses an inventory table.
- Triggers can provide sophisticated auditing. For example, a trigger can be used to find out how many times on average a given salesperson needs to access the database in order to process a single purchase order.
- Triggers can gather statistics on table access. For example, a trigger can tabulate how many queries occur in one day for the small widget in the product catalog table.

As you may have realized by now, triggers are powerful tools. Triggers should be used prudently, because a trigger can fire as often as every time a table is accessed, and that puts an additional strain on the database server. A good rule of thumb is to use a trigger to perform an action that cannot be performed by any other means. For example, if you can use one or more constraints to do the job of a specific trigger, then use the constraints instead of the trigger. Similarly, if your system requires totals that can be calculated during off hours, it may be better to design the system that way instead of having triggers firing during every transaction to create the calculation.

For example, suppose a bank decides when more cash is needed from a central repository by calculating how many $20 bills left the bank on a given day. That calculation can be done after office hours by counting the total bills given out that day. If a trigger fired during the business day to update the $20 bill count, the bank's transaction speeds would significantly degrade during business hours.

Triggers defined on tables are called *table triggers* and will be the subject of the rest of our trigger discussion. The syntax for a trigger is as follows:

```
CREATE OR REPLACE TRIGGER trigger_name fire_time trigger_event
   ON table_name
   [WHEN trigger_restriction]
   [FOR EACH ROW]
   [DECLARE
      declarations]
   BEGIN
      statements
   [EXCEPTION
      WHEN exception_name
      THEN ...]
END trigger_name;
```

Keep reading, and you will see how to build triggers using this syntax.

Trigger Types

The *fire_time* specifies when the trigger will fire. The choices are before or after the trigger event is executed. When using the keyword BEFORE, the trigger is executed before any constraint checking is done on rows affected by the triggering event. No rows are locked. This type of trigger is called, sensibly, a *before trigger*.

If you chose the keyword AFTER, then the trigger will fire after the triggering statement has done its job and after all constraint checks are done. The affected rows are locked during the execution of the trigger in this case. This type of trigger is called an *after trigger*.

The *trigger_event* or triggering statement can be an INSERT, UPDATE, or DELETE.

The *trigger_restriction* is one or more additional conditions to be met in order for the trigger to execute.

The optional FOR EACH ROW set of keywords executes the trigger body for every row that is affected by the triggering statement. Such triggers are called *row triggers*. When the FOR EACH ROW option is absent, the trigger is executed only once for the triggering statement or event. When this is the case, the trigger is referred to as a *statement trigger,* as it executes only once for each triggering statement.

The portion of code between DECLARE and END *trigger_name* is simply a PL/SQL basic block.

You can combine different trigger events using OR. For example:

DELETE OR INSERT *rest_of_statement*

When using UPDATE, you can specify a list of columns:

UPDATE OF *column1*, *column2*, ...

Also when using UPDATE in PL/SQL statements, the new row is accessed with a colon before the word "new" (:new) and the old row is identified by a colon before the word "old" (:old). Thus, :old.column_name will give you the old value for that column in the row before the triggering statement changes it. However, the trigger restriction uses the names "old" and "new" without the preceding colon.

Trigger Example

You will now create a trigger to track the activities of a sales force. Here is the SQL script you'll need. Figure 9-10 shows the end result of the example.

```
-- Add a column to the purchase table. The values will be null.
ALTER TABLE plsql101_purchase
    ADD ORDER_NUMBER NUMBER(10);

-- Create the audit table.
CREATE TABLE plsql101_audit
    (ORDER_NUMBER     NUMBER(10),
     person_code      VARCHAR2(3),
     user_name        CHAR(30),
     user_machine     CHAR(20),
     change_in_quant  NUMBER(5),
     transaction_time DATE,
     FOREIGN KEY (person_code) REFERENCES plsql101_person);

-- Sequence for order numbers
CREATE SEQUENCE order_num_seq;

CREATE OR REPLACE TRIGGER audit_trigger
BEFORE INSERT OR UPDATE ON plsql101_purchase
FOR EACH ROW
DECLARE
    no_name_change EXCEPTION;
    quant_change NUMBER(5) := 0;
```

```
BEGIN
    /* Do not allow any changes to product_name for orders.
       Raise exception and reset the values back to original.
     */
    IF (UPDATING
        AND
        (:NEW.product_name <> :OLD.product_name))
    THEN
        RAISE no_name_change;
    END IF;

    /* Create an order number for old non-numbered orders as well
       as new orders that do not have any order number.
     */
    IF (((UPDATING)
         AND
         (:OLD.ORDER_NUMBER IS NULL))
         OR
         ((INSERTING)
          AND
          (:NEW.ORDER_NUMBER IS NULL)))
    THEN
        SELECT order_num_seq.NEXTVAL
        INTO   :NEW.ORDER_NUMBER
        FROM   dual;
    END IF;

    /* Finally, populate the audit table with user name, user's
       computer or terminal name, the change he or she made to
       the quantity, and the time of the change. If inserting, then
       change to quantity is same as new quantity.
     */

    IF (UPDATING)
    THEN
        quant_change := :NEW.quantity -:OLD.quantity;
    ELSE
        quant_change := :NEW.quantity;
    END IF;

    INSERT INTO plsql101_audit
    VALUES (:NEW.ORDER_NUMBER,
            :NEW.salesperson,
            USER,
            USERENV('TERMINAL'),
            quant_change,
            SYSDATE);
```

```
     EXCEPTION
       WHEN no_name_change THEN
         dbms_output.put_line('Change of product name not allowed');
         dbms_output.put_line('Aborting and resetting to old values');
         :NEW.product_name := :OLD.product_name;
         :NEW.salesperson  := :OLD.salesperson;
         :NEW.ORDER_NUMBER := :OLD.ORDER_NUMBER;
         :NEW.quantity     := :OLD.quantity;
END audit_trigger;
/

col user_name format a30
col user_machine format a20
set pages 9999

SELECT * FROM plsql101_purchase;
SELECT * FROM plsql101_audit;
INSERT INTO plsql101_purchase
     VALUES ('Round Snaphoo', 'LN', '15-NOV-05', 2, NULL);
SELECT * FROM plsql101_purchase WHERE salesperson = 'LN';
SELECT * FROM plsql101_audit;
UPDATE plsql101_purchase SET salesperson = 'LB'
     WHERE salesperson = 'CA' AND quantity = 1;
SELECT * FROM plsql101_purchase WHERE salesperson = 'CA';
SELECT * FROM plsql101_audit;
UPDATE plsql101_purchase SET quantity = 20 WHERE salesperson = 'BB';
SELECT * FROM plsql101_purchase WHERE salesperson = 'BB';
SELECT * FROM plsql101_audit;
UPDATE plsql101_purchase SET product_name = 'Round Snaphoo'
     WHERE salesperson = 'BB';
SELECT * FROM plsql101_purchase WHERE salesperson = 'BB';
SELECT * FROM plsql101_audit;
```

Let's talk about what you just did. First, you added the ORDER_NUMBER column to the purchase table. Then, you created a table for audit records that holds the name of the logged-in user. The user name is entered through the USER function while his or her computer or terminal name is entered using the USERENV('TERMINAL') call to USERENV function. The values for salesperson and any changes to the quantity in the order, as well as the order number and the date of change, are also entered. The trigger will not allow any changes to the product_name and it will automatically generate order numbers for new orders as well as old entries in the purchase table that have no order numbers. The trigger will also insert values into the audit table when the update or insert is successful. The keywords UPDATING and INSERTING tell us whether the triggering action was an update or an insert.

The trigger was tested by first inserting a row into the PLSQL101_PURCHASE table and then comparing the old values to the new by selecting from the table. You then performed two simple updates and followed with a final update that attempted to change the product name for the order.

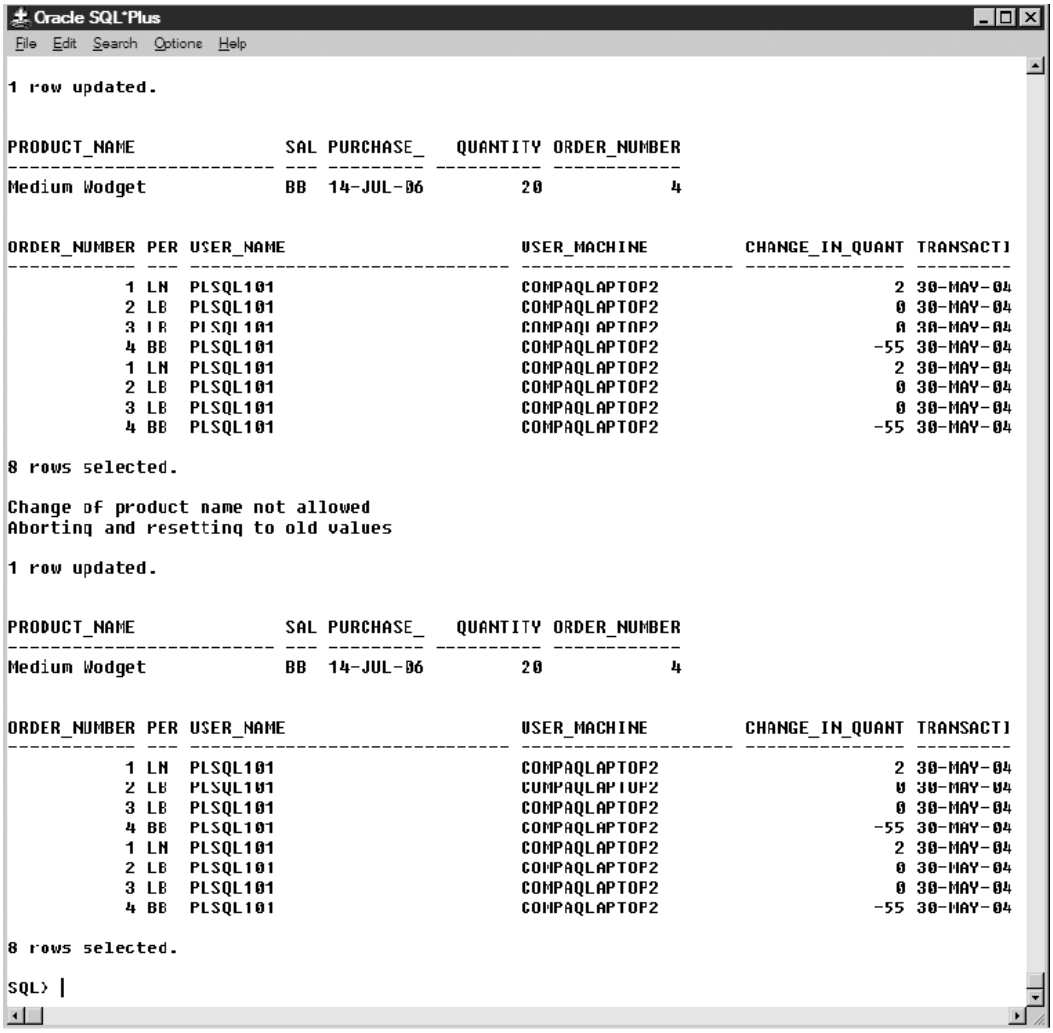


FIGURE 9-10. *Trigger that prohibits changing product name while updating orders*

Modify Triggers

As with views, there is no command to modify a trigger. You simply replace an old trigger with a new one by employing a CREATE OR REPLACE TRIGGER command.

You can also drop a trigger by issuing a command using the following syntax:

DROP TRIGGER *trigger_name;*

Existing triggers can be deactivated and reactivated using commands with the following syntax:

```
ALTER TRIGGER trigger_name DISABLE;
ALTER TRIGGER trigger_name ENABLE;
```

Fine Points Regarding Triggers

You should keep in mind the following points when creating triggers:

- A trigger executing DML statements may result in more triggers being fired. This can potentially lead to a large number of fired triggers.
- A trigger fired by an INSERT statement has meaningful access to new column values only. Because the INSERT creates the row, the old values are null.
- A trigger fired by an UPDATE statement has access to both old and new column values for both BEFORE and AFTER row triggers.
- A trigger fired by a DELETE statement has meaningful access to :old column values only. Because the row no longer exists after the row is deleted, the :new values are NULL. However, you cannot modify :new values. ORA-4084 is raised if you try to modify :new values.
- ROLLBACK, COMMIT, and SAVEPOINT cannot be used inside the trigger body.
- When unhandled exceptions occur, all the changes including the triggering statement are rolled back.
- If more than one trigger is defined for the same triggering event, the order of trigger firing is undefined. That is, you cannot assume in what order the triggers will fire.
- A "mutating table" error condition arises when a trigger tries to read a table and then write to it. While the intention of restricting this type of activity is reasonable, Oracle takes it further than necessary, restricting operations when a table has simply been looked at but not changed. One way around this problem is to create a second table that contains duplicates of the columns the trigger wants to read from the main table. In this scenario, the trigger gathers the values it needs from the second table, and then performs the actions it needs on the first table. When employing this approach, it is essential that all INSERT, UPDATE, and DELETE commands on the main table be mirrored by the trigger to the second table, so they stay synchronized.

XML

The eXtensible Markup Language (XML) has become a popular standard for transferring data between applications. Oracle offers a variety of functions enabling you to work with XML content. A full review of Oracle's XML capabilities is beyond the scope of this book, but you should know how to convert your database's contents into a basic XML output.

Enter the following example code to see how the data in your PLSQL101_PURCHASE table looks when it is represented in XML:

```
SET LONG 2000
SET PAGES 9999
SELECT XMLElement("transactions_for",
                  XMLAttributes(product_name AS "prod"),
                                XMLAgg(XMLElement("date", purchase_date)
                                )
                 )
AS "transaction_list"
FROM plsql101_purchase
GROUP BY product_name
;
```

The XMLElement() function creates an XML row for each data group identified in your GROUP BY statement. The XMLAttributes() function lets you identify what data to include for each data group. The XMLAgg() function "loops" data within each data group…in this example, it loops all the purchase dates for each product.

Chapter Summary

This chapter began with a discussion of coding conventions. Coding conventions are guidelines for writing readable, maintainable, quality code. Coding conventions also facilitate successful modular development in large projects.

You furthered your studies of implicit cursors—or SQL DML within PL/SQL or SQL cursors. Implicit cursors are useful when dealing with only one row at a time. The implicit cursors are not shared across sessions. Implicit cursors allow you to select values directly into PL/SQL variables and allow the use of PL/SQL variables in the WHERE clause.

You learned more about PL/SQL records and declaring variables using anchored types. %ROWTYPE and %TYPE allow you to anchor the type of your record or variable to a specific table row type, cursor row type, or table column type.

Using the well-known SYSDATE system variable, you learned how to use TIMING commands to measure program execution speed and to determine the amount of time a process takes to complete.

We discussed PL/SQL packages, which enable you to hide implementation details for PL/SQL modules, thus allowing for cleaner programming interfaces. Package code can be shared across multiple sessions. Packages have visible package specifications that expose all the usable parts of a package like functions and procedures.

Triggers are used to enforce complex business constraints, rules, and security measures not enforceable using other means. Triggers are fired automatically when the event that triggers them, usually a DML statement, happens. Triggers can be configured to execute before or after the triggering event is executed. Finally, triggers can be used to automate many tasks like auditing user activity or accounting.

Congratulations! Now you know more about PL/SQL than most people you will meet. I wish you all the best in your pursuits.

Chapter Questions

1. **Which of the following are true about SQL DML within PL/SQL?**

   A. There are two ways to implement SQL DML: explicit cursors and implicit cursors.

   B. SQL DML cannot be implemented from within PL/SQL code.

   C. It is not possible to use explicit cursors to execute SQL DML that affects at most a single row.

   D. You can use PL/SQL variables within SQL DML inside PL/SQL code.

2. **Coding conventions are important because:**

   A. Following them eases the maintenance of software.

   B. They allow for better understanding between multitudes of developers of large projects.

   C. They eliminate wasted time dealing with problems that arise due to hard-to-read coding styles.

   D. They always make all code portable.

3. **Which of the following is not true about packages?**

   A. Packages can contain triggers.

   B. Package variables are variables declared in the package specification and are initialized once when the package is loaded into memory.

C. The package execution section is mainly used for assigning values to package variables and doing some one-time work for that package.

D. Functions and procedures declared and defined within a package body, but not declared in its specification, are not accessible to users of the package.

4. Which of the following are true about triggers?

A. Triggers are automatically called by the system.

B. Triggers can call other stored PL/SQL procedures or functions.

C. If an exception is raised during the execution of a trigger, all the changes (including the ones made by the triggering statement) are rolled back if the exception is not handled.

D. You can write triggers on packages, because they are also stored in the database.

Answers to Chapter Questions

1. A, D. There are two ways to implement SQL DML: explicit cursors and implicit cursors.
You can use PL/SQL variables within SQL DML inside PL/SQL code.

Explanation B is certainly not true; the last two chapters have contained numerous examples showing the use of DML commands within PL/SQL code. C is false because an explicit cursor may return a single row or no rows at all.

2. A, B, and C. Following them eases the maintenance of software.
They allow for better understanding between multitudes of developers of large projects.
They eliminate wasted time dealing with problems that arise due to hard-to-read coding styles.

Explanation A, B, and C are all valid reasons to use coding conventions. D is not true. While you can write coding and naming conventions to make code portable to many platforms, you cannot guarantee the code based only on coding conventions. This is because there are vast differences between hardware and software platforms.

3. A. Packages can contain triggers.

Explanation By definition, triggers can only be fired in response to an action taken on a table. They cannot be called as part of a package.

4. A, B, and C. Triggers are automatically called by the system. Triggers can call other stored PL/SQL procedures or functions. If an exception is raised during the execution of a trigger, all the changes (including the ones made by the triggering statement) are rolled back if the exception is not handled.

Explanation D is false. Oracle does not allow you to write triggers that fire in response to package events, for the same reason that triggers cannot be placed inside packages.

CHAPTER 3
The Database Administrator

CRITICAL SKILLS

3.1 Learn the Job of the DBA

3.2 Understand the Oracle Database 10*g* DBA Skill Set

3.3 Perform Day-to-Day Operations

3.4 Understand the Oracle Database 10*g* Infrastructure

3.5 Operate Modes of an Oracle Database 10*g*

3.6 Get Started with Oracle Enterprise Manager

3.7 Manage Database Objects

3.8 Manage Space

3.9 Manage Users

3.10 Manage Privileges for Database Users

So, you've decided to be a *Database Administrator (DBA).* Great choice! On top of that, you've chosen Oracle as the *Database Management System (DBMS)* that you want to work with. Even better! All you need to do now is figure out how to learn what you need to know to do the job. Reading this book is a great start. However, the job of a DBA cannot be learned entirely in a few short months. It is a work in progress that can take several years to become really good at. Don't get us wrong—you can learn the basics that will make you a productive DBA in a few short months, but there is a great deal to learn, and we don't become really good at this job until we've actually run the utility, executed the SQL, or performed the task. In other words, don't just read this book—try the examples and don't be afraid to make mistakes.

CRITICAL SKILL 3.1

Learn the Job of the DBA

The role of a DBA is more of a career than a job. Those of us who have been doing this for many years are always learning new things and just trying to keep up! That's the exciting thing about being a DBA: the job keeps changing. Databases are growing at a phenomenal pace, the number of users is increasing, availability requirements are striving for that magical 24/7 mark, and security has become a much greater concern. As you will see in this book, databases now include more than just data. They are also about the Internet and grid computing and XML and Java. So, how long will it take you to learn how to be a DBA? For as long as you're practicing this career.

There are some concrete steps that you can take to jump-start your learning process. Undertaking an Oracle Certification will provide you with a structured program that offers you clear steps to help learn the details of the job. Instructor-led courses as well as CD- and Internet-based classes can help you through the process. Also, read as much as you can and then get your hands on a test database and practice what you've learned.

Applications come and go, but data stays around. All of the information that makes your company valuable is (or should be) stored in a database. Customer, vendor, employee, and financial data, as well as every other corporate data is stored in a database, and your company would have great difficulty surviving if any of that data was lost. Learn your job well. People are depending on you.

CRITICAL SKILL 3.2

Understand the Oracle Database 10*g* DBA Skill Set

There is good news for DBAs: Oracle has tools to help you do your job and manage your databases. These tools have existed for many versions of Oracle and have improved with each release to the point where the Oracle Database 10*g* offerings are

extensive. In many cases, you will have the option of doing your job using a *Graphical User Interface (GUI),* and you will also have the option of using a command-line interface. We recommend learning both. You will need to use the command-line interface in many cases to schedule work through scripts. The GUI can be used for performing day-to-day operations and can also be used as a great learning tool the first time you perform an operation. In many cases, you will be able to generate the low-level commands from the GUI and can copy them to a file to be used later on.

As we've mentioned, there is a great deal that you will need to know in order to be able to provide well-rounded coverage of your Oracle environment. We can categorize the specialized areas of database management so that you will be aware of the whole picture and can break your work into well-defined groupings.

CRITICAL SKILL 3.3

Perform Day-to-Day Operations

In order to properly perform the role of Database Administrator, you will need to develop and implement solutions that cover all areas of this discipline. The amazing part of this job is that you may be asked to do many, or perhaps all, aspects of your job on any given day. Your daily tasks will vary from doing high-level architecture and design to performing low-level tasks. Let's take a look at the things that you will be getting involved in.

Architecture and Design

DBAs should be involved with the architecture and design of new applications, databases, and even technical infrastructure changes. Decisions made here will have a large impact on database performance and scalability and database knowledge will help choose a better technical implementation. Data design tools such as Oracle Designer can assist the DBA.

Capacity Planning

Short and long range planning needs to be performed on your databases and applications. This will focus on performance and sizing characteristics of your systems that will help to determine upcoming storage, CPU, memory, and network needs. This is an area that is often neglected and can lead to big problems if it is not done properly.

Backup and Recovery

A backup and recovery plan is, of course, critical in order to protect your corporate data. You need to ensure that data can be recovered quickly to the nearest point in time as possible. There is also a performance aspect to this since backups must be

performed using minimal resources while the database is up and running and recoveries need to be performed within a time limit predefined by Service Level Agreements (*sla*) that are developed to meet customers' requirements. A complete backup and recovery implementation should include local recovery and remote recovery that is also referred to as disaster recovery planning (*drp*). You will see more on backup and recovery later in Chapter 5.

Security

This is an area that has become very sensitive due to the number of users that can access our databases and the amount of external, web-based access. Database users need to be authenticated so that we know with certainty who is accessing our database. They must then be given authorization to use the resources that they need to do their job by granting access to the objects in Oracle. This can be managed with Oracle Enterprise Manager, and we will show examples of this later in this chapter. External users require extra web-based security that is beyond the scope of this book.

Performance and Tuning

Performance and tuning is arguably the most exciting area of database management. Changes here are noticed almost immediately and every experienced DBA has stories about small changes they've made that resulted in large performance gains. On the other hand, every performance glitch in the environment will be blamed on the database and you will need to learn how to deal with this. Statspack, OEM Performance Management, and third-party tools will assist you in this area. There is a lot to learn here, but the proper tools will simplify this considerably.

Managing Database Objects

We need to manage all schema objects such as tables, indexes, views, synonyms, sequences, clusters, and source types such as packages, procedures, functions, and triggers to ensure they are valid and organized in a fashion that will deliver adequate performance and have adequate space. The space requirements of schema objects are directly related to tablespaces and datafiles that are growing at incredible rates. Using OEM, this can be simplified, something we will see examples of later in this chapter.

Storage Management

Databases are growing at incredible rates. We need to carefully manage space and pay particular attention to the space used by datafiles and archive logs. Online utilities are supported to help reorg objects while they remain online. Reorgs use considerable resources, however, so do not perform these operations unless it is necessary. See the section "Managing Space" for more on this.

TIP
Do not reorg unless you absolutely need to.

Change Management

Being able to upgrade or change the database is a discipline that includes many areas. Upgrades to the database schema, procedural logic in the database, and database software must all be performed in a controlled manner. Change control procedures and tools such as Oracle's Change Manager and third-party offerings will assist you.

Schedule Jobs

Oracle Database 10*g* comes with a new scheduler that allows you to schedule a job for a specific date and time, and to categorize jobs into job classes that can be prioritized. So, resources can be controlled by job class. Of course, other native scheduling systems such as "at" in Windows and crontab in UNIX can be used as well as other third-party offerings.

Network Management

Oracle Networking is a fundamental component of the database that you will need to become comfortable with. Database connectivity options like Tnsnames, the Oracle Internet Directory (OID), and the Oracle Listener require planning to ensure that performance and security requirements are met in a way that is simple to manage. You will see more of this in the next chapter.

Troubleshooting

Though troubleshooting may not be what you'd consider a classic area of Database Management, it is one area that you will encounter daily. You will need tools to help you with this. Oracle MetaLink technical support, available to customers who purchase the service, is invaluable. Oracle alert logs and dump files will also help you greatly. Experience will be your biggest ally here and the sooner you dive into database support, the faster you will progress.

You've seen the areas of database management that need to be handled, now it's time to look at the Oracle schema and storage infrastructure.

CRITICAL SKILL 3.4

Understand the Oracle Database 10*g* Infrastructure

Oracle's memory and process infrastructure have already been discussed in Chapter 1. In this section, we will take a look at the Oracle schema and storage infrastructure since these are a large part of what you will be required to manage.

Schemas

An Oracle database has many schemas contained in it. The schema is a logical structure that contains objects like segments, views, procedures, functions, packages, triggers, user-defined objects, collection types, sequences, synonyms, and database links. A segment is a data structure that can be a table, index, or temporary or undo segment. The schema name is the user that controls the schema. Examples of schemas are the System, Sys, Scott, and SH schemas. Figure 3-1 shows the relationship between these schema objects.

Segments, Extents, and Blocks

As you can see in Figure 3-1, a schema can have many segments and many segment types. Each segment is a single instance of a table, partition, cluster, index, or temporary or undo segment. So, for example, a table with two indexes is implemented as three segments in the schema. A segment is broken down further into extents, which are a collection of contiguous data blocks. As data is added to Oracle, it will first fill the blocks in the allocated extents and once those extents are full, new extents can be added to the segment as long as space allows. Oracle segment types are listed here:

- Tables are where the data is kept in rows and columns. This is the heart of your database and a table is implemented in one schema and one tablespace. The exception to this is a special type of table called a partitioned table where the table can be split into different ranges or sets of values called a partition and each partition can be implemented in a different tablespace.

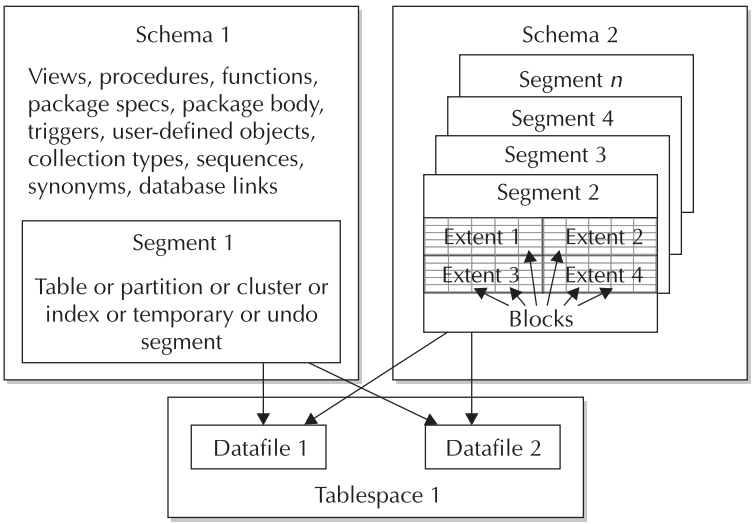


FIGURE 3-1. *The database and user schemas*

Remember, however, that each partition is itself a segment and each segment can only reside in one tablespace. Clustered tables are another special case where two tables with a close link between them can have their data stored together in a single block to improve join operations.

- Indexes are optionally built on tables for performance reasons and to help implement integrity constraints such as primary keys and uniqueness.
- Temporary segments are used as a temporary storage area by Oracle to run an SQL statement. For example, they may be used for sorting data and then discarded once a query or transaction is complete.
- Undo segments are used to manage the before image of changes to allow data to roll back if needed and to help provide data consistency for users querying data that is being changed. There will be more on this in Chapter 5.

Segments can be thought of as physical structures since they actually are used to store data that is kept in a tablespace, although some of this is temporary in nature. There are other structures stored in the schema that are more logical in nature.

Logical Schema Structures

Not everything stored in a database and schema is data. Oracle also manages source modules as well as supporting structures such as sequences that are used to populate new unique and primary key values when inserting data into the database. These objects belong to a schema and are stored in the Oracle Catalog. These can all be easily managed through OEM, as shown in Figure 3-2. Take a look at the following for a brief description of these logical structures:

- Views give you the capability of subsetting a table and combining multiple tables through a single named object. They can be thought of as a stored query. With the exception of a special type of view called a materialized view that is used for data warehousing, data is not stored in views. They are simply a new way of defining access to the underlying tables. These can be used for security, performance, and ease-of-use.
- Synonyms are used to create a new name or alias for another database object such as a table, view, another synonym, and sources such as a procedure, package, function, java class, and so on. They can be used to simplify access. As with views, data is not stored in a synonym.
- Sequences are used to generate new unique numbers that can be used by applications when inserting data into tables.
- Source programs can be stored in the catalog and written in Oracle's proprietary PL/SQL or Java. PL/SQL source types include business logic that can be written as Packages, Procedures, and Functions. Triggers can

also be used to implement business logic, but are often used to implement data integrity since they are not executed directly by a user or source program, but rather are automatically executed when an action is performed on the database. Java Sources and Java Classes are also implemented directly in Oracle. This server-side support of application logic improves performance since the logic resides with the data and it also improves performance.

- User types can be created by you to support object-oriented development. Array types, Object types, and Table types can all be created by you. As well, the Oracle XML Schema Processor supports XML processing by adding data types to XML documents that can be used to ensure the integrity of data in XML documents.

So now that you have seen all of our schema objects, it's time to tie these together to our storage architecture.

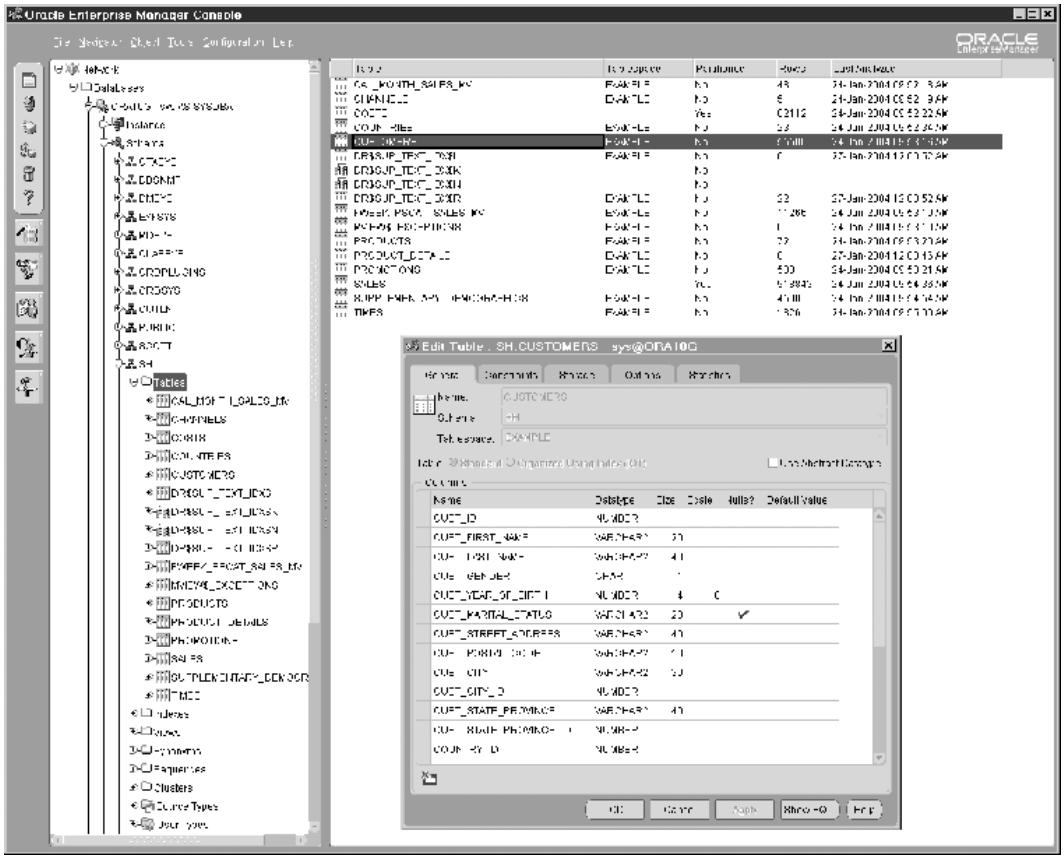


FIGURE 3-2. *Enterprise Manager table definition view*

Storage Structures

As shown in Figure 3-1, the physical schema objects are stored as segments in the database. Each segment can only be stored in a single tablespace and a tablespace can be made up of one or more datafiles. If a tablespace is running out of space, you can expand the datafiles it is made up of, or you can also add a new datafile to the tablespace. A datafile can only store data for a single tablespace.

A single tablespace can store data for multiple segments and in fact for several segment types. Segments from multiple schemas can also exist in the same tablespace. So, for example, table_a from schema1 and index_b from schema2 can both be implemented in the same tablespace. Oh and by the way, a tablespace can only store data for a single database.

The logical structures such as views and source code are stored in the Oracle catalog but are part of a schema. So, this means that the Oracle-supplied SH schema can contain all of the objects that it needs to run the entire application under its own schema name. This provides strong security and management benefits.

Progress Check

1. Name five areas that you will need to address as a DBA.
2. What is a schema and what does it contain?
3. Can a tablespace store more than one segment type?
4. Under which circumstances would you bother to start up the database in nomount mode?

CRITICAL SKILL 3.5

Operate Modes of an Oracle Database 10*g*

Oracle is a software package like many others that you may have used. However, when you run most programs, they run one and only one way. So when I open my accounting software, I run it the same way all the time. However, you have options

Progress Check Answers

1. As a DBA, you will need to address architecture, capacity planning, backup and recovery, and security and performance, among others.

2. A schema is a logical structure that contains objects like segments, views, procedures, functions, packages, triggers, user-defined objects, collection types, sequences, synonyms, and database links.

3. A single tablespace can store data for multiple segments and different segment types. Segments from multiple schemas can also exist in the same tablespace. So, for example, table_a from schema1 and index_b from schema2 can be implemented as two segments in the same tablespace.

4. When started in nomount mode, the parameter file is read and memory structures and processes are started for the instance. The database is not yet associated with the instance. You will use this in cases where you need to re-create the controlfile.

with Oracle. This section discusses the many ways that you can run Oracle. Some of these methods will be important to administrators, while others will allow for full use. This feature is important when you need to perform both critical and noncritical activities, and not interfere with your users or your data.

Modes of Operation

Oracle has several modes of operation. In most cases, when you start Oracle, you will simply issue the command:

```
> Startup;
```

This command actually takes Oracle through three distinct startup phases automatically, or you could also choose to explicitly step through these phases:

1. In the *nomount phase,* the database reads the spfile or the init.ora parameter file and starts up the Oracle memory structures as well as the background processes. The instance is started, but the database is not yet associated with the newly started instance. This is usually used in cases where you need to re-create the controlfile. The command to perform this is

   ```
   > startup nomount;
   ```

2. In order to associate a database with the instance, the instance "mounts" the database. This is done in the *mount phase*. The previously read parameter file is used to find those controlfiles, which contain the name of the data files and redo logs. The database is then mounted to allow some maintenance activities to be performed. Datafiles and redo logs are not opened when the database is in mount mode, so the database is not yet accessible by end users for normal tasks. Commands to mount a database are

   ```
   > startup mount;
   > alter database mount;
   ```

3. When Oracle opens the database in the *open phase,* it opens the data files and redo logs, making the database available for normal operations. Your redo logs must exist in order for the database to open. If they do not, the **resetlogs** command must be used to create new redo logs in the location specified in the control files.

   ```
   > Startup {open} {resetlogs};
   > alter database open;
   ```

Other Ways to Open the Database

There are some other options for opening a database. For example, you may want to open it in Read-Only mode so that no database changes (inserts, updates, or deletes) can be performed. There are also the upgrade/downgrade options that allow a database to be opened to perform a downgrade or upgrade to another version of Oracle.

```
> alter database open read only;
```

A common option you will use to perform maintenance will be to open the database in restricted mode. When you issue the command **startup restrict**, only users with both the **create session** and **restricted session** privileges will be able to use the database. So, as a DBA this is a helpful way to open the database that only you can use.

```
> startup restrict;
```

The database can be placed in a state where only the **sys** and **system** users can query the database without stopping the database and performing a subsequent **startup restrict**. The activities of other users continue until they become inactive. This can be performed using the **quiesce** option of alter session when the Database Resource Manager option has been set up.

```
> alter system quiesce restrict;
> alter system unquiesce;
```

Forcing a Startup

Over time, you will run into situations where Oracle has not shutdown properly and you are unable to restart it. In these rare instances, you will need to use the **force** option of the **startup** command. This will first perform a "shutdown abort" that forces the database to shutdown (see the next section for more information on this) followed by a database startup.

```
> startup force
```

Database and Instance Shutdown

When shutting down an instance, perform these steps, which are reverse from those you just saw when opening a database:

1. Close the database, including the data files and redo logs, so that it is no longer usable for normal tasks.
2. Unmount the database from the instance so that only the instance memory structures and background tasks are left running without a database associated with them.
3. Shut down the instance to close the control files.

In order to shut down a database, four different approaches can be used: Shutdown Normal, Immediate, Transactional, and Abort.

- *Normal* is, in a sense, the "perfect" way to shut down, since this approach will wait for all users to disconnect from the database and all transactions

to complete before the shutdown occurs. Once this command has been issued, new users are not allowed into the system. This can be impractical in cases where users remain on the system for long periods of time.

```
> shutdown normal;
```

- *Immediate* is a practical shutdown approach that also leaves the database in a consistent state. When the database is put through a "shutdown immediate," all current transactions are rolled back and users are disconnected. No new transactions are allowed into the system. This will be relatively quick if the rollback operations are small, and is an excellent way to shut down the database before performing a database backup.

```
> shutdown immediate;
```

- A *transactional shutdown* is similar to the immediate variety except that running transactions are allowed to complete. So, once transactions have been committed, the user running it is disconnected. This is useful in cases where you do not want to shutdown until currently running transactions have finished or in cases where it will be quicker to complete existing transactions than it will be to roll them back.

```
> shutdown transactional
```

- *Abort* is the least graceful shutdown option of the four. When this is used, all transactions are ended immediately without waiting for a rollback or commit and all users are instantly disconnected while the database is brought down. Use this only if you are experiencing problems shutting down the database using one of the three options described previously or in cases where you need to shutdown the database immediately. The database needs to go through recovery procedures the next time it is restarted. After a shutdown abort has been performed, you should try to immediately start up the database so that you can then perform a shutdown (normal, immediate, or transactional) to bring the database down in the proper manner.

```
> shutdown abort;
```

OEM can help with instance and database startup and shutdown, as shown in Figure 3-3. Open OEM. In the left panel, choose the instance you want to work on and select "Instance" under the instance name (in this case, it's ora10g), then on the right side of the panel, choose View And Edit The Values Of Instance Parameters.

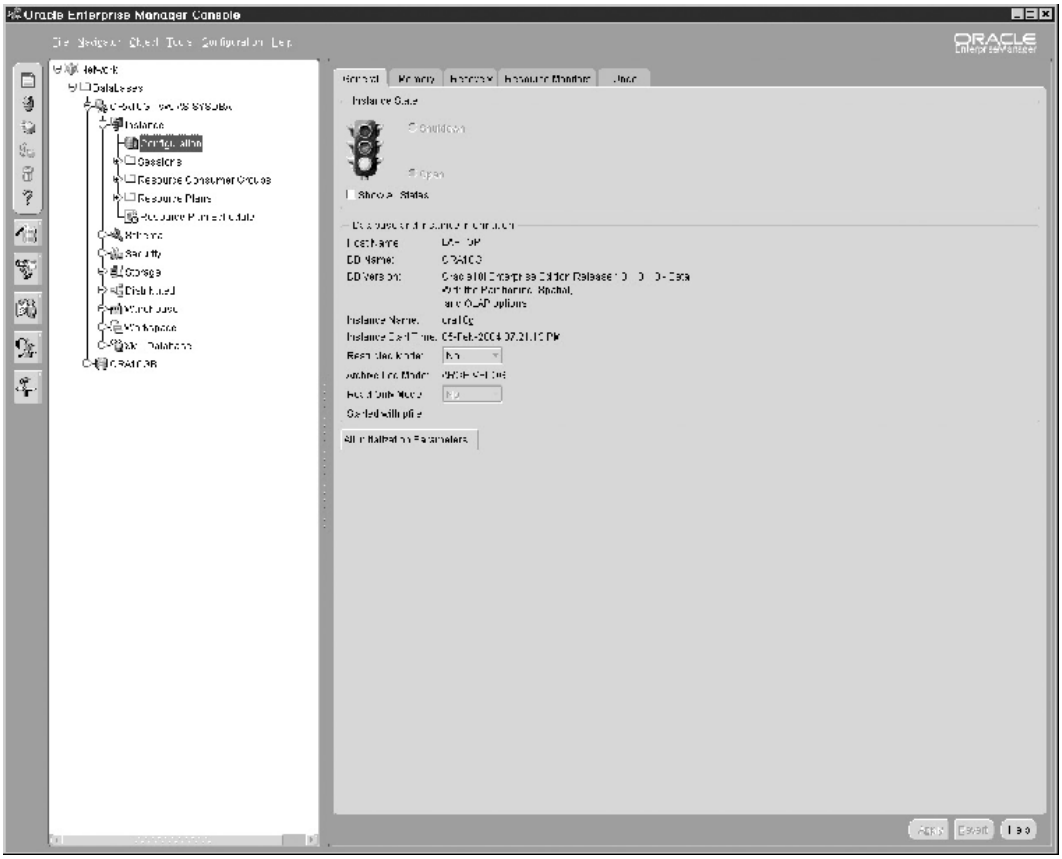


FIGURE 3-3. *Enterprise Manager instance configuration view*

CRITICAL SKILL 3.6

Get Started with Oracle Enterprise Manager

Oracle Enterprise Manager (OEM) is a great tool to assist the beginner DBA through to the experienced one. You should, however, also learn the low-level commands that will allow you to do your job through an interface like SQL*Plus. OEM can help you with this by showing you the SQL that it has generated when you select the Show Sql button that exists on many windows. Given how many options OEM has to help you do your job as a DBA, we will take a quick look at them here.

First off, OEM can be used to manage all of the databases in your network. As you can see in Figure 3-3, once you expand the network, you can select Databases

and manage your databases from there. The right side of this OEM panel shows all of the objects that can be managed through OEM such as instances, schemas, security, distributed, warehouse, and workspace management features.

Instance Configuration

Once you select a database, which in our example is named ora10g, you can drill down to the instance and then the configuration of that instance. Figure 3-3 shows that we can see the state of an instance as well as all initialization parameters and whether the database is running in archive log mode and if it is in a restricted state. As you can see from the tabs on the right panel of this screen, we can see and manage memory settings, recovery options, resource monitors in effect, and undo information.

User Sessions

Now that we have a good handle on managing our instances and databases, we can drill down to our user sessions to see exactly what is going on inside the database. By choosing a session, we can see some general information such as the user session ID, when they logged in, and what the OS username and terminal name are for this user. As you can see from Figure 3-4, we can also see the SQL that is currently running, along with the explain plan being used. You can follow the order that each explain step is being performed in by the Step # column and can step through the plan or see it in a graphical layout using the far right column. You can also manage sessions and disconnect users by right-clicking the username and issuing the **kill session** command. I admit that the command name may be a bit harsh, but it does get the idea across.

Resource Consumer Groups

Next, we can select the Resource Consumer Groups item to see all of the groups that exist. A resource consumer group provides a way to group together users so that they can share similar processing requirements. The DATABASE_RESOURCE_ MANAGER package is used to allocate the maximum amount of CPU that a session can use or to set a limit for parallel execution for a session or to set the number of sessions that can be active for a consumer group as a few examples of this capability. OEM can assist in managing these groups by giving us an easy way to add new groups and edit those that exist. This panel allows us to enter a description of the group and attach users and database roles to a group. If you look at Figure 3-5, you will see all of the resource consumer groups listed. If you select one of these consumer groups, you will be presented with the capabilities to manage users, roles, and general information it.

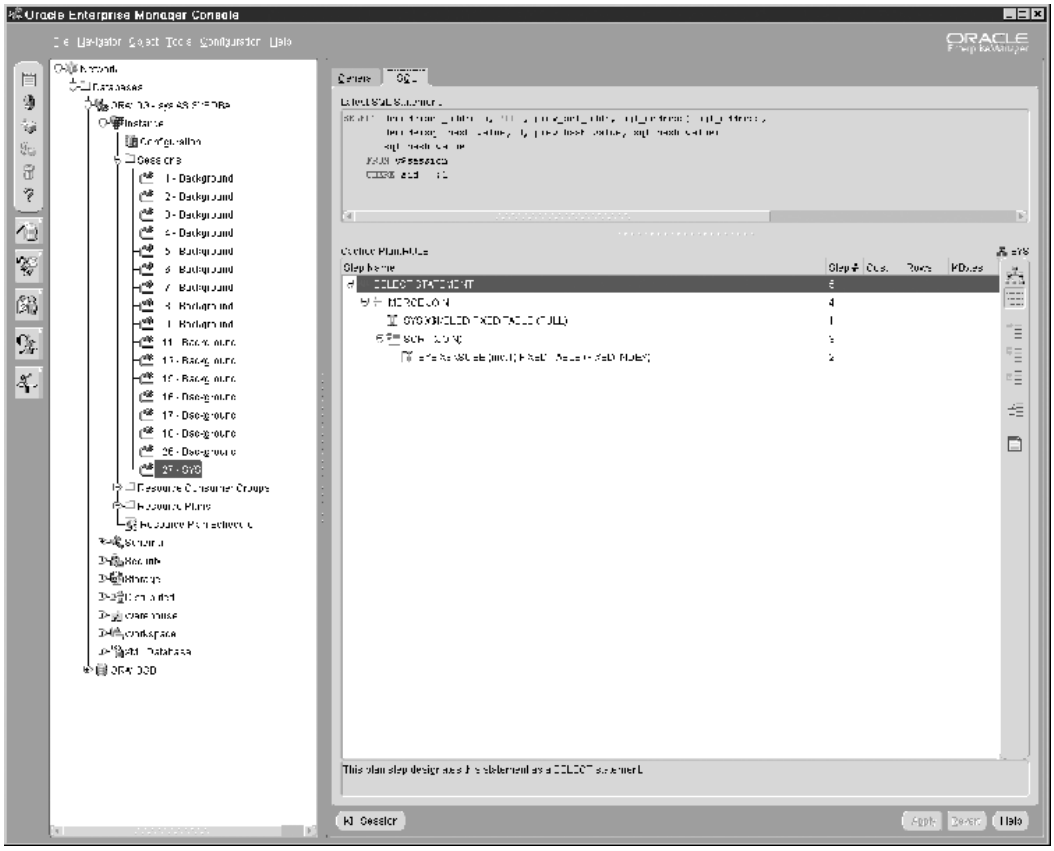


FIGURE 3-4. *SQL explain plan*

A resource plan builds on the resource consumer groups by providing a way to define how system resources will be allocated to the resource consumer groups that we just discussed. Figure 3-5 shows a list of the groups and subplans that can be set up here. We see tabs that allow us to define maximum parallelism, concurrently active sessions, undo pool space, and execution time limits for the group. Group switching allows for a session to change groups after a predefined amount of execution time has been reached. Presumably, you would move the user to a lower priority group to free resources to other sessions. The resource plan schedule can be used to set daily schedules to enable and disable resource plans.

Schema, Security, and Storage Management

The next items on the OEM console are schema, security, and storage management. We will visit these in sections 3.7, 3.8, and 3.9/3.10, respectively. It is worth mentioning now, however, that all three of these can be completely managed through OEM.

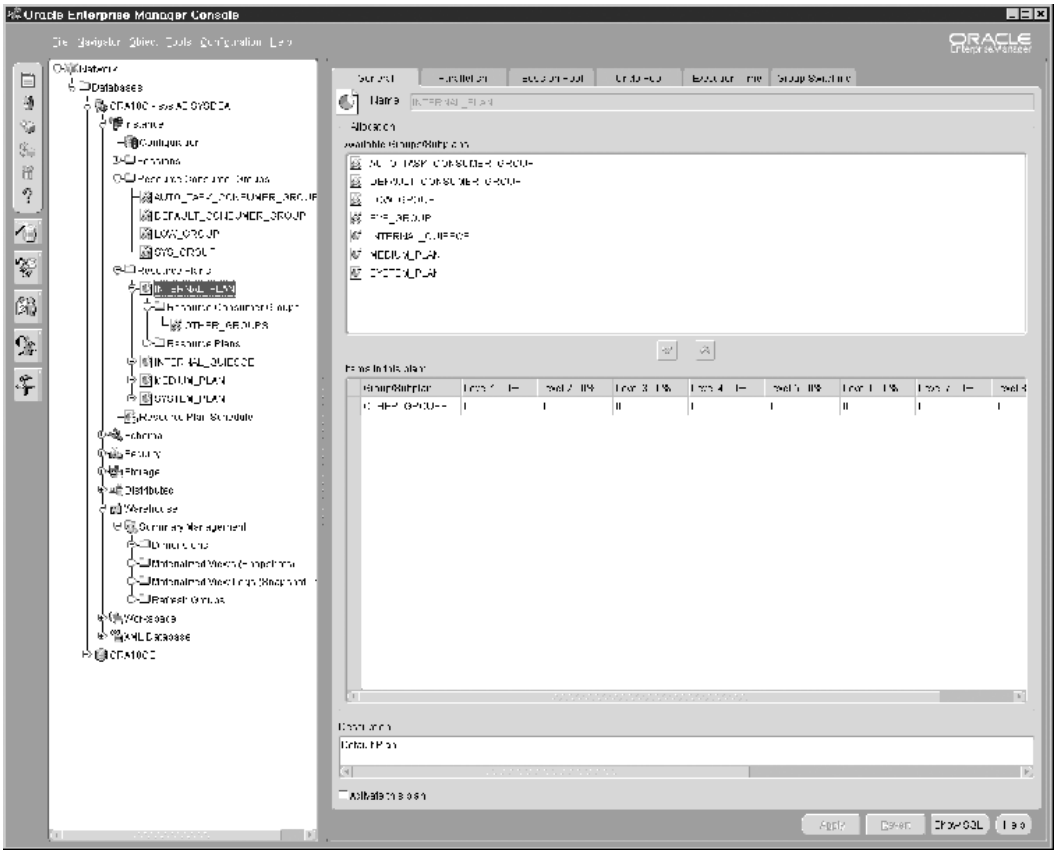


FIGURE 3-5. *Enterprise Manager resource group view*

Distributed Management

Some Oracle distributed capabilities are handled through the Distributed option. These include the ability to:

- Manage in-doubt transactions that can result from two-phase commit.
- Create, edit, and drop database links.
- Use streams to implement messaging.
- Use advanced queues and replication to pass messages and data to applications.

This can be a difficult area to manage and having a tool such as the OEM Console to help us out with this is a very welcome feature.

Warehouse Features

Warehouse options such as summary management, materialized views, and dimensions can all be dealt with through OEM, as shown in Figure 3-5.

Other Tools

You will notice that the toolbar has an option called Tools. This includes more advanced tools for managing our environment. Let's very quickly review the Tools that are included here. These tools can all be selected, as shown in Figure 3-6.

Database Tools to analyze data, perform backup management, and provide data management for utilities such as export, import, and load are included in the first option. Choose Tools and then Database Tools to get to these. Once Database Tools has been chosen, you will be presented with options to back up, recover, maintain, and configure your backup and recovery jobs. Backup management can be selected under Tools, as shown in Figure 3-6.

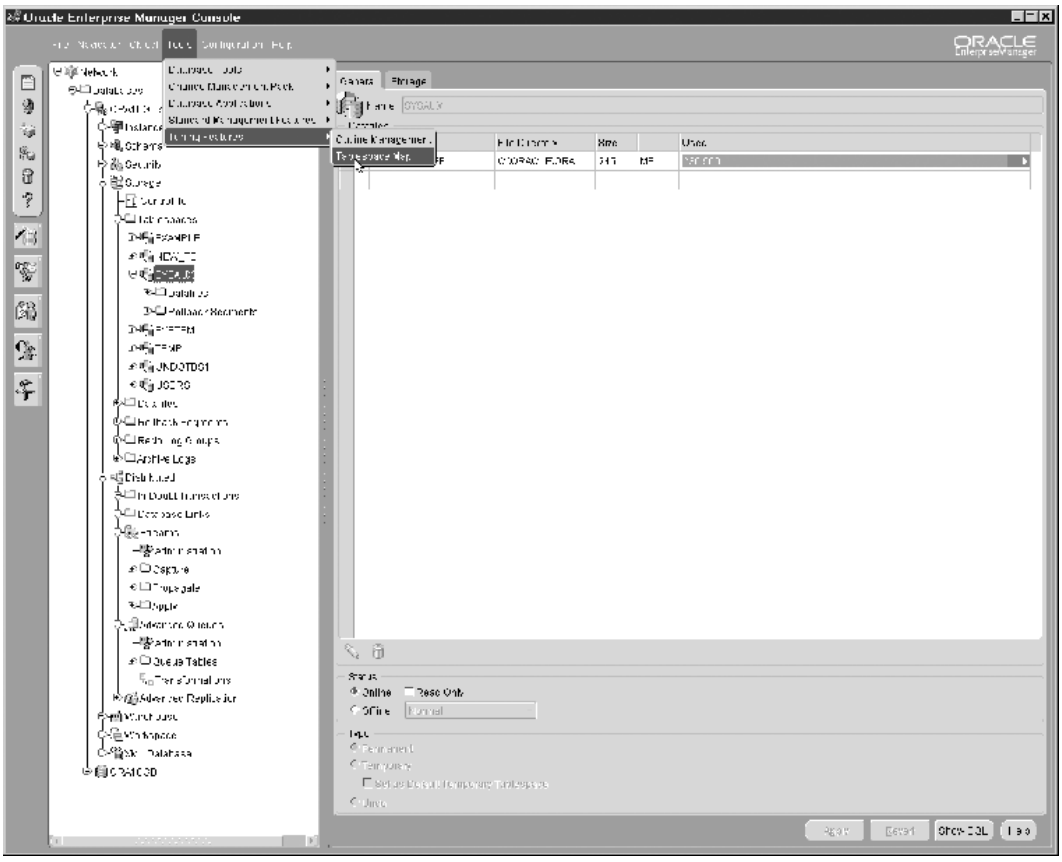


FIGURE 3-6. *Enterprise Manager tool options*

Database change management can be performed through the Change Management Pack. Under Tools, choose Change Management Pack or Standard Management Features and these will lead you to the Change Manager utility.

Database applications will provide support for the spatial index advisor, SQL*Plus Worksheet, and the Oracle Text Manager.

Tuning facilities such as performance manager, outline management, and tablespace maps are provided through Standard Management Features and Tuning Features, as shown in Figure 3-6.

As you can see from this overview of OEM console capabilities, many of the tools that we need to perform our day-to-day tasks can be found in this one console. Now that we have confidence that there's a toolset to support us, let's take a quick look at what you need to think about when managing database objects.

CRITICAL SKILL 3.7

Manage Database Objects

A large part of your job as a DBA will be to manage the objects that exist in a database. Let's look at the objects that you need to concern yourself with and discuss the main management issues that you will have in each of these areas.

Controlfiles

It is critical to the database that you have at least one valid control file for your database. These are small files and can be multiplexed by the Oracle instance. Ensuring that you have at least three copies of the controlfiles (remember, they are small), as well as text and binary backups whenever a data file, log file, or tablespace is changed and on a regularly scheduled basis (at least daily) will go a long way towards ensuring that your control files are in good shape. Controlfiles will be discussed in more detail in Chapter 5.

Redo Logs

Redo logs are necessary to ensure database integrity and should be duplexed in Oracle. Oracle mirroring helps even if your redo logs are mirrored by your storage subsystem since Oracle will use the alternate redo log if one should become corrupt. You will need to ensure that you have enough redo logs and that they are sized properly to support database performance. How large should your redo logs be? They should be large enough that a log switch does not usually occur more than once every 15 minutes due to the checkpointing that occurs during a log switch and the overhead that is incurred during this operation. How many redo logs should you have? You should have enough redo logs that the system will not wrap around to a log that has not yet completed a checkpoint or completed archiving (for systems in archivelog mode). Redo logs can be added, deleted, and switched through OEM.

Undo Management

The Undo segment is where the before images of changed rows are stored. Oracle will manage your undo segments for you, but you need to determine how large to make the tablespace that the Undo segment is stored in. The size that you make this depends on the length of time that you want the undo information to be available to you. If you look at Figure 3-7, you will see how OEM helps you determine the length of time that Undo can be retained based on the system activity and Undo tablespace. This is in the Configuration section for an instance. If the tablespace is not the correct size, it can be changed using the Storage feature of OEM, which you will see later in this chapter. Undo segments are covered further in Chapter 5.

If you choose to implement user-managed rollback segments, then these can be managed in the Storage section of OEM by choosing Rollback Segments and then selecting the segment name that you want to manage. If you look at Figure 3-7, you will see a Rollback Segment named System. By the way, the System rollback segment will always exist but should never be used as a rollback segment for user processes.

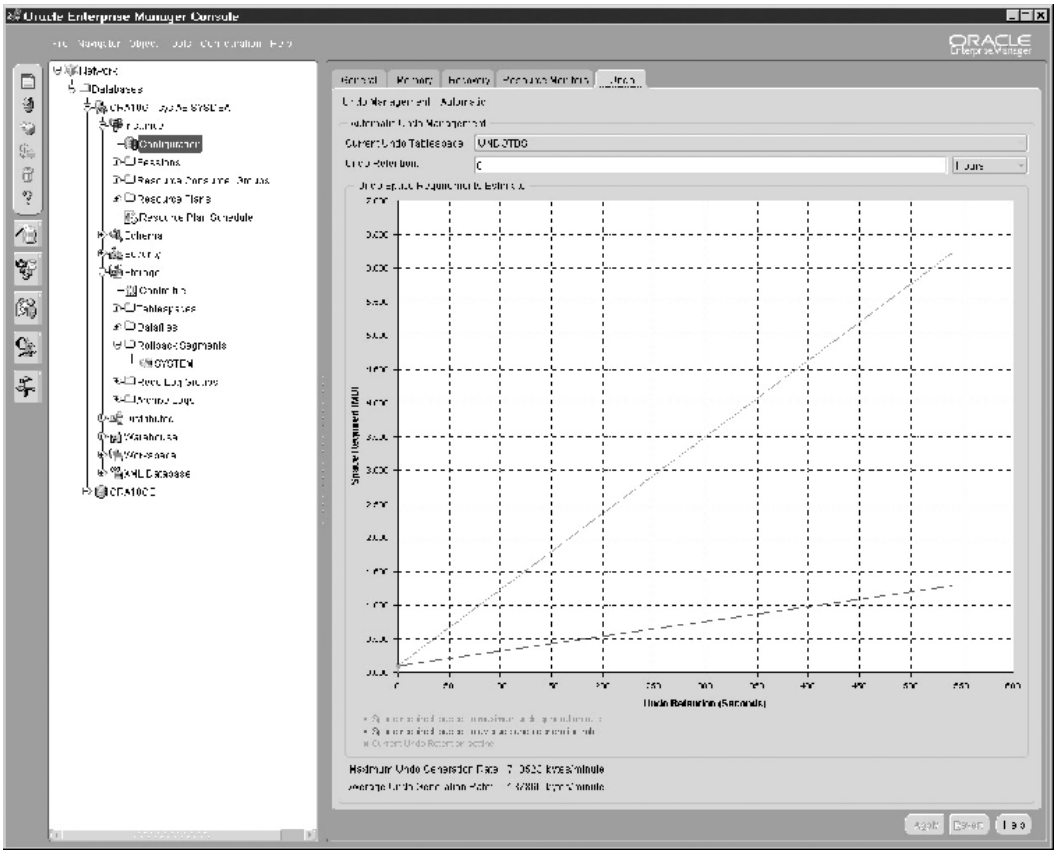


FIGURE 3-7. *Enterprise Manager Automatic Undo Management view*

Schema Objects

Schema objects were discussed earlier in this chapter, and you saw that we can manage schema objects through OEM. There are also some things that you may want to do with your own SQL scripts that run as scheduled jobs. When managing schemas, you need to ensure that those physical objects that take up a great deal of space, do in fact have enough space to grow. This includes tables, indexes, clusters, and partitioned tables. Manage this space through the tablespace that they are implemented in and ensure that there is enough room to grow in the tablespace. Ensuring that the extent sizes are large enough that you do not need to allocate too many extents is something that you need to monitor. But, do not become reorg-happy. You do not need to reorg a table if it is in hundreds of extents. You only need to reorg if there are a large number of chained or migrated rows. Indexes, on the other hand, will need to be reorged more frequently. We will find out more about managing space in the next section.

Figure 3-2 shows an example of how the SH.Customers table can be managed through OEM. Note the Storage tab that allows you to change the table's storage parameters. You should also try to maintain statistics on your tables and indexes so they are up-to-date. This will assist the optimizer make better decisions when choosing access paths for your queries and can be used to validate the structures. In Oracle Database 10*g,* a scheduler job called *gather_stats_job* will run during a maintenance window between 10:00 P.M. and 6:00 A.M., by default, and will run statistics for those objects in cases where they have not been collected yet or are stale. Setting the Oracle Database 10*g* initialization parameter **statistics_level** to typical (the default) will allow Oracle to automatically update statistics as a background task on a regular basis and is the recommended approach for gathering statistics. In pre–Oracle Database 10*g* releases, the DBMS_STATS package should be run manually or can use the *Monitoring* keyword in a CREATE or ALTER table. Monitoring is a deprecated feature in Oracle Database 10*g* and the keyword (along with "nomonitoring") will be ignored.

Logical schema objects that do not take up a lot of space need to be watched to ensure they are not invalid. Triggers, views, synonyms, procedures, functions, and packages are examples of the objects that should be valid. You can check this with the SQL statement that follows.

```
select owner, object_name, object_type
from dba_objects where status ^= 'VALID';
```

We've looked at many of the database objects that will require your attention. Let's now explore one area that requires special attention due to the size of today's databases.

Ask the Expert

Q: Why is it important for DBAs to get involved with the architecture and design of a new system?

A: Decisions made on the technical infrastructure as well as data and application designs here will have a large impact on database performance and scalability. Database knowledge will help choose a better technical implementation. Once chosen, these can be difficult to change.

Q: Which method do you normally use to shut down a database?

A: Although the **shutdown normal** operation is a recommended approach, it is often impractical since you need users to disconnect themselves. The approach that I prefer is to perform a checkpoint using the command **alter system checkpoint** which will write data out to data files and speed up the restart. I then perform a **shutdown abort**, immediately followed by a **startup restrict**, and **shutdown immediate**. This is a fast, guaranteed shutdown that leaves the database in a consistent state once all of the steps have been completed.

Q: What is the best way to become a good Oracle DBA quickly and then to keep improving?

A: There are many things that you will need to do and many skills that you'll need to develop to do this job. First, learning the basic DBA skills, which you can get from books such as this as well as from courses, will give you a head start. Practicing what you see is probably the quickest and most practical way to learn. Getting involved in supporting some databases in development and production will force you to learn very quickly. Then working on development systems for different types of applications will help to round out your skills. Keep reading and learning and never assume that you know it all and you will do very well.

CRITICAL SKILL 3.8

Manage Space

The challenge of managing data in your Oracle Database 10*g* is one that provides you with options. In this section, we will look at the methods that have been used in the many versions of the database to manage your information. Today's version of the

database provides us with options. The first that we will discuss is managing your data and the files in which they reside in a manual way. Another option, automatic storage management, is discussed in Chapter 9.

Archive Logs

When you put the database in archive logging mode, the redo logs are written out to a directory that is named in your parameter or SPFILE. If that directory becomes full and the database attempts to write another archive log, the database activity will be suspended until sufficient space is made available for the new file. Create a large directory and schedule jobs to move the archive log files from online storage to tape before you encounter a space issue. RMAN does a nice job of helping you manage this. Please see Chapter 5 for more information on this.

Tablespaces and Datafiles

Space should be managed at the datafile and tablespace level rather than at a lower level such as a table or index. Using locally managed tablespaces with uniform extent sizes will simplify your management. Do not worry that you have some extents in a tablespace or for an object. This does not create a performance issue since the extents contain a number of blocks that must be contiguous. You can see the amount of space available in your datafiles by selecting Datafiles in OEM, as in Figure 3-8. This shows the amount of free space available in the currently allocated space. If you have used the autoextend feature to allow a datafile to extend in size when more space is needed, the extra space is not shown in this graph. Do not allow temporary tablespaces or undo tablespaces to autoextend since they will grow to use all of the space.

TIP
*Do not autoextend **temporary** and **undo** tablespaces, since they will quickly grow to use all of the space to which they can autoextend.*

What do you do if you run out of space in a datafile? Just enter **OEM**, click the datafile, and choose the Storage tab. Once there, you can change the autoextend feature and enter the size of the extensions that you would like. Do not forget to limit the size of the datafile so that it does not grow to use all of your space. After you've completed this, click Apply and you're done. If you select the Show SQL button, you can see the **alter database** syntax, which is also shown next.

```
alter database datafile '/u01/oradata/ora10g/example01.dbf'
autoextend on next 50M maxsize 5000M;
```

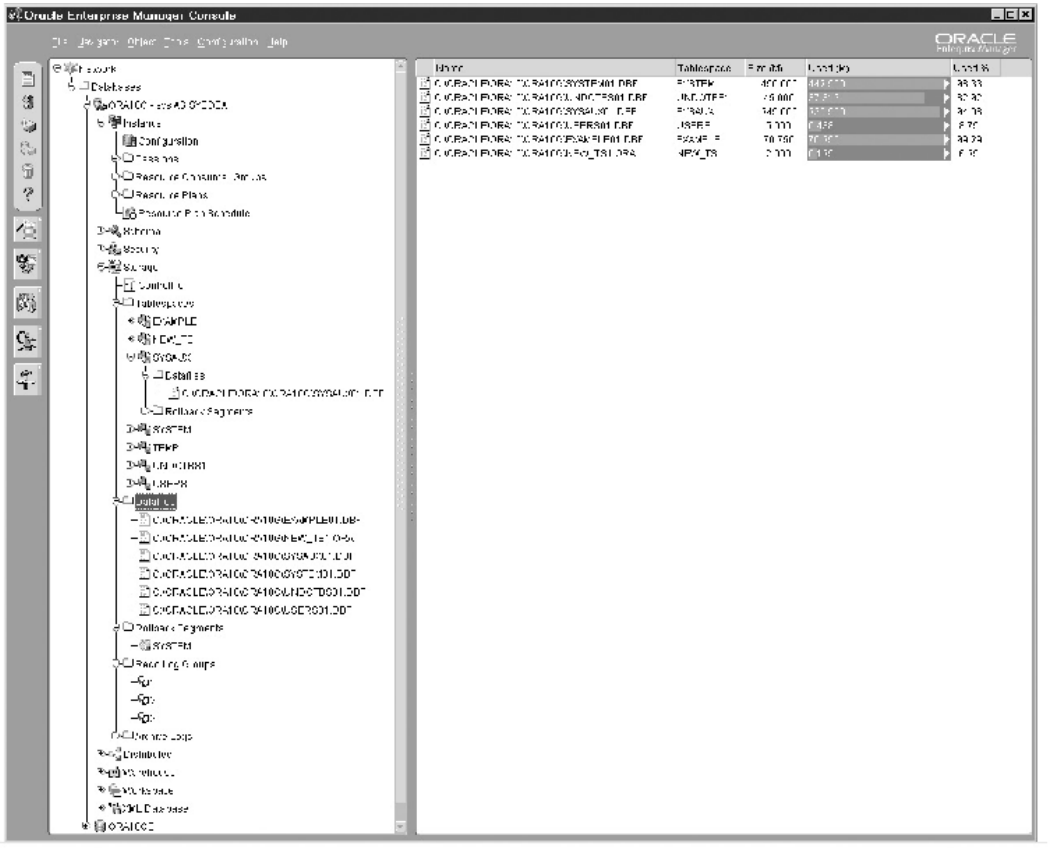


FIGURE 3-8. *Tablespace view in Enterprise Manager*

You can write your own scripts to compare the amount of allocated space for a datafile in view dba_data_files to the amount of free space, as shown in view dba_free_space.

OEM also provides you with a more detailed map of how space is used. In OEM, select a tablespace and then navigate from Tools to Tuning Features, finally choosing Tablespace Map. This opens a graphical layout showing each segment in the tablespace. From the tablespace map, you can choose the Tablespace Analysis Report tab for a written report on the space being used.

Managing the database objects discussed earlier will be a large part of your role as a DBA. In the next section, let's take a look at setting up and managing users. After all, without database users, there is no point in doing any of this!

Progress Check

1. What's better: "shutdown transactional" or "shutdown immediate"?
2. Do you only need to worry about logical schema objects that do not take up a large amount of space?
3. What happens if your archive log directory becomes full?
4. Why would you want to use a command-line interface rather than a GUI to perform your tasks as a DBA?

CRITICAL SKILL 3.9

Manage Users

Before you can do anything in Oracle, you need to have a user ID created to enable you to log in to Oracle. As a DBA, you will begin with the SYS or SYSTEM accounts since these accounts both have the DBA role and exist in all Oracle databases. They are often used to perform database administration tasks. The SYS account is also granted the **sysdba** privilege and is the schema that the Oracle catalog is stored in. You should only use the SYS account when you need to perform a task as SYS or need the **sysdba** privilege. If your database was created using the Database Configuration Assistant (dbca), then you will also automatically get the SYSMAN and DBSNMP accounts. SYSMAN is used to administer Oracle Enterprise Manager (OEM) and DBSNMP is used by the agent that OEM employs to monitor Oracle databases. Several other accounts will also be set up for the "example" schemas, such as the Sales History ('SH') user that we will utilize throughout this book. The OUTLN schema will be created to allow you to use plan stability through the stored outline feature. Depending on the options you choose when creating your database, other accounts may be set up for you. For example, if you install the OLAP option, the OLAPSYS account will be created.

Progress Check Answers

1. Both leave your database in a consistent state. It depends on how long your transactions will take to complete or roll back. If all things are equal and you think that it will take as long to commit the transactions that are already running, then you should use "shutdown transactional" since commits will be allowed to complete and no data will be lost.

2. Logical schema objects need to be watched to ensure they are in a valid state.

3. If database attempts to write an archive log after the directory has become full, the database activity will be suspended until sufficient space is made available for the new file.

4. You may want to place the command in a script that is scheduled or run as a repetitive task.

Create a User

When you create a user, you can either use the **create user** syntax or the OEM, which is an easier approach. In order to create a user, you will need to decide the following things:

- The default tablespace where segments created by this user will be placed unless a tablespace name is used in the DDL to override this.
- Whether to expire the password so that the user needs to change it the first time they log in to Oracle.
- A temporary tablespace to store internal data used by Oracle while queries are running. Sort operations make use of the temporary tablespace if there is not enough room in the SGA to perform the sort operation.
- Whether to employ user quotas on tablespaces, which put a limit on the amount of space that a user's objects can take up in that tablespace.
- The authentication type, which allows you to specify whether you want Oracle to force the user to specify a password when they log in, or you can trust the operating system to do this for you.
- The initial password that the user will log in with. The user must change this during the first log in if you chose to expire the password in advance of the user's first logon.
- Privileges to grant to the user. These can be direct privileges or roles. We will discuss them in the next section.
- A profile for the user, which can be employed to manage the user's session by limiting resources that sessions can use, and that help implement corporate password policies. We will also see this in the next section.
- Whether to lock or unlock the user.

The OEM console in Figure 3-9 shows the options available to you to create and edit a user. For each user, there are eight separate tabs that allow you to easily enter a user's information. You can see the SQL that will be generated by selecting the Show Sql button at the bottom of the panel. Another great option allows you to model a user and create another user like one that already exists. To do this, click the user that you want to model, select Object from the top of the panel, and then select the Create Like option.

Here is a sample **CREATE USER** statement:

```
CREATE USER "NEWUSER" PROFILE "DEFAULT" IDENTIFIED BY "newpassword"
PASSWORD EXPIRE DEFAULT TABLESPACE "USERS" TEMPORARY TABLESPACE "TEMP"
QUOTA UNLIMITED ON TEMP QUOTA UNLIMITED ON USERS
ACCOUNT UNLOCK;
GRANT "CONNECT" TO "NEWUSER";
```

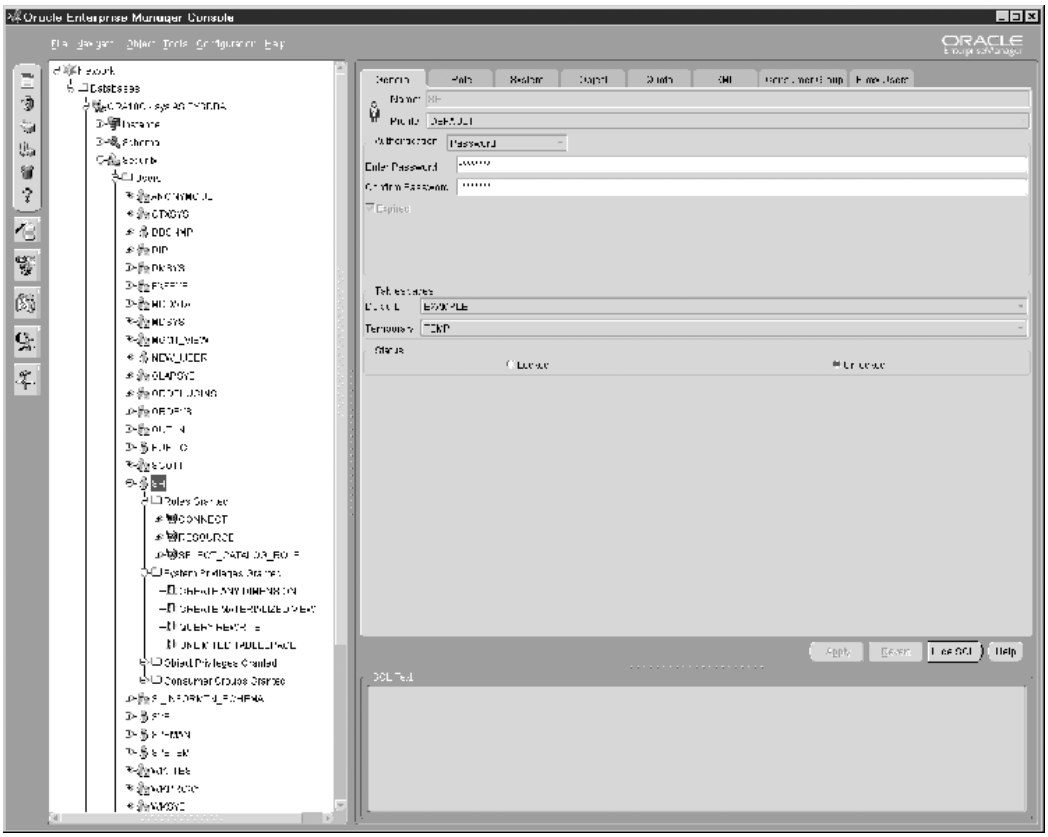


FIGURE 3-9. *User Management view*

Edit Users

Once a user has been created, you will be asked at different times to edit users to change quotas or reset passwords or unlock an account. This can be easily performed through OEM by selecting the User, choosing the option you want to change through the Gui, and then applying the change.

Editing users can also be performed using the **ALTER USER** statement, as shown next, where a user account is unlocked, the password is changed, and a tablespace quota is increased.

```
ALTER USER "username"  IDENTIFIED BY "newpwd " QUOTA UNLIMITED
ON TOOLS ACCOUNT UNLOCK;
```

We've now created a user and it's time to grant them some privileges. Let's see how we do this in the next section.

CRITICAL SKILL 3.10

Manage Privileges for Database Users

Creating a user in Oracle has accomplished the first part of user setup and that is authentication. We have a user ID and password and have authorized this user to use an Oracle database. Once the user logs in, however, they will not be able to do very much because they will not have privileges that allow them to access any objects. This leads us to the second step of setting up a user: authorization. In order to authorize a user to perform their tasks, we need to grant access.

Grant Authority

You now need to give permission to the user to do things in Oracle. Actions like accessing a table or executing a procedure or running a utility require you to "grant" the authority to that user. When you perform a grant, you can specify four things:

- The user that is being granted the authority.
- The object that is being granted. Examples of these are a table, procedure, or role.
- The type of access being granted, such as select, insert, update, or delete on a table, or execute on a procedure, function, or package.
- Whether this user has authority to then grant the same authority to other users. By default, they do not, but this can be added by using the With Grant option.

Here are two examples that grant a user "NEWUSER" access to a table and then to a package.

```
GRANT SELECT ON "TABLE_NAME" TO "NEWUSER" WITH GRANT OPTION;
GRANT INSERT ON "TABLE_NAME" TO "NEWUSER" WITH GRANT OPTION;
GRANT EXECUTE ON "PROCEDURE_NAME" TO "NEWUSER"
```

Types of Grants

There are two types of grants that can be given to a user: system privileges and object privileges.

- System privileges are predefined Oracle privileges granting authority to overall system objects rather than individual ones. The ability to perform a **create tablespace**, **alter system**, and **back up any table** are just a few examples of some system-level privileges that can be granted to a user.
- Object privileges are a lower-level authority where a named object is granted to a user. So, the ability to perform an operation on a particular

table, or execute an individual function, package, or procedure are object privileges as opposed to the ability to **execute any procedure** or **select any table**, which are system-level privileges.

Take Away Authority

What is given can be taken away. In order to take privileges away from a user, we use the **REVOKE** command and the syntax is very similar to the syntax we use when issuing a grant. Here are two examples of a **REVOKE** operation:

```
REVOKE INSERT ON "TABLE_NAME" FROM "NEWUSER";
REVOKE EXECUTE ON "TABLE_NAME" FROM "NEWUSER";
```

Roles

When you think of the number of privileges that need to be managed in situations where you have thousands of database objects as well as thousands of users, you quickly realize that it would be nice to organize the privileges into groups that can be easily managed. This is where roles come into play.

A "role" is used to group privileges together into a predefined group that can be granted to users. So, rather than granting object and system privileges individually to every user in your system, you can grant them to a role, which in turn is granted to the user.

Oracle-Defined Roles

Some special roles are created by Oracle through the install process or by running Oracle-supplied scripts. The DBA, Connect, Resource, Imp_Full_Database, and Select_Catalog_Role are some examples of roles that are supplied by Oracle and should not be changed.

Create and Grant a Role

Roles are created using the **create** statement in the same manner as creating users. We can also revoke privileges from roles and drop roles when they are no longer needed. Roles can also be granted to other roles. You can see an example of this next where the Oracle role **CONNECT** is granted to the newly created role **TESTROLE**, along with a system and object privilege.

```
CREATE ROLE "TESTROLE";
GRANT CONNECT TO "TESTROLE"
GRANT EXECUTE ANY PROCEDURE TO "TESTROLE"
GRANT SELECT ON "table_name" TO "TESTROLE"
```

The new role can then be granted to a user as shown next, where "testrole" is granted to user "Testuser."

```
Grant "testrole" to "Testuser";
```

The "TESTROLE" is then dropped since it is no longer required.

```
DROP ROLE "TESTROLE";
```

Now that we've created users and roles, we can fine-tune our management of these by implementing some user policies through *profiles,* which we will explore next.

Profiles

A profile can be used to implement a password management policy, as well as limit resources for a user. When you created the user NEWUSER earlier, a password was supplied along with the DEFAULT profile. Using this DEFAULT profile, the user never needs to change their password and there are no limits placed on any system resources. You can create new profiles to implement your corporate password policies in Oracle. For example, you can specify the number of days after which a user must change their password. You can also establish a policy where a password cannot be reused within a certain period of time and must contain a certain number of changes. A function can be used to ensure that a complex password is created by the user. For example, you may require that a password be more than eight characters long, use alpha, numeric, and special characters, and that it does not repeat a character more than twice. This can all be implemented in a function. An account can be locked after a specified number of login attempts and can remain locked for the number of days defined in the profile.

System limits for a user can also be implemented by a profile. These include limiting system resources such as those for CPU, connect, and idle time as well as the number of sessions employed by the user, limits on reads, and the SGA used. You should note, however, that the Database Resource Manager is the preferred way to limit resources and that you should use profiles to manage passwords.

The following is an example of the creation of a new policy that will lock an account after three failed login attempts and will keep the account locked indefinitely. The password needs to be changed every 60 days and the new password will be verified by your custom function **COMPLEX_PASSWORD**. The old password cannot be reused for 120 days.

```
CREATE PROFILE "NEWPOLICY"
FAILED_LOGIN_ATTEMPTS 3
PASSWORD_LOCK_TIME UNLIMITED
PASSWORD_LIFE_TIME 60
PASSWORD_REUSE_TIME 120
PASSWORD_VERIFY_FUNCTION COMPLEX_PASSWORD
```

Now, let's grant this policy to user NEWUSER:

```
ALTER USER NEWUSER PROFILE NEWPOLICY;
```

In Conclusion

As you have seen in this chapter, there is a great deal that a DBA needs to be aware of to properly manage a database. The good news is that you will have tools such as OEM to help you. Do your best to keep your environment as simple as you possibly can! You will be glad that you did as your overall database environment continues to grow.

Project 3-1 Creating Essential Objects

This project will walk you through the creation of the essential storage and schema objects after a database has been created, which in this project will be called ora10g. You will create a new tablespace called **NEW_TS** and will than add a user **NEW_USER** who will be given the authority to this tablespace. You will then create a role called **NEW_ROLE** and grant privileges to it. Afterward, you'll grant this role to the new user. A table and index will be created on this tablespace by the new user. Lastly, you will resize the undo tablespace to make it larger. You will see how to do this in OEM and the generated SQL will also be shown to you so you can do this in SQL*Plus.

Step by Step

1. You have been asked to create a new used named **NEW_USER** who will need to create objects in a new tablespace called **NEW_TS** that should be sized at 5MB. Your first step will be to create the tablespace. In OEM, log in as user SYSTEM, go to database ora10g, choose storage, then choose tablespace and select an existing tablespace to model. Under Objects in the toolbar, select the Create Like option to model your new tablespace after the existing one. Enter the new tablespace name, datafile name, and all properties including the size. Make this a locally managed tablespace 5MB in size with uniform extents 96KB in size. If you choose the Show Sql button, you will see the generated SQL. It should look something like the following SQL. You can either apply the change in OEM or you can copy and paste the generated SQL and run it in SQL*Plus.

```
CREATE TABLESPACE "NEW_TS" LOGGING
DATAFILE 'C:\ORACLE\ORA10\ORA10G\NEW_TS1.ora' SIZE 2M REUSE AUTOEXTEND ON
NEXT  1280K MAXSIZE  32767M EXTENT MANAGEMENT LOCAL UNIFORM SIZE 96K SEGMENT
SPACE MANAGEMENT  AUTO;
```

2. Now you will create **NEW_USER**. As with the preceding tablespace creation, you can model an existing user. In OEM, go to Security and then to User, choose an existing user to model, and select Object from the toolbar. Once again, use the Create Like feature. The user should now have a password of **new_password**, which will be unlocked. Set the default tablespace to NEW_TS.

```
CREATE USER "NEW_USER"  PROFILE "DEFAULT" IDENTIFIED BY "new_password" PASSWORD
EXPIRE DEFAULT TABLESPACE "NEW_TS"
TEMPORARY TABLESPACE "TEMP" QUOTA UNLIMITED     ON "TEMP";
```

3. Create a role called NEW_ROLE. In OEM, go to security, and then choose Role. Under Object in the toolbar, select Create and enter the role name.

```
CREATE ROLE "NEW_ROLE"  NOT IDENTIFIED;
```

4. Grant the **CREATE TABLE** system privilege, the **OLAP_USER** role, and the object privilege **SELECT** on table **SQLPLUS_PRODUCT_PROFILE** to **NEW_ROLE**. In OEM, go to role and choose **NEW_ROLE**. Use the tabs System, Object, and Role to choose the objects listed here. Click the Apply button to make the changes. The generated SQL will look like the three grants listed next.

```
GRANT CREATE TABLE TO "NEW_ROLE";
GRANT SELECT ON  "SYSTEM"."SQLPLUS_PRODUCT_PROFILE" TO "NEW_ROLE";
GRANT "OLAP_USER" TO "NEW_ROLE";
```

5. Grant **NEW_ROLE** and connect to **NEW_USER**. Also, give **NEW_USER** an unlimited quota on **NEW_TS** to allow for objects to be created in the tablespace. In OEM, navigate to Users and choose **NEW_USER**. Once there, choose the Role tab and select **NEW_ROLE**, and then select the down arrow. Click the Apply button to make the change.

```
GRANT "NEW_ROLE" TO "NEW_USER";
ALTER USER "NEW_USER" DEFAULT ROLE  ALL;
ALTER USER "NEW_USER"  QUOTA UNLIMITED ON "NEW_TS";
```

6. You will now log into the database as **NEW_USER** and can use OEM with the **NEW_USER** account. Once in OEM, you will create a table called **NEW_TABLE** with columns col01 as number(15) and col02 as varchar2(30). In OEM, in the toolbar, select Object and under that choose Create, and then choose Table. Make sure the table is created in **NEW_TS**. Follow the screens to add col01 and col02. You will then create a primary key called **NEW_TABLE_PK** using col01. Follow the screens and choose the options you would like. We recommend you name any keys and constraints rather than relying on system defaults. Choose Finish and you have created a new table with a primary key!

```
CREATE TABLE "NEW_USER"."NEW_TABLE"
("COL01" NUMBER(15) NOT NULL,
 "COL02" VARCHAR2(30) NOT NULL,
CONSTRAINT "NEW_TABLE_PK" PRIMARY KEY("COL01"),
CONSTRAINT "NEW_TABLE_U1" UNIQUE("COL01"))
TABLESPACE "NEW_TS";
```

7. You now have one last task: resizing the undo tablespace to add 100MB to it. Log in to OEM as user System and choose the datafile under the **undo** tablespace. Enter the new size and click Apply. It's as easy as that. The SQL to increase this from 50MB to 150MB is shown here:

```
ALTER DATABASE DATAFILE '/u01/oradata/ORA10G/UNDOTBS01.DBF' RESIZE  150M;
```

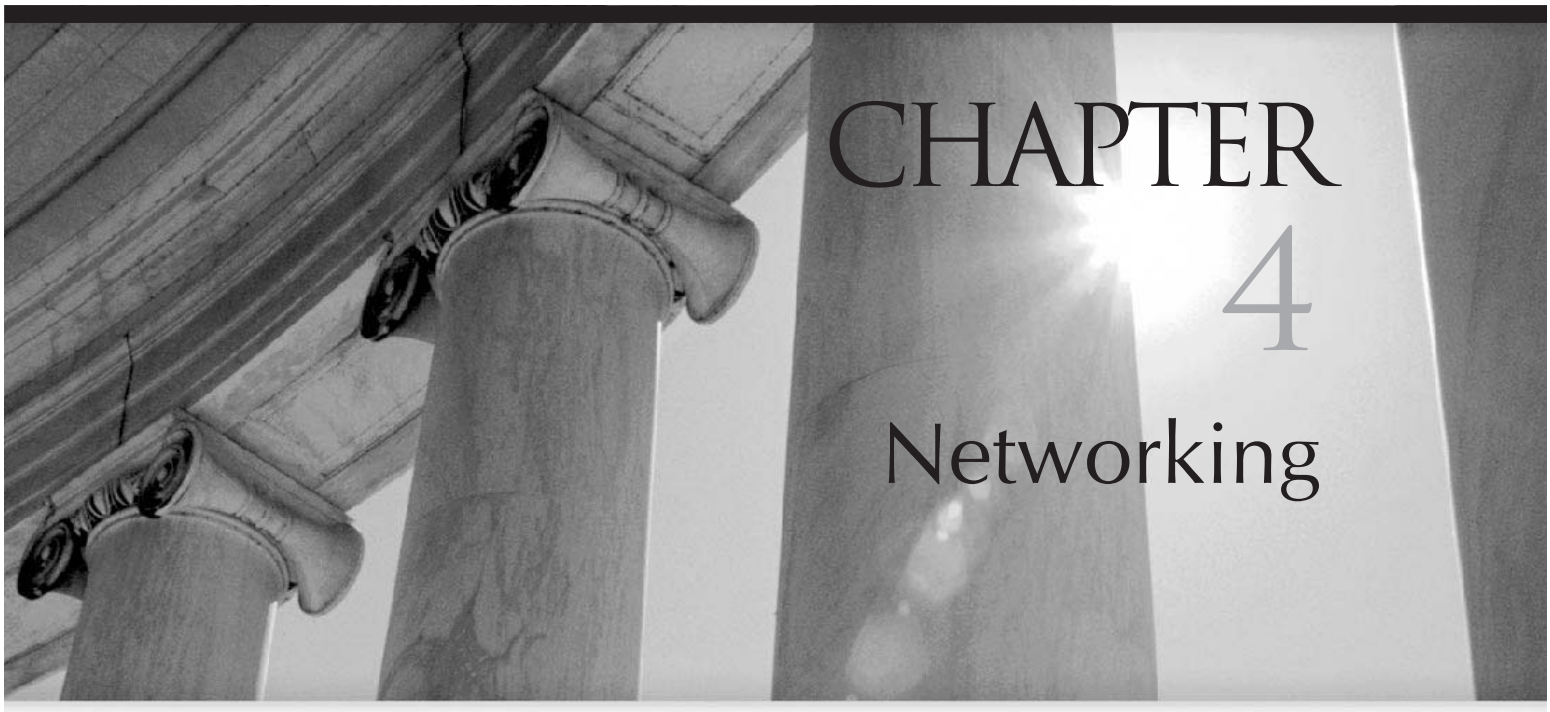
(continued)

Project Summary

This project has taken you through the basic steps of creating an environment for a new user, including using roles and granting privileges. You've seen how to manage users as well as space and have even created objects. Armed with these capabilities, you are now on your way to being a productive DBA. Congratulations!

☑ Chapter 3 Mastery Check

1. What is the benefit of a role?
2. Should a table that is in tens or hundreds of extents be reorged?
3. What is the preferred method for collecting object statistics?
4. What is a segment?
5. What is an extent?
6. Name two reasons for implementing an index.
7. How can you place a database in maintenance mode without first shutting it down?
8. How can we limit the resources that a particular user can consume and how does this work?
9. When managing undo segments, what are the things that you need to think about?
10. What is likely to happen if you turn on the autoextend property for undo and temporary tablespaces with a maxsize set to unlimited?
11. What is special about the SYS user account and how does it differ from SYSTEM?
12. What are temporary tablespaces used for?
13. What are the two aspects of security that are covered in Oracle's implementation?
14. Name and describe the types of privileges that can be granted to a user.
15. How would you implement your corporate password policy in Oracle?



CHAPTER 4 Networking

CRITICAL SKILLS

4.1 Use Oracle Net Services

4.2 Learn the Difference Between Dedicated and Shared Server Architectures

4.3 Define Connections

4.4 Use the Oracle Net Listener

4.5 Learn Naming Methods

4.6 Use Oracle Configuration Files

4.7 Use Administration Tools

4.8 Use Profiles

4.9 Network in a Multitiered Environment

This chapter introduces Oracle Net Services, which allow database applications running on remote systems to access an Oracle database. It creates and maintains the network connection, and also exchanges data between the application and the database.

Oracle networking plays a critical role in performance and availability. Each new version of Oracle is designed to support more data and users than the previous release. This increased amount of database activity and network traffic needs to be addressed from an availability and performance perspective and should be managed by the DBA. A DBA also has to be able to determine if a performance issue is due to networking, and if so, then they must be able to resolve any network performance issues from a database configuration perspective.

Throughout this chapter we will refer to DBAs, which in this context means anyone that is performing networking administration operations to make the database connectivity work. These days, more developers are managing their own development databases and performing operations traditionally reserved for DBAs.

NOTE
Oracle Net Services is a large topic. The emphasis in this chapter is to introduce DBAs to Oracle Net Services terminology and concepts, feature/functionality, and key components and tools. Once a beginning DBA reads this section, they should be able to understand the Oracle networking references and be capable of performing simple operations using the Oracle GUI tools and wizards for Oracle Net Services.

CRITICAL SKILL 4.1

Use Oracle Net Services

Oracle Net Services is the software component that allows enterprise connectivity across heterogeneous environments. Oracle Net is the part of Oracle Net Services that manages data communication between a remote application and the Oracle database, and runs on top of a network protocol like TCP/IP. The software used by Oracle Net software resides on the remote system and the Oracle database platform.

A listener process must be running on the database server to receive the network request. (A listener is a program that listens on a port for incoming network requests and then hands the request to another program for processing.) The listener then determines the appropriate type of process to handle the request.

The network protocol sends a request to the Oracle Protocol layer, which sends the information to the Oracle Net Foundation layer, which then communicates with the database server. The Oracle network communication stack, shown in Figure 4-1, is similar on both the client- and server-side.

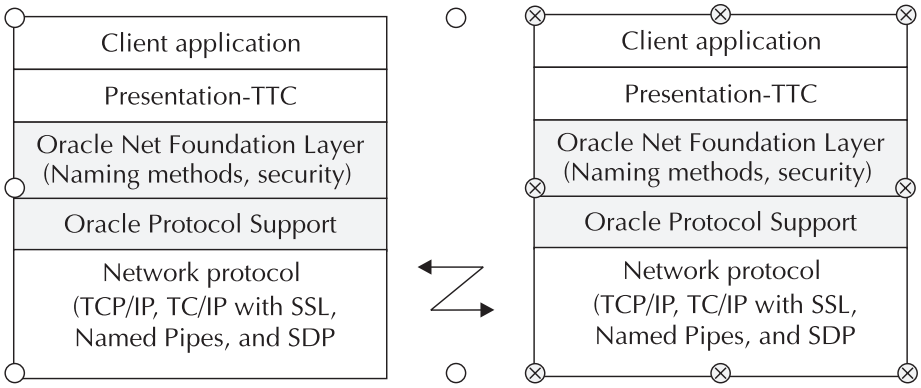


FIGURE 4-1. *The Oracle network communication stack*

Oracle Net (Oracle Net Foundation Layer and Oracle Protocol Support) fits into the session layer of the Open Systems Interconnect (OSI) model (visit www.ietf.org for more information about the OSI model).

Network Protocols

Oracle supports a number of industry standard protocols. These protocols transport the data between the remote platform and the database server platform. The protocols also display how users need to work with data differently than they did a few years ago. Oracle-supporting protocols like SDP, HTTP, FTP, and WebDAV show that Oracle Database 10*g* enhances network performance and offers increased flexibility for users working with data. In this section, the term application server will be used to address both web and application server services available in the middle tier. Table 4-1 lists the supported industry-standard protocols.

Protocol	Description
TCP/IP	The Transmission Control Protocol/Internet Protocol (TCP/IP) is the standard protocol used in client server environments.
TCP/IP with SSL	TCP/IP with Secure Sockets Layer (SSL) provides authentication (certificates and private keys) encryption. The Oracle Advanced Security option is required for this protocol.

TABLE 4-1. *Standard Industry Network Protocols*

Protocol	Description
SDP	The Sockets Directory Protocol (SDP) is an industry-standard high-speed protocol. SDP is used with an InfiniBand network. The InfiniBand network takes the messaging burden off the CPU and onto the network hardware. This network reduces the overhead of TCP/IP, providing increased bandwidth.
Named Pipes	Supports interprocess communication between remote platforms and the database server platform using pipes. A pipe is opened on one end and information is sent down the pipe to allow I/O between the platforms.
HTTP	The Hypertext Transport Protocol (HTTP) is an industry-standard protocol that is primarily used between clients and application servers. Oracle can also start up an HTTP listener to handle a request over HTTP directly.
FTP	File Transfer Protocol (FTP) is a standard method for transferring files across the Internet. It makes it easy to transfer files back and forth between different platforms. A server that can receive an FTP connection is referred to as an FTP server or FTP site. FTP addresses looks similar to HTTP; ftp://ftp.trubix.com is an example of an FTP server address.
WebDAV	The WWW Distributed Authoring Protocol (WebDAV) supports collaborative authoring over the Internet. The benefits of WebDAV include locking mechanisms, interoperable publishing with HTTP and XML support, writing over the Web with embedded devices, versioning, and Access Control Lists.

TABLE 4-1. *Standard Industry Network Protocols* (continued)

Optimize Network Bandwidth

Multitiered architectures need to maximize the bandwidth between the application server and the database server platforms. Oracle Net Services supports the high-speed networks of InfiniBand, a channel-based, high-speed interconnect technology designed to optimize performance between different platforms. It's used for server clustering and network interfaces to storage area networks (SANs) and local area networks (LANs). Vendors such as Hewlett-Packard, IBM, Sun Microsystems, Dell, and Microsoft support InfiniBand technology, and the SDP protocol, an industry-standard wire protocol, is also used with the InfiniBand network. Highly

active multitiered environments should consider using high-speed interconnects between the application server and the database server.

Character Sets

There can be character set differences between the application platforms and the database server. This is important because if the character sets are different between the database server and the application environment, data conversion will occur. If there are any conversion issues, the data will be malformed. If the character sets are not defined, the database default is the US7ASCII.

New Oracle Database 10*g*'s should strongly consider a Unicode character set such as AL32UTF8. The presentation layer manages character set and data type conversions between these two platforms. Two Task Common (TTC) is the presentation layer used by client/server environments.

The Oracle environmental variable, **NLS_LANG**, can be used to control locale behavior for the database and the application environment. (A locale is a linguistic and cultural environment where the application is running.) The database also contains **NLS_ initialization** parameters that can set language characteristics.

Two Oracle tools that can help with data conversion issues are the Database Character Set Scanner and the Database Character Set Scanner CSALTER script. The Database Character Set Scanner utility reports on conversion issues relating to migrating from one database character set to another. The Database Character Set Scanner generates a report on conversion issues concerning migration. Scans can be performed at the database, table, and user level. The Database Character Set Scanner CSALTER script should be used when migrating to a superset of the current database character set. A full database scan must be performed by the database character set scanner before running the CSALTER script, which performs the character set conversion. This is an alternative to using export/import to perform the conversion. However, the database should be backed up before running the CSALTER script. Look at the *Globalization Support Guide* for more detailed information.

The **NLS_LANG** parameter is defined with a language, territory, and character set component. The default is AMERICAN_AMERICA.US7ASCII. The following shows the format:

```
NLS_LANG = language_territory.charset
```

Connections

A connection is an Oracle communication path between a user process and the Oracle database server. If this communication path is dropped, a user must establish a new session. A transaction is rolled back if the connection for its session is lost. A session is a specific connection for a user between the user process and the Oracle database server.

Maintain Connections

The Oracle Net Foundation Layer establishes and maintains connections with the database server. Transparent Network Substrate (TNS) is the common interface between all the industry-standard protocols. Oracle Protocol Support maps the industry-standard protocols (TCP/IP, TCP/IP with SSL, SDP and Named Pipes) used in the connection.

Figure 4-2 shows us how Oracle Net works. Oracle Net software will reside on the database server platform and the platform that is running the Oracle applications. With an application server, HTTP runs on top of a network protocol between the browser platform and the application server platform. Oracle Net then runs on top of a network protocol between the application server and the database server. For a client/server configuration, Oracle Net will reside on the client platform and the database server platform, and will run on top of a network protocol between the client and the database server platforms.

If Java programs are running, a Java Database Connectivity (JDBC) OCI, or Thin driver, will communicate with Oracle Net to process the database request. A JDBC OCI driver requires Oracle Net on the remote platform and the database server. A JDBC Thin driver written entirely in Java uses JavaNet to communicate, and requires Oracle Net only on the server platform. Chapter 7 will discuss the Java drivers in more detail.

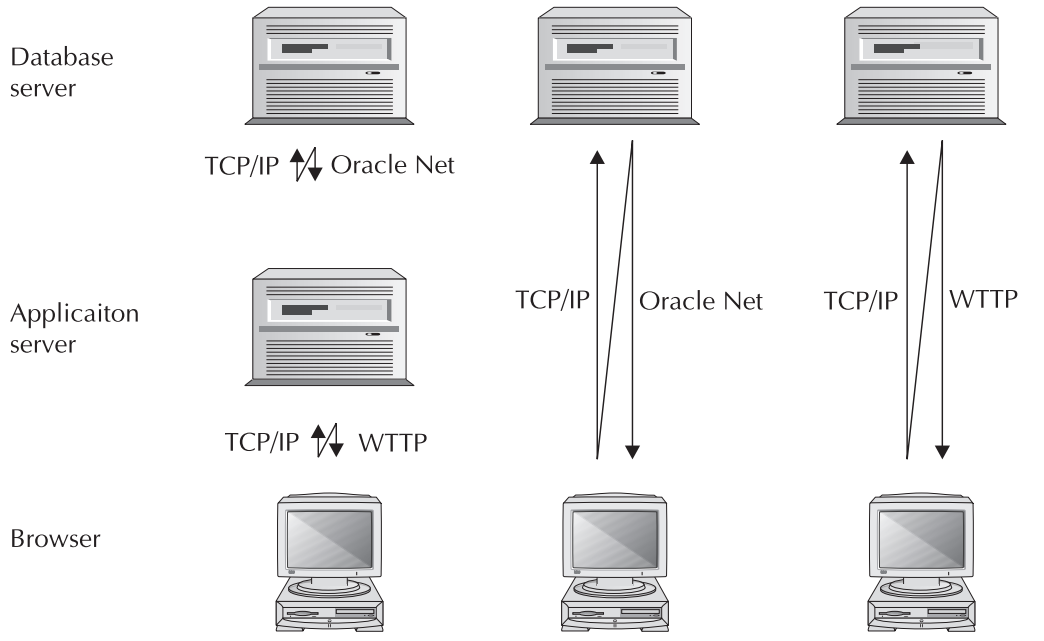


FIGURE 4-2. *An Oracle network overview*

Define a Location

Locations need to be defined so a remote application can find the correct Oracle database server on the network. A service name, such as **customer.us.trubix.com**, is used to define the unique location of each database server. In the preceding example, **customer** is the database name and **us.trubix.com** is the domain name. On the plus side, if the physical location of the database is changed, the service name can stay the same.

A database can support multiple services. The service name, defined with the initialization parameter **SERVICE_NAMES**, makes the physical location of the database transparent and will default to the global database name (the name of your database), which uses the format database_name.database_domain, as in customer.us.trubix.com.

The database domain name is the domain where the database is located, and is made up of the initialization parameters **DB_NAME** and **DB_DOMAIN**. The combination of the **DB_NAME** and **DB_DOMAIN** (customer.us.trubix.com) name distinguishes one database from another, as shown in the following examples:

```
DB_NAME=customer
DB_DOMAIN=us.trubix.com
```

CRITICAL SKILL 4.2

Learn the Difference Between Dedicated and Shared Server Architectures

An Oracle database server can be configured to run a dedicated or shared server architecture. This decision determines how the listener processes requests and how server processes work for an Oracle instance. Server processes are the interface between the Oracle database server and user processes, the latter of which must go through a server process that handles the database communication between the user process and the database. The following are a few facts about server processes:

- Processes database requests, accesses data, and returns the results.
- Performs data translations and conversions between the application and database server environments.
- Protects the database server from illegal operations by the user processes. A server process accesses Oracle database and memory structures on behalf of the user process. This separates user process activity from direct access to Oracle's internal memory.

Dedicated Server

A dedicated server environment uses a "dedicated" server process for each user process. The benefit is that each user process has a dedicated server process to handle all of its database requests. If there are a hundred separate sessions, there will be a hundred dedicated server processes running on the same platform as the database server.

The problem is that each dedicated server process is often idle a large percentage of the time. This takes up a lot of operating system resources for server processes that are sitting idle, and creates issues when large numbers of users are accessing a system. Oracle databases that allow access from the Internet can have tremendous spikes of activity that generate a large number of dedicated server processes. The dedicated server architecture also does not support FTP, HTTP, or WebDAV clients.

Figure 4-3 illustrates that dedicated server processes run on the database server platform. A dedicated server process will be run for each user session.

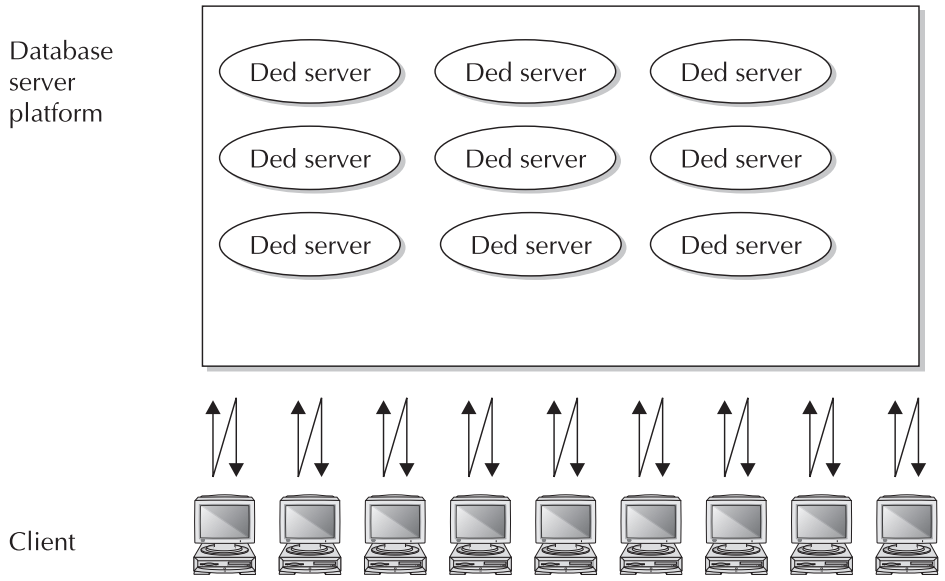


FIGURE 4-3. *The dedicated server architecture*

Shared Server

A shared server architecture offers increased scalability for a large number of users. This is possible because a single server process can be "shared" among a number of user processes, allowing a single server process to be able to support a large number of user processes. If there are 100 separate sessions, there may in turn be 20 shared server processes supporting them. Having a small pool of server processes that can support a large number of sessions increases scalability. This shared server architecture is much more scalable than a dedicated architecture as the number of users for a system increase. The shared server process can also handle large spikes of user activity much better than a dedicated server process configuration.

When a user request arrives, the listener will route the request to a dispatcher, which then processes and routes the request to a common queue. From a pool of shared server processes, an idle shared server will see if there is work in the common queue. Requests are processed on a first-in first-out basis. The shared server then processes the request and puts the results in a response queue (each dispatcher has one) that a dispatcher can return to the user process. Afterward, the dispatcher returns the results from its response queue to the appropriate user process.

A dispatcher supports multiple connections with virtual circuits, which are sections of shared memory that contain the information necessary for client communication. The dispatcher puts the virtual circuit on the common (request) queue accessed by the server process.

There are some administration operations that cannot be performed through a dispatcher, however. To perform these restricted administration operations in a shared server environment, the DBA needs to connect with a dedicated server process instead of a dispatcher process. The restricted operation needs a connect descriptor with a setting of **SERVER=DEDICATED**, defined in the **CONNECT_DATA** section. Restricted operations include the following:

- Starting up an instance
- Shutting down an instance
- Media recovery

As Figure 4-4 shows, a shared server process can support multiple user sessions.

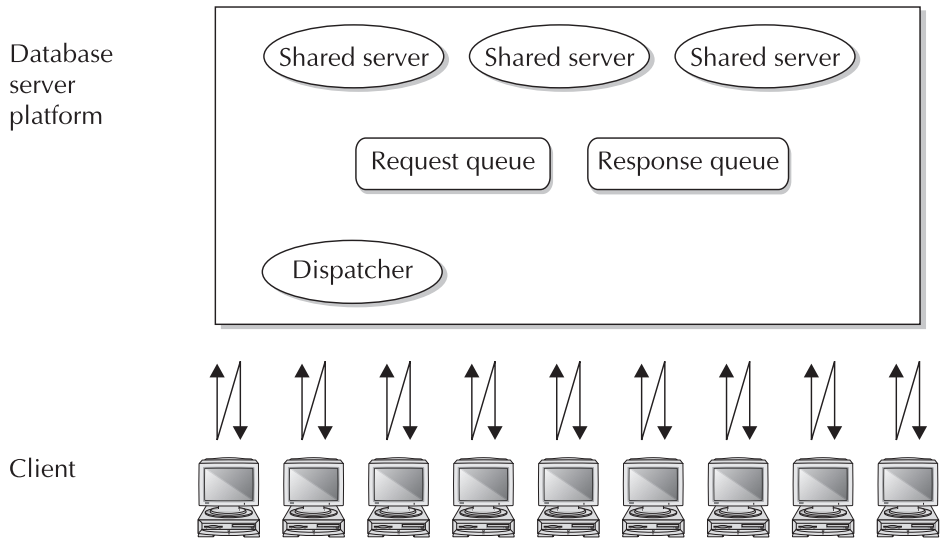


FIGURE 4-4. *The shared server architecture*

Table 4-2 illustrates the initialization parameters that are used to configure the shared server architecture. Possible values for these parameters are dependent on the level of user activity and the types of operations the server processes are executing.

Oracle Initialization Parameter	Definition
DISPATCHERS	Defines the number of dispatcher processes to start in a shared server architecture. The number of dispatchers can be dynamically added or reduced. There must be at least one dispatcher for each network protocol. Additional dispatchers can be defined based upon the workload.
MAX_DISPATCHERS	Defines the maximum number of dispatchers. This is not a fixed limit. In this release, this value can be dynamically exceeded at runtime.

TABLE 4-2. *Initialization Parameters Used by Shared Servers*

Oracle Initialization Parameter	Definition
SHARED_SERVERS	Defines the number of shared servers to invoke on database startup in a shared server architecture.
MAX_SHARED_SERVERS	Defines the maximum number of shared server processes.
SESSIONS	Defines the maximum number of sessions that can be active in a system.
SHARED_SERVER__SESSIONS	Defines the maximum number of shared server sessions that can be started in a system. Allows dedicated sessions to be reserved in a shared server environment. Sessions started above this limit will use dedicated server processes.
CIRCUITS	Defines the maximum number of virtual circuits.
LARGE_POOL_SIZE	Defines the size of the large pool area in the SGA. If a large pool exists, the session information will be stored in the large pool, not the shared pool area.

TABLE 4-2. *Initialization Parameters Used by Shared Servers* (continued)

Oracle recommends starting with one shared server process for every ten connections. It then automatically increases the number of shared servers based upon the workload up to the MAX_SHARED_SERVERS that are defined. The PMON process is responsible for adding and removing shared servers. The number of shared servers will never drop below the value contained in the SHARED_SERVERS parameter. You should also note that the parameters that control the minimum and maximum number of these shared can be set dynamically and therefore you can always ensure that you can react quickly to shared server issues.

Set Dispatchers

To set the number of dispatchers, determine the maximum number of concurrent sessions and divide this by the number of connections per dispatcher. Then, dependent upon the level of activity, the number of dispatchers may need to be increased or decreased. A single dispatcher can handle a large number of shared server processes, but the number of dispatchers per shared server is dependent upon the activity of the shared server processes.

One of the following attributes—**PROTOCOL**, **ADDRESS**, or **DESCRIPTION**—can be set with dispatchers. **PROTOCOL** defines the network protocol to use, **ADDRESS** defines the network protocol address on which the dispatchers listen, and **DESCRIPTION** is the network description. Default values are used if the attributes are not defined, and additional network options can be defined if the **ADDRESS** or **DESCRIPTION** attribute is set.

Additional attributes that can be set with ADDRESS or DESCRIPTION include the following:

- **SESSIONS** Defines the maximum number of network sessions per dispatcher.
- **CONNECTIONS** Defines the maximum number of network connections per dispatcher.
- **TICKS** Defines the length of a network tick (seconds). A tick defines the length of time for a message to get from the client to the database server or from the database server to the client.
- **POOL** Defines the timeout in ticks for incoming (IN=15) and outgoing (OUT=20) connections, and whether connection pooling is enabled. The number of ticks multiplied by the POOL value determines the total connection pool timeout.
- **MULTIPLEX** Defines if multiplexing with the Connection Manager is set for incoming and outgoing connections. Multiplexing allows multiple sessions to transport over a single network connection. This is used to increase the network capacity for a large number of sessions.
- **LISTENER** Defines the network name of an address for the listener.
- **SERVICE** Defines the server names that dispatchers determine with the listeners.
- **INDEX** Defines which dispatcher should be modified.

In your init.ora file, you will define the dispatchers. The following are examples of different types of entries that will typically be created to support shared servers:

Define the number of dispatchers to start:

```
DISPATCHERS='(PROTOCOL=TCP)(DISPATCHERS=5)'
```

Define a dispatcher to start on a specific port:

```
DISPATCHERS='(ADDRESS=(PROTOCOL=TCP)(DISPATCHERS=5))'
```

Define a dispatcher with more options:

```
DISPATCHERS="(DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)
             (HOST=eclipse)(PORT=1521)(QUEUESIZE=20)))
             (DISPATCHERS=2)
             (SERVICE = customer.us.trubix.com)
             (SESSIONS=2000)
             (CONNECTIONS = 2000)
             (MULTIPLEX = ON)
             (POOL = ON)
             (TICK = 5)"
```

As you see, there are numerous options that may be used, depending on the configuration methods that you select when configuring the dispatcher.

Views to Monitor the Shared Server

The following views can be used to monitor the load on the dispatchers:

- V$DISPATCHER
- V$DISPATCHER_RATE
- V$QUEUE
- V$DISPATCHER_CONFIG

The following views can be used to monitor the load on the shared servers:

- V$SHARED_SERVER
- V$SHARED_SERVER_MONITOR
- V$QUEUE

The V$CIRCUIT view can be used to monitor virtual circuits.

The following views can be used to monitor the SGA memory associated with the shared server environment:

- V$SGA
- V$SGASTAT
- V$SHARED_POOL_RESERVED

These views provide you with the ability to monitor your database and the activity related to your shared servers and database. We encourage you to take

a look at the data in these tables before and after you implement shared servers, to see how they change your database and how it functions.

CRITICAL SKILL 4.3

Define Connections

This section will discuss the core components required to handle Oracle connections.

A Connect Descriptor

A connect descriptor is used to define the service name and the location of the database. The address component of a connect descriptor defines the protocol, host name, and port number. Though port numbers can be between 1 to 65535, those from 1 to 1024 are usually reserved for special processes. The connect data component of the description describes the service to which you want to connect. If you do not include the **instance_name** in your descriptor, it will default to the Oracle SID if not defined.

A sample connect descriptor for **customer.us.trubix.com** looks like the following:

```
(DESCRIPTION =
  (ADDRESS=(PROTOCOL=tcp)(HOST=eclipse)(PORT=1521))
  (CONNECT_DATA=
      (SERVICE_NAME=customer.us.trubix.com)))
```

A specific connect descriptor can be defined for a specific service handler. For example, in a shared server architecture, a dedicated service handler can be chosen, which can be set to dedicated **(SERVER=dedicated)** or shared **(SERVER=shared)**. If no dispatchers are available, a dedicated server will be used and the default service handler is shared.

```
 (DESCRIPTION =
  (ADDRESS=(PROTOCOL=tcp)(HOST=eclipse)(PORT=1521))
 (CONNECT_DATA=
      (SERVICE_NAME=customer.us.trubix.com)
       (SERVER=dedicated)))
```

Define a Connect Descriptor

When establishing a connection, a detailed connect descriptor can be defined, or a manual name that maps to a connect descriptor can be used. The following example shows you how to define a manual connect descriptor or name a connection descriptor name.

```
-- Manual definition of a connection descriptor
CONNECT
```

```
username/password@(DESCRIPTION = (ADDRESS=(PROTOCOL=tcp) (HOST=eclipse)
(PORT=1521))  (CONNECT_DATA= (SERVICE_NAME=customer.us.trubix.com)))
-- Connect using a pre-defined descriptor
CONNECT username/password@cust
```

The Oracle Connection Manager

The Oracle Connection Manager processes and filters requests to the database server. It can also optimize network performance for a large number of sessions. Figure 4-5 illustrates the various layers between the users and the database that need to be controlled by the manager.

The Oracle Connection Manager Control utility allows administration of the Oracle Connection Manager. The syntax is

```
cmctl {command} [parameter1 … parameterN] {-c instance_name} {-p password}
```

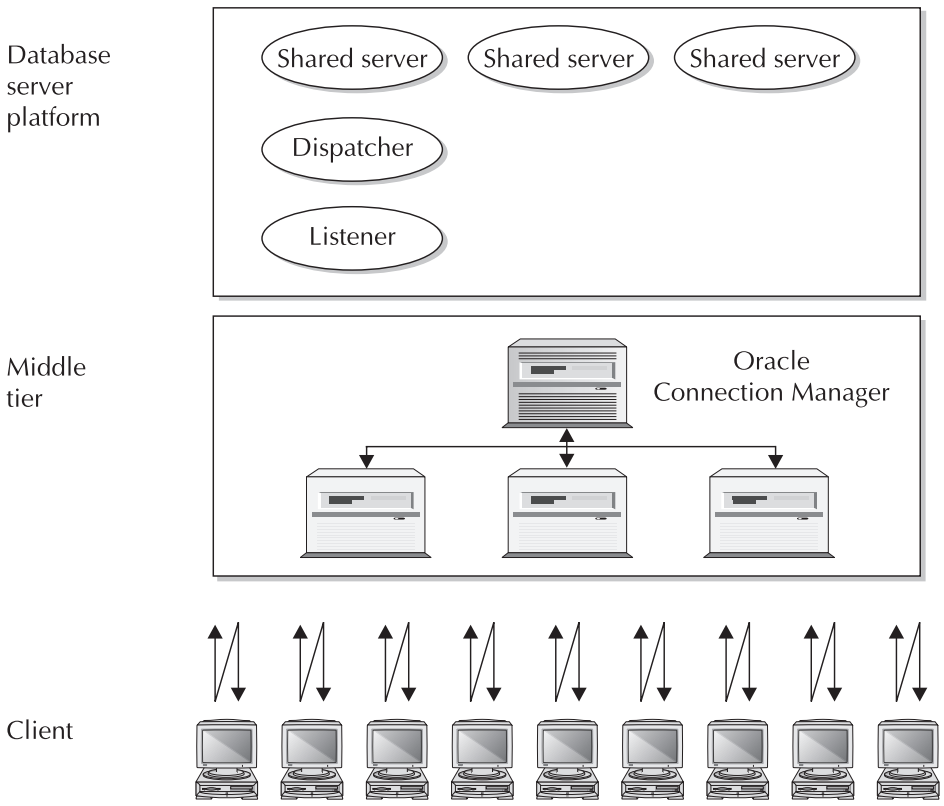


FIGURE 4-5. *The Oracle Connection Manager architecture*

Connection Manager commands can be executed from within the utility, as shown here:

```
cmctl
CMCTL> startup -c cman0
```

The Oracle Connection Manager can offload network I/O from the application servers.

We will now move on and look at the Oracle Connection Manager options to include session multiplexing and firewall access control.

Session Multiplexing

The Oracle Connection Manager allows a number of different client network sessions to be shared (multiplexed) through a single network connection to the database server. Multiplexing sessions increases the number of network sessions that can be supported. Similarly, multiple Connection Managers can be used to handle hundreds or thousands of concurrent users; they run on the application server platform in order to multiplex sessions to the Oracle database server.

Firewall Access Control

The Oracle Connection Manager can define filtering rules to grant or deny access to the database server; this is done via the Oracle Net Firewall Proxy. The Oracle Net Firewall Proxy is software that provides Oracle Connection Manager features through different firewall vendors.

Progress Check

1. The protocol _____ supports collaborative authoring over the Internet.
2. True or False: The SDP protocol adds advanced network security features.
3. True or False: A virtual circuit is a section of shared memory that contains information for client communication.
4. True or False: Port numbers from 1 to 1024 are usually reserved for SSL.
5. The _____ server architecture does not support FTP, HTTP, or WebDAV clients.
6. True or False: The Oracle Connection Manager supports multiplexing sessions.

CRITICAL SKILL 4.4

Use the Oracle Net Listener

The Oracle Net Listener (listener) listens on a network port (listening endpoints) for incoming database requests. A listening endpoint defines the protocol addresses the listener is defined to listen on. Listening endpoints include HTTP, FTP, WebDAV, and Oracle XML. Look at the *ORACLE XML DB Developer's Guide* for more detail on registering FTP, HTTP, and WebDAV listening points.

The process is fairly simple. The listener receives a request and hands the request to a service handler, which is a server process that runs on the same platform as the Oracle database server. The service handler can be a dedicated server or a dispatcher, the latter of which works with shared servers.

The PMON background process registers the service information to the listener. During registration, PMON gives the listener information on the database services and instance information. PMON then tries to register with the listener once the listener has been started. Dynamic registration is supported with the **alter system register** command. If PMON has not registered with the listener, a TNS listener error will occur. View the *Oracle Database 10g Error Messages* reference manual for more details.

The listener will receive the database request and spawn a dedicated server process if the environment is configured for the dedicated server architecture. The dispatcher will hand the request over to a dispatcher if running a shared server architecture. A client application can bypass the listener if it is running on the same platform as the database server. Once the listener hands off the request it will resume listening for additional network requests.

A default listener (named listener) is configured at installation with the Oracle Net Configuration Assistant making it easy to start up the default listener when a system is first built. An additional ICP protocol address is defined for external routes during installation.

Progress Check Answers

1. The protocol *WebDAV* supports collaborative authoring over the Internet.
2. False. The SDP protocol is used with high-speed networks.
3. True. A virtual circuit is a section of shared memory that contains information for client communication.
4. False. Ports 1 to 1024 are used for special processes. They are not reserved for SSL.
5. The *dedicated* server architecture does not support FTP, HTTP, or WebDAV clients.
6. True. Yes, this is one of the advantages of using the Oracle Connection Manager.

The following is a sample listener.ora file:

```
LISTENER =
  (DESCRIPTION_LIST =
    (DESCRIPTION =
      (ADDRESS_LIST =
        (ADDRESS = (PROTOCOL = IPC)(KEY = EXTPROC0))
      )
      (ADDRESS_LIST =
        (ADDRESS = (PROTOCOL = TCP)(HOST = eclipse)(PORT = 1521))
      )
    )
  )
```

Table 4-3 illustrates the contents of the listener.ora file.

In the following, **host** defines the server name, **PORT** defines the port number, **SERVER** defines the host server name, **PIPE** defines the pipe name, and **KEY** defines a unique name for the service. It is recommended to use the Oracle SID value for the key.

Table 4-4 defines the components of the protocol definition.

After installation, the Oracle Net Manager can be used to modify the listener configuration. Some of the values that can be configured for the listener include:

- If the default port of 1521 is not specified, the **LOCAL_LISTENER** initialization parameter needs to be defined through a naming method. The **LOCAL_LISTENER** parameter is dynamic and can be set with the **alter system** command.

Parameter	Description
DESCRIPTION	Defines a connect descriptor for a net service name.
DESCRIPTION_LIST	Defines a list of connect descriptors.
LISTENER	Defines the listener alias.
ADDRESS	Defines the listener protocol address.
ADDRESS_LIST	Defines a list of protocol addresses that contain common behavior.

TABLE 4-3. *Listener.ora File Formats*

- Be careful, because the **LISTENER** parameter overrides the **LOCAL_LISTENER** parameter. A host system can have multiple IP addresses, and a listener can be configured to listen on them.
- The I/O buffer size for send and receive operations can be defined.
- Heterogeneous services can be set to support additional services such as external routines.
- The **QUEUESIZE** parameter can be defined for environments that may have a large number of concurrent connection requests for a listener on a listening endpoint.

Password Authentication

A password needs to be set for the listener. The **change_password** command can be used to change a password or set a new password. If a password is not set, someone can accidentally impact the availability of the database—for example, accidentally shutting down the listener. If you don't have a listener, new sessions cannot be established. It is important that a DBA protect access to listener management.

The following example sets the listener password:

```
lsnrctl> change_password
Old password: <enter>
New password: newpassword
Reenter new password: newpassword
lsnrctl> save_config
```

Protocol	Example
TCP	(PROTOCOL=tcp)(host=eclipse)(PORT=1521)
TCP/IP with SSL	(PROTOCOL=tcps)(host=eclipse)(PORT=2484)
IPC	(PROTOCOL=ipc)(KEY=cust)
Named pipes	(PROTOCOL=nmp)(SERVER=eclipse)(PIPE=pipe01)
SDP	(PROTOCOL=sdp)(host=eclipse)(PORT=1521)

TABLE 4-4. *Protocol Examples for the listener.ora File*

Multiple Listeners

Multiple listeners can be defined for a service, and offer a number of advantages for more complex environments. These advantages include the following:

- Failover
- Transparent application failover
- Load balancing

The following is a sample connect descriptor for a listener:

```
(DESCRIPTION =
  (ADDRESS_LIST=
    (ADDRESS=(PROTOCOL=tcp)(HOST=eclipse)(PORT=1521))
   (CONNECT_DATA=
      (SERVICE_NAME=customer.us.trubix.com)))
```

Connection Pooling

A shared server architecture is used to improve user scalability. So it is assumed that if this architecture is being used there is a potential for a large number of users. As mentioned previously, at any point in time there can be a large percentage of idle processes. Connection pooling allows the database server to timeout sessions that are idle and then use the connection to support an active session. These sessions remain open but in an idle state. When they become active again, a connection is reestablished.

CRITICAL SKILL 4.5

Learn Naming Methods

A naming method defines the type of repository used to configure Oracle network information. This repository is accessed to define where the Oracle database server is located.

Oracle supports various types of naming methods, such as:

- Directory naming (centralized configuration)
- Local naming (client configuration)
- External naming (external configuration)
- Easy naming (manual configuration)

Directory Naming Method

For centralized network management, Oracle Net Services uses a Lightweight Directory Access Protocol (LDAP) directory server as the repository. LDAP uses hierarchical structures (directories) that contain different components of a communication path. The LDAP directory stores all database network information, policies, security, and authentication information in this centralized repository. Remote applications will go to the centralized repository to find network configuration information. The results are then returned containing the communication path to the Oracle database server.

Different vendors provide their own LDAP directory server. The Oracle LDAP directory, for instance, is named the Oracle Internet Directory (OID). While the Microsoft version of this is named Microsoft Active Directory.

You should note that there are some restrictions when using the Microsoft Active Directory. The Oracle Net Configuration Assistant may be used with the Microsoft Active Directory, however the Oracle Internet Directory Configuration tool cannot be used with the Microsoft Active Directory.

Storing network information in a centralized location is much more efficient from an administration perspective. Make a change in one place and it is reflected everywhere. It's also better from a security perspective because the database location is stored in a centralized repository instead of a file on a local machine.

Directory Information Trees

LDAP directory servers store information in a hierarchical tree structure called a Directory Information Tree (DIT). DITs are typically organized in a Domain Name Space (DNS) structure (usually along corporate or geographical lines), and are defined by the Oracle Internet Directory Configuration Assistant. Every node in the tree is referred to as an entry, each of which can be modified with the Oracle Enterprise Manager or the Oracle Net Manager. The following example shows how a connect descriptor maps to a DIT:

```
(DESCRIPTION =
  (ADDRESS=(PROTOCOL=tcp)(HOST=eclipse)(PORT=1521))
 (CONNECT_DATA=
      (SERVICE_NAME=customer.us.trubix.com)))
```

Figure 4-6 illustrates how the directories are organized and may be navigated when using the Oracle Internet Directory Configuration Assistant. It is important to know your directory trees to ensure that you correctly move through your hierarchy.

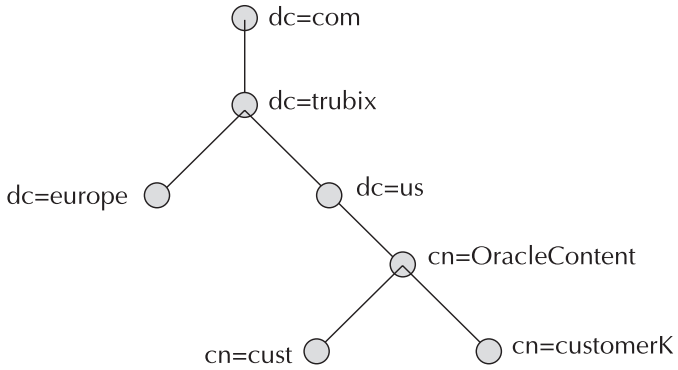


FIGURE 4-6. *A Directory Information Tree (DIT)*

Distinguished Names

A distinguished name (DN) defines where an entry resides in the directory path, and begins at the lowest entry. The DN for the customer distinguished name is dn:cn=customer, cn=OracleContext, dc=us, dc=trubix, and dc=com. Relative distinguished names (RDNs), on the other hand, define the sequences within the path. An RDN contains an attribute that defines the RDN. An important RDN is the Oracle Context, which defines the default location for connect identifiers. An identity management realm, meanwhile, defines a set of identities that share the same administration policies.

How to Find the Directory Naming Information

With this naming method, a client needs to find the centralized information that is stored in the LDAP repository to be able to connect to the database server. There are two ways to find the centralized directory naming information stored on a separate system.

- The Static Method, which works via a local ldap.ora file.
- The Dynamic Method, which works via a domain name server (DNS).

A ldap.ora file is a statically configured file containing the location of the LDAP server. DNS uses name servers to map names and IP addresses for systems. If the latter changes, the next time the name is looked for on the domain name server, it will map to the new IP address.

Net Service Alias Entries

A net service alias entry is another name for a net service name. A net service alias references the directory location. The name **cust** in the directory information tree is a net service alias. Aliases simplify management by using a short alias instead of having to specify the full path.

The Local Naming Method

The local naming method uses a local configuration file called *tnsnames.ora*. The tnsnames.ora file stores net service names and connect descriptors, and resides on the platform running the database application. It contains the information required to find and connect to the Oracle database server. The following definition defines the address (protocol, host, port number) along with the dedicated server environment and which service to connect to.

```
CUST =
  (DESCRIPTION =
    (ADDRESS_LIST =
      (ADDRESS = (PROTOCOL = TCP)(HOST = eclipse)(PORT = 1521))
    )
    (CONNECT_DATA =
      (SERVER = DEDICATED)
      (SERVICE_NAME = CUST)
    )
  )
```

This is a simple file to configure. The problem is if you have 1000 users, you need to make sure the tnsnames.ora file has been updated for all of the client machines. From a security perspective, it is not ideal to allow clients access to a server location and the connection information.

The Easy Naming Method

The easy naming method explicitly defines the connect information. The connect information contains the host, port, service name, and instance name. This allows someone to connect in a specific way without going through the configuration effort. The format is

```
CONNECT username/password@eclipse:1521/customer.us.trubix.com/cust
```

An advantage of the easy naming method is that it is easy to configure. The user need only provide minimal information to get a connection. As a result, no other

naming methods need to be configured. This method cannot be used if more advanced features are required.

The External Naming Method

The external naming method uses net service names that are defined in a non-Oracle environment. This naming method works well for administrators that want to use their native naming service, and allows them to use native tools and utilities with which they have experience. The disadvantage of this approach is that Oracle Net tools cannot be used for these native naming methods. Supported non-Oracle services include the Network Information Service (NIS) or Cell Directory Services (CDS). CDS is part of a Distributed Computing Environment (DCE) environment. DCE is an integrated distributed environment designed to resolve interoperability issues with heterogeneous environments. DCE is maintained by the Open Systems Foundation (OSF).

Which Naming Method to Use

The local naming method (tnsnames.ora) has traditionally been the most popular method. However, there are a number of administration and security issues in stored local configuration with a tnsnames.ora file. The directory (centralized) naming method is more scalable and has less administration than the local naming method. For large systems, the directory method is becoming more popular. Oracle Names is an Oracle proprietary centralized naming method and is no longer supported in Oracle Database 10*g*. Oracle Name environments should migrate to the directory naming method. The easy naming method and external naming method are not used as often.

CRITICAL SKILL 4.6

Use Oracle Configuration Files

Remote applications will look for Oracle Net configuration files to determine how to access the Oracle database server. Configuration files can be found in the ORACLE_HOME/network/admin directory location. Table 4-5 defines the primary configuration files.

Syntax for Configuration Files

DBAs can use the management tools to modify Oracle Net Services configurations. However, since the configuration files have a simple syntax, it is easy to modify the configuration files directly. The following is an example of the listener.ora file.

```
# LISTENER.ORA Date: 04/25/2004
LISTENER =
  (DESCRIPTION_LIST =
    (DESCRIPTION =
      (ADDRESS_LIST =
        (ADDRESS = (PROTOCOL = IPC)(KEY = EXTPROC0))
      )
      (ADDRESS_LIST =
        (ADDRESS = (PROTOCOL = TCP)(HOST = eclipse)(PORT = 1521))
      )
    )
  )
```

Network Configuration Filename	Description
listener.ora	The listener.ora file defines how the listeners are configured on the database server.
sqlnet.ora	The sqlnet.ora file resides on the database server and the local platform. Profile information is stored in the sqlnet.ora file. This file defines information on service names, naming methods, external naming information, Advanced Security parameters, and database access information. The TNS_ADMIN environmental variable can override the default location.
tnsnames.ora	Resides on the local system and is used with the local naming method. Defines net service names and connect descriptor information.
cman.ora	The configuration file for the Oracle Connection Manager. This file resides on the same platform where the Oracle Connection Manager runs.
ldap.ora	The directory usage file is created by the Oracle Internet Directory Configuration Assistant.

TABLE 4-5. *Primary Configuration Files for Oracle Net Services*

Should a DBA want to modify the files directly, the following syntax rules must be followed:

- Comments must begin with a pound sign (#). Anything following the pound sign is treated as a comment.
- Keywords are not case sensitive and cannot contain spaces.
- Spaces are optional around equal (=) signs.
- Values can only contain spaces if they are surrounded by quotes. The values may be case sensitive depending on the operating system and protocol.
- A connect descriptor can be no more than 4KB in length.
- All characters must be part of the network set.

CRITICAL SKILL 4.7

Use Administration Tools

Oracle Net Services contains a number of user interfaces and tools that simplify the management of the Oracle network, including the following:

- Oracle Enterprise Manager (OEM)
- The OEM console
- Oracle Net Manager
- Oracle Net Configuration Assistant
- Oracle Connection Manager
- Oracle Internet Directory Configuration Assistant
- Command-line utilities
- Oracle Advanced Security

The Oracle Enterprise Manager

Along with database administration, OEM allows configuration of Oracle Net Services. OEM can be used to perform the following administration features:

- The configuration of listeners
- The configuration of naming definitions such as connect descriptors

The Oracle Net Manager

The Oracle Net Manager allows the configuration of Oracle Net Services and can be started from the OEM console, by choosing Tools | Service Management | Oracle Net Manager.

The Oracle Net Manager provides the following administration support:

- **Listeners** Supports creating and configuring listeners.
- **Naming** Supports defining simple names. Simple names specify information for connect descriptors and service location information.
- **Naming methods** Supports the definition of naming methods.

Some of the functionality in OEM is also available in the Oracle Net Manager. Table 4-6 shows the overlapping functionality and the differences between the two tools.

The following can be used to start Oracle Net Manager manually through UNIX:

```
$ $ORACLE_HOME/bin/netmgr
```

Oracle Net Manager can also be started manually through Windows by selecting Start | Programs | Oracle—OraHome10 | Configuration and Migration Tools | Net Manager.

Oracle Enterprise Manager	Oracle Net Manager
Local naming (tnsnames.ora)	Local naming (tnsnames.ora)
Directory naming	Directory naming
Listeners	Listeners
Oracle home support for multiple hosts	Oracle home support for a single host
Search capability on local and directory names	Profiles
Export directory entries to tnsnames.ora file	
Changing tracing and logging settings	

TABLE 4-6. *Common Features and Differences Between OEM and Oracle Net Manager*

The OEM Console

The Oracle Enterprise Manager Central Console is a web-based interface for managing the entire enterprise from the console. It offers a lot more functionality than the standard Oracle Enterprise Manager that comes with a typical database install. The default ports for running in a non-secure mode are 7777-7877; default ports for running in a secure mode are 4443-4533.

You can access the OEM Central Console from the following URLs: http://<oms hostname>.<domain>.<port>/em and https://<oms hostname>.<domain>.<port>/em. The OEM Central Console requires the Oracle Management Service unless the Oracle Management Agent is installed separately.

The OEM Components

The OEM console uses the following components, which are installed with the Oracle application server:

- **The Oracle Management Service** A web-based application that runs on the Oracle application server. It provides the user interface for the OEM console, and interfaces with the management agents to process and monitor information.
- **The Oracle Management Agent** Monitors information from sites that need to be managed and which are loaded into the management service.
- **The Oracle Management Repository** Contains all the information managed by the Oracle Enterprise Manager.

Before installing the Complete Enterprise Manager, make sure to read the requirements for the complete installation that includes the Oracle Application Server 10*g,* Web Cache, and the Management Service application.

The Oracle Net Configuration Assistant

The Oracle Net Configuration Assistant is used during installation to configure the basic network components. The Oracle Net Configuration Assistant can also be run standalone to modify the same values configured during installation. Configurable components include the following:

- Naming methods
- Net service names (tnsnames.ora)
- Listener names and protocol addresses
- Directory server usage

The following can be used to start the Oracle Net Configuration Assistant manually through UNIX:

```
$  $ORACLE_HOME/bin/netca
```

The Oracle Net Configuration Assistant can also be started manually through Windows by selecting Start | Programs | Oracle—OraHome10 | Configuration and Migration Tools | Net Configuration Assistant.

The Oracle Internet Directory Configuration Assistant

The Oracle Internet Directory Configuration Assistant can be used to configure the Oracle Internet Directory. The directory configuration file ldap.ora can be configured with the Oracle Internet Directory Configuration Assistant or the Oracle Net Configuration Assistant. The ldap.ora file can reside in different locations depending on which tool created the ldap.ora file.

- If created by the OID Configuration Assistant, the ldap.ora file is stored in the ORACLE_HOME/ldap/admin directory.
- If created by the Oracle Net Configuration Assistant, the ldap.ora file is stored in the ORACLE_HOME/network/admin directory.
- The ldap.ora file location can be manually specified with the LDAP_ADMIN or TNS_ADMIN environmental variables.

Command-Line Utilities

The Listener Control utility can be used to start and stop listeners, check their status, and perform tracing and other management operations. The syntax is

```
lsnrctl  command [listener_name]
```

Listener commands can also be executed from within the Listener Control utility. The listener name is the one defined in the listener.ora file, but a default listener named LISTENER can be used instead. If LISTENER is used, a listener name does not need to be specified.

The following shows how to stop the listener. Here, executing the **lsnrctl** command generates an LSNRCTL prompt:

```
$ lsnrctl
LSNRCTL> stop
Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=IPC)(KEY=EXTPROC0)))
The command completed successfully
```

The next example shows a sample of the type of information displayed when starting the listener:

```
LSNRCTL> start

starting tnslsnr: please wait...
 TNSLSNR for 32-bit Windows: Version 10.1.0.2.0 -
System parameter file is C:\oracle\ora10\network\admin\listener.ora
Log messages written to C:\oracle\ora10\network\log\listener.log
Listening on: (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=eclipse)(PORT=1521)))
Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=IPC)(KEY=EXTPROC0)))
STATUS of the LISTENER
------------------------
Alias                     LISTENER
Version                   TNSLSNR for 32-bit Windows: Version 10.1.0.2.0
Start Date                03-FEB-2004 21:26:56
Uptime                    0 days 0 hr. 0 min. 2 sec
Trace Level               off
Security                  OFF
SNMP                      OFF
Listener Parameter File   C:\oracle\ora10\network\admin\listener.ora
Listener Log File         C:\oracle\ora10\network\log\listener.log
Listening Endpoints Summary...
  (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=eclipse)(PORT=1521)))
Services Summary...
Service "cust" has 1 instance(s).
  Instance "cust", status UNKNOWN, has 1 handler(s) for this service...
The command completed successfully
```

The **status** command displays detailed information on the status of the listener. Information includes the start time of the listener, the location of log and configuration files, and so on.

```
LSNRCTL> status
```

The **services** command lists dispatchers in a shared server environment and dedicated servers in a dedicated server environment.

```
LSNRCTL> services
```

Here is a list of listener commands:

- **change_password**
- **exit**
- **help**
- **quit**
- **reload**
- **save_config**

- **services**
- **set**
- **show**
- **spawn**
- **start**
- **status**
- **stop**
- **trace**
- **version**

The **set** command can be used to modify different parameter values for a listener. The **set** command, by itself, will display the parameter values that can be modified.

```
LSNRCTL> set
password                        rawmode
displaymode                     trc_file
trc_directory                   trc_level
log_file                        log_directory
log_status                      current_listener
inbound_connect_timeout         startup_waittime
save_config_on_stop
```

The Oracle Advanced Security Option

The Oracle Advanced Security option supports data encryption, enhanced authentication, integrity checking, single sign-on, and the Distributed Computing Environment (DCE). The Oracle Net Manager is used to configure Oracle Advanced Security options.

Dispatchers

The **DISPATCHERS** parameter can be set to define how dispatchers will work with the shared server architecture. Dispatchers must be defined to work with different protocols, as shown in the following:

```
DISPATCHERS="(PROTOCOL=tcp)(DISPATCHERS=6)(CONNECTIONS=1000)"
DISPATCHERS="(PROTOCOL=tcps)(DISPATCHERS=6)(CONNECTIONS=1000)"
```

Connection pooling can also be defined as shown next:

```
DISPATCHERS="(PROTOCOL=tcp)(DISPATCHERS=6)(POOL=on)
(TICK=1)(CONNECTIONS=1000)(SESSIONS=5000)"
DISPATCHERS="(PROTOCOL=tcps)(DISPATCHERS=6)(POOL=on)
(TICK=1)(CONNECTIONS=1000)(SESSIONS=5000)"
```

Project 4-1 Testing a Connection

The following project will walk you through the steps of testing a connection to an Oracle database server.

Step by Step

The first step is to test the network connectivity between the remote system and the Oracle database server. The **ping** command will verify network access. If ping is successful, the remote system can resolve the name of the host server name. The host server name should be defined in the hosts file for the operating system.

The hosts file in UNIX is in the /etc directory; the hosts files in Windows is in the\winnt directory. The following is an example hosts file entry.

```
eclipse     customer.us.trubix.com
```

1. Ping the host server name.

   ```
   ping eclipse
   ```

   If the ping is not successful using the host server name then use the IP address to verify that the remote system can access the host server through the network.

   ```
   ping 122.23.20.24
   ```

2. Start the listener. If the listener does not start, check the listener.ora file for the proper entries. The listener.ora file can be found in ORACLE_HOME/network/admin directory.

   ```
   lsnrctl start listener_name
   ```

3. Verify that the service registration has been completed and that the listener is ready to handle requests.

   ```
   lsnrctl services listener_name
   ```

   Service registration is impacted by a number of initialization parameters. They include **SERVICE_NAMES** (cust.us.acme.com) and **INSTANCE_NAME** (cust). The **SERVICE_NAMES** parameter defaults to the global database name. The global database name is made up of the **DB_NAME** and **DB_DOMAIN** parameters.

4. The remote system now needs to be configured. The Oracle Net Configuration Assistant can be used for configuration. Start the Oracle Net Configuration Assistant.

5. Of the four configuration options on the Welcome page, select the Local Net Service Name configuration.

6. Select Add, and then click Next.
7. Enter the service name (**cust**) and click Next.
8. Select the protocol (TCP/IP) and click Next.
9. Select the host name and port number, and then select Next.
10. Select Yes, perform a test, and then click Next. If the test fails, check whether the instance and listener are running. If they are, check the protocol information, and if it still fails, double-check the username and password used for the test.
11. Enter the net service name and click Next.
12. Select No when asked if would you like to configure another net service name, and then click Next.
13. At the Congratulations screen, select Next and click Finish.
14. The local naming method will create a connect descriptor in the tnsnames.ora file similar to this one:

```
cust=
(DESCRIPTION =
  (ADDRESS=(PROTOCOL=tcp)(HOST=eclipse)(PORT=1521))
 (CONNECT_DATA=
      (SERVICE_NAME=customer.us.trubix.com)))
```

15. For the final test, log into Oracle and see if you can connect using the new net service name:

```
SQL> CONNECT username/password@cust
```

The tnsping utility can also be used to test a service. If unsuccessful, it will return the error that occurred. tnsping requires the net service name found in the tnsnames.ora file. The count parameter defines how many attempts are made to reach the server.

```
tnsping net_service_name  [count]
```

If unable to connect, the trcroute utility can be used to get more detailed error information. The trcroute utility tracks the TNS address of every node it accesses in the path.

```
trcroute net_service_name
```

Project Summary

This project walked you through the steps a DBA will go through to test a simple connection for an Oracle database server using the local naming method.

CRITICAL SKILL 4.8

Use Profiles

A profile contains a set of parameters that define Oracle Net options on the remote or database server. Profiles are stored in the sqlnet.ora file and can be used to

- Route connections to specific processes
- Control access through protocol-specific parameters
- Prioritize naming methods
- Control logging and tracing features
- Configure for external naming
- Define how the client domain should append to unqualified names

During installation, the priority order for the naming methods will be defined. If the first naming method cannot resolve the connect identifier, the next naming method will be checked. The results will then be stored in the sqlnet.ora file, as shown in the following example:

```
NAMES.DIRECTORY_PATH=(ezconnect, tnsnames)
```

After installation, Oracle Net Manager can be used to modify the sqlnet.ora configuration file.

Control Access

The sqlnet.ora file can be used to grant or deny access to the Oracle database server. Table 4-7 displays sqlnet.ora parameters that control access.

sqlnet.ora Parameter Name	Description
TCP.VALIDNODE_CHECKING	Determines where to control access to the database. If this parameter is set, the following parameters will be used to define the access.
TCP.EXCLUDED_NODES	Defines which systems are denied access to the database.
TCP.INVITED_NODES	Defines which systems are granted access to the database.

TABLE 4-7. *sqlnet.ora Parameters*

The Oracle Net Manager is used to define database access control. To define database access control, perform the following steps using Oracle Net Manager:

1. After starting Net Manager, select Local | Profile.
2. Choose General.
3. Select Access Rights.
4. Choose Check TCP/IP Client Access Rights.
5. In the Clients Excluded From Access and the Clients Allowed To Access fields access control can now be defined.

CRITICAL SKILL 4.9

Network in a Multitiered Environment

Although the Oracle Database 10*g* has new features that simplify database administration, the environment the database server runs in is becoming more complex. The following areas continue to increase the complexity of Oracle networking environments:

- Oracle Database 10*g*–supporting HTTP, FTP, and WebDAV protocols are changing how data is used and accessed.
- The OEM Central Console is changing how Oracle DBAs perform administration across multiple databases.
- Multitiered architectures are placing increasing demands on network performance and security.

Traditionally, most Oracle networks have been set with the local naming method. In the future, more Oracle networking environments will work with multitiered architectures, the Oracle OEM Central Console, encryption, and the directory naming method. Companies are going to need people with skills to manage these complex environments. This chapter introduced you to the main components of Oracle Net Services. To begin working with Oracle Net Services, you may want to look at the following areas in the following order in terms of developing your skills:

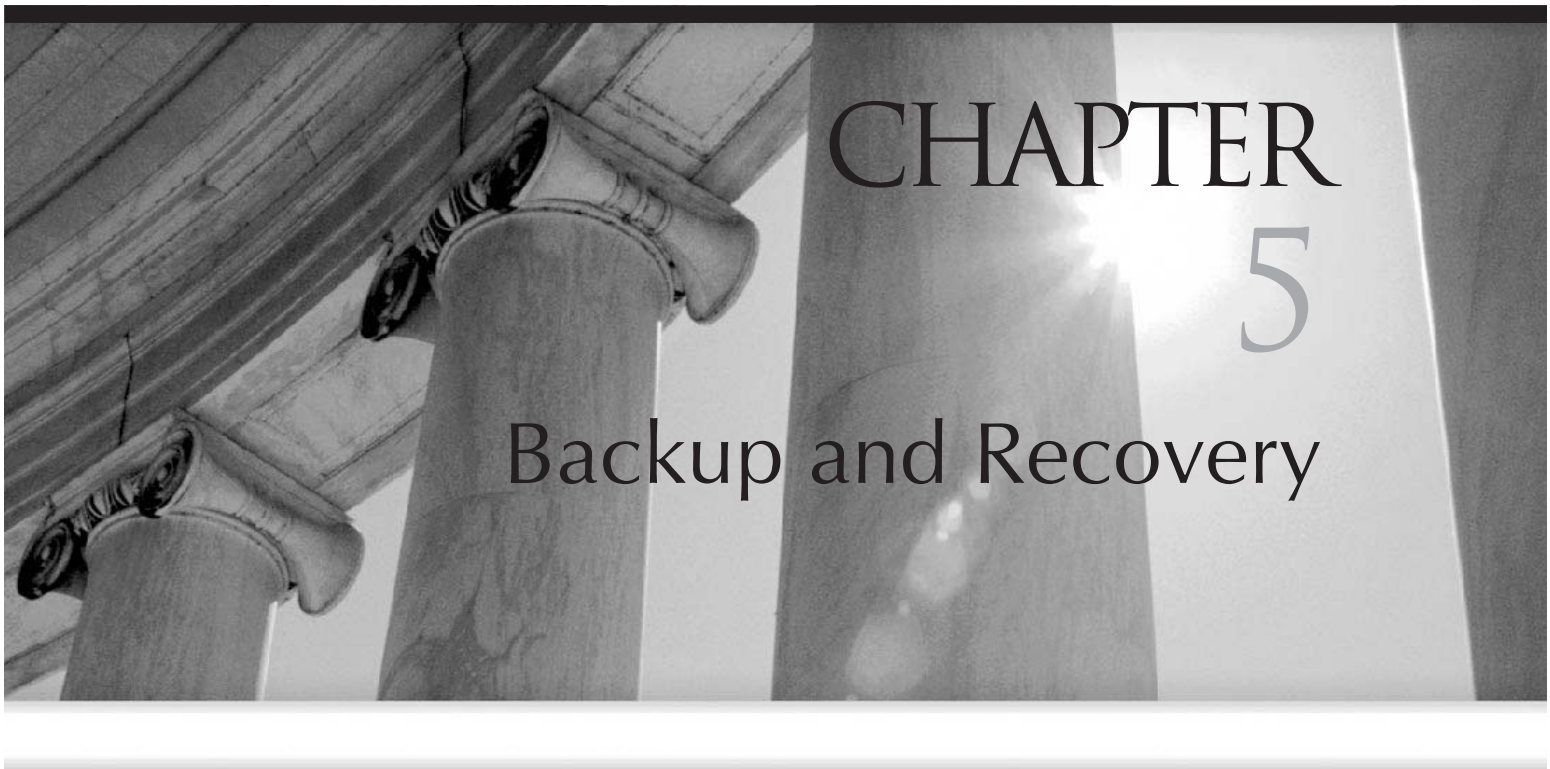
- Strengthen your understanding of the Oracle Net Services architecture.
- Obtain a solid understanding of configuring dedicated and shared server environments.
- Become comfortable working with listeners and the local naming method.

- Get comfortable working with the directory naming method.
- Be able to work with the OEM Central Console and the environment required to support it.

This list should be able to keep you busy for a few days. After that, developing skill in tuning and troubleshooting the Oracle Net Services environment will be important. Not included in these discussions, but also very important, is the ability to troubleshoot and tune the network from an operating system perspective.

☑ Chapter 4 Mastery Check

1. The _____ background process registers the service information to the listener.
2. True or False: The **LOCAL_LISTENER** parameter should be set to work with port 1521.
3. The _____ is used during installation to configure Oracle Net Services.
4. The _____file can be used to define, grant, or deny access to the Oracle database server.
5. The _____utility can also be used to test a service.
6. A _____ contains a set of parameters that define Oracle Net options on the remote or database server.
7. The ldap.ora file location can be manually specified with the _____ or **TNS_ADMIN** environmental variables.
8. True or False: The easy naming method is a valid naming method.
9. The Oracle LDAP directory is called the _____.
10. True or False: The Oracle Management Service is a repository of information generated by the Management Agent.



CHAPTER 5
Backup and Recovery

CRITICAL SKILLS

5.1 Oracle Backup and Recovery Fundamentals

5.2 Learn about Oracle User-Managed Backup and Recovery

5.3 Write a Database Backup

5.4 Back Up Archived Redo Logs

5.5 Get Started with Oracle Data Pump

5.6 Use Oracle Data Pump Export

5.7 Work with Oracle Data Pump Import

5.8 Use Traditional Export and Import

5.9 Get Started with Recovery Manager

This chapter discusses many concepts that are very important to Oracle DBAs and users. Backing up your data is crucial, and this chapter discusses how to do so as well as how to recover when things go wrong. As we have said before, the best way to learn is to do, and backup and recovery are tasks that every DBA must learn and, more important, practice. Just remember that if you do plan to perform the exercises and examples in this chapter, do it on a database that is not being used, or create one just for this purpose…just in case.

CRITICAL SKILL 5.1

Oracle Backup and Recovery Fundamentals

As you should already know, data is a valuable asset. To ensure that you can protect your investment, it is important to insure your valuable property. To support this important data need, Oracle Database 10*g* provides numerous features to enable you to protect your investment. The ability to back up your data in case of a failure is an invaluable capability. Now you have the chance to back up your data without interruption to your business processes. Just as important as it is to back up your data is the ability to quickly recovery from a failure. Whether you lose data due to hardware, software, or human failures, the time to recover costs businesses opportunity and money. This chapter introduces you to how Oracle supports the need to back up and recover data.

Where Do I Start?

Oracle's implementation of backup and recovery is an extensive one that provides you with the advantage of having many options that you can use. This is a good thing, but can leave you wondering, "Where should I start and which options are best for me?" This chapter will take you on a quick tour of backup and recovery and should leave you with a good understanding of how this is implemented in Oracle. As you review the backup and recovery utilities presented in this chapter, keep in mind that we strongly recommend using *Recovery Manager* (*RMAN*) for performing backup and recovery and will explain why later. But for now, just know that we're off to a good start since we've answered our first question already!

One of the most important elements of an advanced database management system (DBMS) is the capability to perform backup and recovery in a manner that guarantees data will not be lost. Oracle provides you with many options that can be used, from basic backup and recovery through advanced facilities to keep the database up in a high-availability environment. As a DBA, when you need to deal with a situation where the database is corrupted and needs to be recovered, there is nothing more comforting than knowing that you have valid backups for recovery and that you know how to use them!

In this chapter, you will see basic approaches and sound practices for performing backup and recovery. We will cover some examples and provide you with scripts you can use to start implementing your own backup and recovery procedures.

Three fundamental types of backups and recoveries can be performed in Oracle:

- **Physical backup and recovery** This is performed on the entire database without regard for the underlying logical data structures. All of the database files are backed up together so they may be recovered simultaneously. These are often referred to as hot or cold backups.
- **Logical backup and recovery** This is performed by choosing specific logical database structures such as named tables, indexes, and perhaps even schemas. They allow you to restore the database in a more granular fashion than is possible with a physical backup. Logical backups are implemented by tools such as Oracle's Data Pump Export and Data Pump Import facilities. You should note that you cannot use a logical backup for a recovery. You can only use it for a restore.
- **Recovery Manager (RMAN)** This Oracle tool allows you to perform physical database backups in a more controlled manner. With RMAN, the backups and recoveries are managed for you through the RMAN toolset as well as with a GUI interface using Enterprise Management. Syntax is simplified and the scripting is powerful and consistent across platforms. This is the toolset that Oracle has been investing in and moving toward since Oracle 8 and is the recovery toolset we recommend you use.

TIP

Which types of backups should you use: physical or logical? That's easy! Both, whenever possible. Always try to have more than one way to restore or recover data when faced with this task. Having a logical and physical backup on hand provides you, the DBA, with more options when presented with a recovery scenario.

Backup Architecture

There are many types of failures and corruptions that can occur and impact the database, including server, network, and media failures that may render the database inoperable. They can come in the form of data corruptions caused by software failures in the OS, in Oracle, or in the application. Human error can also create problems with the database, but these errors are never the result of the DBA, of course!

In order to understand the type of backup and recovery needed for a given situation, it's important to understand Oracle's database architecture fundamentals.

The database architecture, as it relates to backup and recovery principles, includes many components. Let's examine those structures critical to performing Oracle backup and recovery.

Oracle Binaries

Oracle binaries are the programs that make up the actual installed Oracle software, and which perform the logic of the Oracle database. This should be backed up after the install of every release and product patch. A patch is software containing fixes for known problems and, in some cases, enhancements to major versions or releases of the database. Patches are installed over the top of a release and in some cases after other patches have already been applied.

Though you can always reinstall the software, you should back up your Oracle binaries for the following reasons:

- Installs of software are slower than file restores.
- CDs and web sites that contain the software for download may not be available.
- You may not remember the exact patch level applied to a particular server.

So, the Oracle binaries should be backed up after every software change and on a regularly scheduled basis. At a minimum, there should be a weekly backup.

The Parameter Files

The text-based init.ora parameter file and executable *Server Parameter file* (*spfile*) contain a list of directives of how the instance will operate once it has been started. All parameters that define the database are either stored in these files, derived from parameters that are stored here, or are set to system defaults. These files are not volatile, but should be backed up so that the current state of the database can be re-created from a consistent set of backups. Not having a backed-up parameter file forces you to guess which parameters the database is using.

TIP
Back up the init.ora file and spfile on a nightly basis.

Control Files

Introduced in Chapter 1, the control file contains information that assists the recovery process. The history of archive logs, the name of the current online redo log file, and datafile header checkpoint data are some of the information maintained by the control file. This is a small but critical piece of the database without which Oracle cannot run! Because of this, control files should be multiplexed so that at least three copies are used. A text version of this file and a binary version should both be backed up.

TIP
Back up a text and binary version of the control files with your regular database backups, and every time you alter a data file, tablespace, or redo logs.

```
alter database backup controlfile to trace;                -- text backup
alter database backup controlfile to '/directory/file';    -- binary backup
```

Redo Logs

When data is changed in Oracle, data buffers are changed to reflect the change to tables and indexes. For performance purposes, these are usually not written out to physical disk immediately. In order to protect the data, change records are written out to allow changes to be undone (*undo records*) when a transaction is rolled back, or redone (*redo records*) for the purpose of forward recovery. At transaction commit time, all redo records that make up the transaction have been written to the redo log files along with a unique system change number (*scn*) and the time of the change. Once redo logs have been written, data protection is guaranteed. The changes to the data files are in the buffer and can be written out at a later time. Multiple log files in a database are used in a round-robin format. So, once one redo log file fills up, the next redo log will then be used until it is full, followed by the next one and so on until finally the first redo log will be used again. This is a continuous cycle. Redo logs should be multiplexed so each redo log can be a group of two or more identical members. In this manner, if there is a problem with one file being corrupted, the database can still operate as long as the other file(s) remain intact. The redo logs are absolutely required by Oracle to ensure that changes to data aren't lost!

Undo Segments

When data is changed, as mentioned earlier, "before images" of the data are created to allow a transaction to roll back. This is accomplished through undo records being written to undo segments (also called rollback segments) and tablespaces. These tablespaces are managed in the same way as any other tablespace and the data in undo tablespaces are subsequently logged as redo logs. Rollback segments allow changes to be undone either for system reasons, perhaps due to a transaction that has failed, or because the application explicitly has requested that a rollback be performed. Undo or rollback tablespaces need to be included as part of your backup strategy.

Checkpoints

As you've seen, the redo logs and database data are not written out at the same time. The redo logs are guaranteed to be written out at commit time, but the data is not changed simultaneously. If that's the case, just when then is the data written from the buffers to the data files? This is determined by one type of Oracle process called Database Writer Process (DBWn); this process manages the writing of information to

the database. DBWn writes changes to the data files to free up dirty buffers (buffers that have changed data in them) to allow more changes to occur at system checkpoint time. A checkpoint is a background event that ensures all of the changed data has been written to the data files.

Archive Logs

Archive logs are the mechanism used to provide continuous availability to an Oracle database by allowing you to back up the database while it is running. This is known as a *hot backup.* They also allow you to recover databases by performing a "roll-forward" of changes using redo logs up to either the current point in time or to a time that we specify the database should be rolled forward to. This cannot be done with online redo logs because they are written to sequentially and eventually wrap-around. When that occurs, the previous records that existed in the wrapped redo file are overwritten. By placing the database in archivelog mode, online redo logs can be written out to files to be kept indefinitely. The files can be named with sequential incrementing names so that we know the order they should be applied in. As with redo logs, archive logs can be multiplexed. In other words, more than one copy of each archive log can be written to different locations.

Datafiles, Tablespaces, Segments, Extents, and Blocks

Datafiles are the low level structures that make up what you probably think of as a database. To put it simply, the tables and indexes that make up your applications are stored in tablespaces and each tablespace is created on one or more datafiles. A particular datafile will store data for one tablespace and a tablespace can contain many tables and indexes. Tables and indexes are a subset of a type of database object called a *segment.* Examples of segments are indexes, tables, rollback/undos, clusters, lobindexes, and lobsegments. A segment is made up of extents that are a collection of contiguous blocks. So, to put this into a single sentence, a tablespace is created on one or more datafiles and consists of one or more segments made up of one or more extents that are a contiguous collection of blocks. Got it? Good. It's an important set of relationships to understand.

From a backup and recovery point-of-view, it's important to be aware of the relationship between tables, tablespaces, and datafiles. Whenever you perform a backup where you are not backing up the entire database at the same time, it is important to consider any referential integrity constraints enforced by the backup or application that must be honored. You should employ a naming standard that makes it easy to determine the tablespace that a data file supports.

Trace Files

There are three types of dump files that contain information about errors that occur in the database. Background dumps are written out by Oracle background processes when an error occurs. User dumps are files written for user processes for the purpose of debugging. Core dumps are a place where Oracle dumps core files in a UNIX environment. These may be worth backing up as a history of problems that have occurred to help you troubleshoot future issues. One particular file that should be backed up regularly is a special trace file called an *alert log.* This file reports on a great deal of activity such as when the database is stopped and started, when checkpoints occurred and the system change number (*scn*—a unique number given to every change in the database) where the current *incarnation* or version of the database began. This is all valuable information that can be of great assistance when it comes time to recover your database.

TIP
Back up your alert log with your regular database backups.

You have now seen the structures that are critical to your backup and recovery operations. Armed with this knowledge, you are ready to learn about *User-Managed Backup and Recovery.*

Progress Check

1. Name some files that should be backed up as part of your strategy.
2. What does multiplexing mean and which objects should be multiplexed?
3. Why would you want to use archive logging?

Progress Check Answers

1. Some files that should be backed up include parameter, control, undo, archive log, data, online redo, dump, and trace files.

2. Multiplexing is a term to describe data that's written to more than one location or file at the same time. Redo logs, archive logs, and control files should be multiplexed and each copy should go to a different disk to protect against the loss of one disk.

3. Archive logging allows you to perform full recovery of the database. Without archive logs, no recovery is possible (only restores can be performed). Also, the database can be backed up while it is up and running. It is needed to deliver high availability.

CRITICAL SKILL 5.2

Learn about Oracle User-Managed Backup and Recovery

Oracle supports backing up data in a number of ways. This section discusses how and why to use user-managed backups. These backups are by nature handled more mechanically than other methods and are just as effective. Also presented here is the information needed to recover your first database. Please remember that you should try this on test databases before trying your first backup and ultimate recovery on a business database.

Types of User-Managed Backups

User-managed database backups can be performed as either cold or hot physical backups. A *cold backup* means that all users are disconnected from the database and it is shut down in order to perform the backup. A *hot backup* is performed while the database is up and end users can remain connected to the database. In fact, they can be changing the very data that is being backed up! Let's examine these in more detail.

Cold Backups

Cold backups are the simplest type of backup operation you can perform. Cold backups are performed with the database completely shut down in a consistent manner. Once that is done, all database files should be backed up to disk or tape. Once the file copies are complete, the database can be started and users can resume their activity. The database does not need to be in archivelog mode in order to perform a cold backup but without archive logging, the database can only be recovered to the point in time that the cold backup was done. Cold backups are a simple option and limited in the way they must be run, but once you have a cold backup, it can be easier to work with and can provide a fair degree of functionality.

In order to perform a cold backup, the database must be shut down in a consistent manner. In other words, the database should be shut down by issuing one of the following commands:

- **shutdown normal**
- **shutdown immediate**
- **shutdown transactional**

Do not perform a cold backup of the database immediately after a **shutdown abort**. If you must shut down the database in this manner, follow it up with a **startup restrict** and **shutdown [immediate, transactional, normal]**. In this way, you can be confident that you have a database in which all of the transactions have

completed or rolled back and the data is in a consistent state. When the database has been shut down, copy the files to another location on disk or to tape. The files that you should back up include

- All database datafiles and tablespaces including system, temp, and rollback/undo
- Control files, backup binary control files, and text control files
- Archive logs if they are being used
- Alert logs
- Oracle password files if they exist
- Parameter files init<SID>.ora and spfile
- Redo logs—BUT you should be careful whenever restoring redo logs since the restore of a redo log could overwrite existing current redo logs that contain the final entries in the redo stream needed to complete the recovery. Because of this, Oracle recommends not backing up redo logs.

Once the backups have been completed, the database can be restarted. If the backups were made to disk, these files can later be backed up to tape after the database is restarted.

You should be careful whenever restoring redo logs since the restore of a redo log could overwrite existing redo logs that contain the final entries in the redo stream needed to complete the recovery. Because of this (to repeat ourselves), Oracle recommends not backing up redo logs.

Hot Backups

A hot backup is a backup done while the database is up and running. The entire database can be backed up, or a subset of the tablespaces or data files can be backed up at one time, and while this is happening, end users can continue to perform all of their normal operations against it. In order to do this, the database must be running in archivelog mode. This is done by setting the parameter **log_archive_start = true** (for pre–Oracle Database 10*g* databases only) and then running the sql statement **alter database archivelog** (this is needed for Oracle Database 10*g* and earlier versions) while the database is mounted. The tablespaces to be backed up are put in backup mode with the **alter tablespace *tablespace_name* begin backup** command. The data files are then copied using OS copies, and the backup is completed with the **alter tablespace *tablespace_name* end backup** command. This looks like the following:

```
alter tablespace <tablespace_name> begin backup;
[os file copy command such as cp in unix or ocopy in Windows]
alter tablespace <tablespace_name> end backup;
```

Once the backup is complete, you will need to ensure that all of the log records created during the backup operation have been subsequently archived. Do this with the sql statement **archive log current**. This command ensures that all redo logs have been archived and it will wait for the archive to complete. You should note that the ocopy utility is required in Windows environments to allow a file to be shared between the copy utility and Oracle. It is not needed in UNIX environments.

After a hot backup has been successfully completed, the database can be recovered to a particular point in time by restoring the data files from the hot backup and rolling forward archive logs to the time required. Online redo logs should never be backed up during a hot backup. Rather, archive the current redo logs and back those up. As a result, you will create the redo logs at the end of recovery when an **alter database open resetlogs** is performed (resetlogs is discussed later in this chapter in the section "Recovery Using Backup Control Files").

In order to recover from a hot or cold backup it is important to remember that all of the files that make up the database must be recovered to the same point in time in order to keep the entire database consistent. The exception to this rule is that read-only tablespaces can be restored to the point that they were made read-only. This makes sense since the tablespace cannot be changed once it has been made read-only. In order to recover a tablespace that is open for read-write operations to a point in time that is different from the rest of the database, a special operation called Tablespace Point In Time Recovery (TSPITR) must be performed which requires a clone database and is beyond the scope of this chapter.

Whenever a tablespace status changes to read-only or read-write, it should be backed up. You will need to keep track of these backups so that you know where they are when it comes time to use them in a recovery situation. Consider backing up "read only" tablespaces periodically to deal with potential expiry dates on tape as well as other tape management problems that could result from older tapes.

TIP

Run hot backups when the system is not busy. Also, only put one tablespace between the begin and end backup operations to reduce the amount of system overhead associated with this activity since system logging is increased on tablespaces that are in backup mode. You can group multiple tablespaces together in cases where change activity will not be high on them during the backup.

Hot backups and archivelogs will be a requirement of every system that has true high-availability requirements.

Recovery from a Cold Backup

Database recovery can be broken into two distinct steps. The first step involves file restores where files are copied from tape or a disk backup to a location on disk where the actual database resides. This is the location of files pointed to by the control files. The second step is forward recovery where the archive logs can be processed and applied to the database making the data as current as possible. In the case of the database in noarchivelog mode (which is often the case where cold backups are concerned), there are no logs with which to recover, so all data files, control files, and redo logs are simply restored to their proper location. Other files such as the init.ora and spfile parameter files, as well as password files, must also be in the proper place.

Ask the Expert

Q: Why would I ever want to use cold backups if hot backups are so powerful?

A: There are situations where you only need to restore a database from a cold backup and where high availability is not a concern. In these cases, you can consider using a cold backup.

Q: How often should I back up read-only tablespaces?

A: Back up read-only tablespaces periodically to deal with potential expiry dates on tape, as well as other tape management problems that could result from older tapes. When using RMAN, back these up once previous backups become "obsolete." We will cover obsolete backups in the RMAN section.

Q: What is the downside to performing hot backups and running in archivelog mode, if any?

A: You will need to manage the archive log files, but RMAN can help you with this (more information can be had in the upcoming RMAN section). There is also extra logging that occurs when a tablespace is placed in backup mode. This can be overcome by backing up when the database is not busy or by using RMAN, which does not place tablespaces in backup mode. Restores from hot backups require more care and practice but the benefits to hot backups outweigh the disadvantages by a great deal.

Restoring a database from a cold backup is one of the simpler things you can do as a DBA, and this simplicity is perhaps the biggest benefit of performing a cold backup. A cold backup of a database that is in archivelog mode can be recovered, but there is no recovery from a cold backup that is not in archivelog mode (note that a hot backup is only performed on databases in archivelog mode). There are only file restores. Once these files have been restored, the database can be started. That's it!

Recovery from a Hot Backup

This is one of the places where you will earn your stripes as a DBA since you will always need to perform recovery from a hot backup. To clarify this point, recovery can be performed on any database that is in archivelog mode, whether the backup was a hot or cold one, but hot backups always require that recovery be performed. There are two fundamental types of recovery: *complete recovery* and *incomplete recovery.*

Complete recovery describes a recovery where the database is restored and then recovered forward using all available archive logs. You are performing as complete a recovery as you can, with no data loss. Complete recovery can be performed at the database, tablespace, datafile, or block level.

Incomplete or point-in-time recovery is one where the database is restored and then optionally rolled forward to a predetermined point in time or *system change number* (*scn*) by applying only some, but not all, of the logs. This produces a version of the database that is not current and is often done to bring the database back to a time before a problem occurred. There are three fundamental types of incomplete recovery:

- Cancel-based is a recovery that runs until you issue a **cancel** command.
- Timestamp recovery applies to all of the logs until a timestamp you enter is reached.
- Change-based recovery applies to all of the logs until an scn you enter is reached.

Examples of these are shown next:

```
SQL> recover database until cancel;
SQL> recover database until change 1234567;
SQL> recover database until time '2004-04-15:14:33:00';
```

TIP
When performing a recovery, always try to recover as much data as possible by running a complete recovery or applying archive logs to the latest timestamp or scn that you possibly can.

Seven Steps to Recovery

The fundamental steps to perform when doing a recovery are summed up here:

1. Restore data files from tape or a backup location on disk to the location where the database file should reside.
2. Startup nomount. This step reads the parameter file, allocates the memory structure of the SGA and starts the background Oracle processes. Also, the alert log and trace files are opened. Note that the data files are not open during a Startup nomount. This step has to be performed if the control file needs to be rebuilt.
3. Create the control file. This step is optional and only needed if the control file is unavailable. A text version of the control file should be used to create a new binary version of the control file.
4. Ensure that all the data files to recover are online. Read-only data files once restored do not need to be recovered since no data will have changed in these files.
5. Mount the database. This step associates a database with the instance that was started in step 2. The database, however, is not opened at this time. The control file listed in the parameter file is opened and all database files are located.
6. Recover the database by locating and applying the archive logs.
7. Open the database. The database, including the redo logs and data files, is opened with the **Startup Open** command.

In some cases, you only need to recover a single tablespace or data file without touching the rest of the database. These must be complete recoveries and the tablespace or data file must be taken offline to perform this. A block level recovery can also be performed, but only by RMAN and can be done with the datafile online. This feature allows you to recover a small number of corrupt blocks of a datafile and is one of the great reasons to use RMAN!

Recovery Using Backup Control Files

You can create both a text version of the control file and a binary version of the control file as backups. When recovering the database, you should try to use the current control file. If that is not possible, then your next option should be to try to use a backup control file since it contains useful information that assists recovery that is not included in the text-based control file. With a backup control file, you will need to perform media recovery and use the **using backup control file** syntax when performing the **recover database** command. A **resetlogs** command will then

Ask the Expert

Q: What would happen if I restored the redo logs before I performed a point-in-time recovery? It seems like this is the best approach to use.

A: There is an end-of-redo marker on the online redo logs that will stop the recovery immediately. Oracle will think the forward recovery is complete and archive logs will not be applied.

Q: How can I find out the state of a file when a backup control file was taken? I need to know which files are read-write, read-only, or offline, but how can I do that?

A: Whenever you back up a control file, run an sql script that queries **dba_data_files** and writes the status of all of your data files to a file that is kept with the backup control file. We will show you an example of this in the following section.

need to be performed when the database is opened and this will create new redo logs as well as a new version, or *incarnation,* of the database. You also need to know the status of data files when the backup control file was created. If a data file had a status of read-write when the backup control file was created, but should be opened as a read-only file, then it should be taken offline before recovery begins. Backup control files are a useful and sometimes required feature, but can complicate your database recovery.

TIP
Always back up the database after performing an incomplete recovery and opening the database with the Resetlogs option.

CRITICAL SKILL 5.3

Write a Database Backup

When you decide to use a user-managed backup strategy rather than RMAN, you will need to develop scripts to perform hot or cold backups. One of the most important things you should do to simplify your maintenance requirements is to develop scripts that are generated from the Oracle catalog. If done properly, you won't need to change your backup scripts every time you add a new file or change the location of a file.

TIP
Automate your backups with scripts that are generated from the Oracle Catalog.

Whenever you perform a backup, it is extremely useful to know the status of your database including the data files and parameters in effect. Information such as which data files are open in read-only mode at backup time is invalidable, as is a listing of the file locations and sizes. Shown next is a simple example of some SQL queries that provides information about the state of a database when you need to restore:

```
select * from dba_tablespaces;  -- Tablespace Information
select * from dba_data_files;   -- Data file Information
select * from v$datafile;       -- More data file information
select * from v$logfile;        -- log file information
select * from v$log;            -- more log file information
select * from v$controlfile;    -- control file information
select * from v$parameter;      -- database parameters in effect
select * from v$nls_parameters; -- language characters in effect
-- Get the log history information for the past 3 days
select * from v$log_history where first_time > sysdate - 3;
```

The preceding should be spooled to the backup directory and kept with your backups. You can list the specific columns you want to see in the previous queries, but when it comes to needing information during a high-pressure recovery, we would rather err on the side of having a little too much information rather than risk missing a piece of information that would be useful. Once you have this information, your backup can be performed. The following is an example of a hot backup SQL script. This script must be executed on a database running in archivelog mode.

```
set echo on;
spool /u02/backup/ora10g/hotBackup1.lst;
alter system archive log current;
alter tablespace INDX begin backup;
! cp /u01/oradata/ora10g/indx01.dbf /u02/backup/ora10g
alter tablespace INDX end backup;
alter tablespace TABLESPACE_n begin backup;
! cp /u01/oradata/ora10g/tablespace_n01.dbf /u02/backup/ora10g
! cp /u01/oradata/ora10g/tablespace_n02.dbf /u02/backup/ora10g
alter tablespace TABLESPACE_n end backup;
… more tablespaces …
alter tablespace SYSTEM begin backup;
! cp /u01/oradata/ora10g/system01.dbf /u02/backup/ora10g
alter tablespace SYSTEM end backup;
-- Backup the log file
alter system archive log current;
--  Create 3 copies of a binary controlfile backup.
alter database backup controlfile to /u02/backup/ora10g/CONTROL01.CTL' reuse;
alter database backup controlfile to /u02/backup/ora10g/CONTROL02.CTL' reuse;
alter database backup controlfile to /u02/backup/ora10g/CONTROL03.CTL' reuse;
```

```
-- Create a text version of a controlfile backup
alter database backup controlfile to trace;
spool off;
exit;
```

This is a SQL script that can be run from a UNIX shell script or a Windows command file. To run this in Windows environments, the file copies are performed using the **host start /wait c:\oracle\ora81\bin\ocopy.exe** command rather than with the UNIX **! cp** command, which hosts out and runs the UNIX version of copy. *ocopy* is an Oracle copy utility that must be run under Windows to allow file sharing to occur during hot backups. The standard DOS **copy** command does not allow this.

Cold backups are similar to the preceding except that the **begin backup** and **end backup** commands are not needed. The copy commands are surrounded by a consistent database shutdown before the copies have started, and a startup after the copies have completed. Note that in Windows environments, you should use the standard "copy" utility for cold backups.

You should also add your parameter files, dump files, and alert logs to your backups. Once you've added those, you'll have everything backed up except for your archive logs. Let's see how to manage those next.

CRITICAL SKILL 5.4

Back Up Archived Redo Logs

Managing archive logs is one of the more difficult tasks on a busy Oracle database. You will want to have archive logs available to you in case they are needed for a database recovery. At the same time, the archive logs must be written to disk and if disk space fills up, the instance will stop processing requests until more space becomes available. Trying to balance both of these competing requirements can be tricky, especially if your system writes a large number of log records.

To meet the first requirement of trying to keep the archive logs available to your online system in the event of a recovery, try to keep archive logs since the last backup (or, even better, the last two backups) on disk. Compress the archive files if you need to. If you are unable to keep archive logs online due to space issues, then you will need to write a script that regularly backs up the archive logs to tape and deletes them from disk. An example of a space management script that backs up archive logs once the archive directory is over 50 percent full is shown here:

```
#Pseudo-shell-code for free archive log space
# Check used and free space: this is a very simple script
# df -k  (on linux: location of fields varies by platform)
# Filesystem   1k-blocks Used      Available Use%    Mounted on
# /dev/hda3    3763404   102676    3469556   3%       /
Log_arch_dest='/u01/oradata/db01/arch'
arch_dir_mountPoint=`df -k ${log_arch_dest}|grep -v blocks|awk '{print $6}'`
arch_dir_freeSpace=`df -k ${log_arch_dest}|grep -v blocks|awk '{print $4}'`
```

```
arch_dir_used=`df -k ${LOG_ARCH_DEST}|grep -v blocks|awk '{print $3}'`
if [${arch_dir_freeSpace} -le  ${arch_dir_Used}]; then
 echo "Place archiving logic here"
fi
```

All of this is unnecessary when you use RMAN since it will back up archive logs to tape, delete the files on disk, and manage the tape files in the RMAN repository. We will see more of this later in the "Get Started with Recovery Manager" section.

CRITICAL SKILL 5.5

Get Started with Oracle Data Pump

Oracle Data Pump is a new utility available with Oracle Database 10*g* that can be used to move data and *metadata* (metadata is the "data about the data," or in Oracle terms is the catalog information) from one database to another. If you are used to the pre–Oracle Database 10*g* versions of Export and Import, you will be familiar with the functionality of Data Pump Export and Data Pump Import and will recognize a similar interface with these new utilities. However, these are completely separate utilities. The performance of Oracle's new utilities Data Pump Export and Data Pump Import will increase greatly over the old Export and Import utilities and can also take advantage of parallelism to accomplish this. The Data Pump Export and Import utilities use the **expdp** and **impdp** commands, respectively. You are encouraged to use these rather than the pre–Oracle Database 10*g* exp and imp utilities since those do not support all Oracle Database 10*g* features, while the Data Pump utilities do.

Data Pump will allow a subset of data and metadata to be moved through filters implemented in the Export and Import parameters. The Data Pump Export utility unloads data, metadata, and control information from the database into one or more operating system files that are called dump files. These are written in a proprietary format that can only be read by the Data Pump Import utility. These can be imported into a target database that resides on another server and a totally different operating system.

The Data Pump Import utility can read these dump files and load a target database with metadata, data, and all objects that have been previously exported. For example, table DDL, security in the form of grants, objects such as triggers, stored procedures, and views can also be imported, among other things. In fact an entire target database can be created from a Data Pump Full Export using the Import utility. Some useful options provided through Data Pump are

- The ability to view object DDL without running it using the SQLFILE parameter
- The network import which allows a Data Pump Import to occur using a source database rather than a dump file set
- The ability to restart Data Pump jobs using parameter **start_job** to restart import jobs

- Using the Parallel parameter to define the maximum number of threads and degrees of parallelism for export and import jobs
- The ability to now monitor jobs by detaching and reattaching to running jobs
- The ability to estimate the amount of space an export file will occupy by using the **estimate_only** clause

The Data Pump Export and Import for data and metadata are performed using the Data Pump *application programming interface* (*API*) and uses procedures in the DBMS_DATAPUMP PL/SQL Package. The metadata API is implemented through the DBMS_METADATA package. This package retrieves metadata in XML format that can be used in many ways. For example, XML can be transformed into DDL or *XSLT* (*Extensible Stylesheet Language Transformation*) and the XML itself can be used to create an object. There is a new Remap attribute that allows the attributes of an object to be changed. For example, schema names can be changed using this feature. The Data Pump API supports all objects needed to perform a full export.

There are three ways to perform Data Pump Export and Import utilities. There is the command-line interface where export and import parameters are listed on a command line or in a script. A variation of the command-line interface is to add a parameter file using the **parfile** parameter, which points to a different file where all of the import or export parameters are listed. An interactive-command interface can also be used by entering CTRL-C during an import or export run which will then allow you to enter commands when prompted.

Let's now explore some details about actual running Data Pump exports and imports.

CRITICAL SKILL 5.6

Use Oracle Data Pump Export

There are five mutually exclusive modes for performing the Oracle Data Pump Export:

- Full Export is where the entire database is exported using the **full** parameter. This can be used to completely rebuild the database if needed.
- Schema Export is the default mode and allows you to export one or more schemas in the database. The **schemas** parameter is used to run this. Please note that objects in other schemas related or dependent on objects in this schema are not exported unless the other schema is also mentioned in the schema list.
- Table Export allows for the export of tables or partitions and their dependent objects using the **tables** parameter.
- Tablespace Export can be used to unload all of the tables that have been created in the given tablespace set using the **tablespaces** parameter.

- Transportable Tablespace mode differs from the preceding bullet in that only the metadata is exported from the database for a given tablespace set. This uses the **transport_tablespaces** parameter.

The **exp_full_database** role must be granted to a user performing a full or tablespace export or an export of a schema or table that is outside of the user's schema.

A useful feature of the Data Pump Export is the use of filters that can be used on both data and metadata to restrict the rows to be exported. For data, this places restrictions on the rows to be exported. The data filters are applied with the query parameter and the filter is executed once per table per job. For metadata, either the **exclude** or **include** parameters can be used and these are mutually exclusive commands. When filters are applied to metadata, the objects that are included will also have their dependent objects included. For example, included tables will also have indexes, triggers, grants, and constraints included with them. You can use the **datapump_paths** view to see which objects can be filtered on. When multiple filters are applied to an object, they are processed with an **and** condition between them. When using filters, we recommend using the **parfile** parameter and placing all parameters in the **parfile** including the filter operators.

The parameters for the Data Pump Export command can be seen using the command **expdp help=y**. A subset of the output from this, which contains the parameters along with a brief description, is shown next.

Export parameters extracted from the command: **expdt help=y**

```
>expdp help=y
Keyword                 Description (Default)
------------------------------------------------------------------------------
ATTACH                  Attach to existing job, e.g. ATTACH, [=job name].
CONTENT                 Specifies data to unload where the valid keywords are:
                        (ALL), DATA_ONLY, and METADATA_ONLY.
DIRECTORY               Directory object to be used for dumpfiles and logfiles.
DUMPFILE                List of destination dump files (expdat.dmp),
                        e.g., DUMPFILE=scott1.dmp, scott2.dmp, dmpdir:scott3.dmp.
ESTIMATE                Calculate job estimates where the valid keywords are
                        (BLOCKS), SAMPLING, and STATISTICS.
ESTIMATE_ONLY           Calculate job estimates without performing the export.
EXCLUDE                 Exclude specific object types, e.g., EXCLUDE=TABLE:EMP.
FILESIZE                Specify the size of each dumpfile in units of bytes.
FLASHBACK_SCN           SCN used to reset session snapshot.
FLASHBACK_TIME          Time used to get the SCN closest to the specified time.
FULL                    Export entire database (N).
HELP                    Display Help messages (N).
INCLUDE                 Include specific object types, e.g., INCLUDE=TABLE_DATA.
JOB_NAME                Name of export job to create.
LOGFILE                 Log file name (export.log).
NETWORK_LINK            Name of remote database link to the source system.
NOLOGFILE               Do not write logfile (N).
PARALLEL                Change the number of active workers for current job.
PARFILE                 Specify parameter file.
QUERY                   Predicate clause used to export a subset of a table.
```

```
SCHEMAS               List of schemas to export (login schema).
STATUS                Frequency (secs) job status is to be monitored where
                      the default (0) will show new status when available.
TABLES                Identifies a list of tables to export - one schema only.
TABLESPACES           Identifies a list of tablespaces to export.
TRANSPORT_FULL_CHECK  Verify storage segments of all tables (N).
TRANSPORT_TABLESPACES Export transportable tablespace metadata (N).
VERSION               Version of objects to export where valid keywords are
                      (COMPATIBLE), LATEST, or any valid database version.
The following commands are valid while in interactive mode.
Command               Description
------------------------------------------------------------------------------
ADD_FILE              Add dumpfile to dumpfile set.
                      ADD_FILE=<dirobj:>dumpfile-name
CONTINUE_CLIENT       Return to logging mode. Job will be re-started if idle.
EXIT_CLIENT           Quit client session and leave job running.
HELP                  Summarize interactive commands.
KILL_JOB              Detach and delete job.
PARALLEL              Change the number of active workers for current job.
                      PARALLEL=<number of workers>.
START_JOB             Start/resume current job.
STATUS                Frequency (secs) job status is to be monitored where
                      the default (0) will show new status when available.
                      STATUS=[interval]
STOP_JOB              Stops job execution and exits the client.
```

The values in brackets in the preceding list are the default values in use for the parameter. Some parameters worth noting are explored further in the following bullet points.

- DIRECTORY is the directory that is created using the sql **create directory** syntax in Oracle and is the location that the dump file is written to. The default name is **DPUMP_DIR**. For example, set this as follows:

```
create or replace directory DPUMP_DIR as '\u01\';
grant read, write on dpump_dir to export_user;
```

- ESTIMATE allows you to specify whether to estimate the space in blocks (the default), by sampling data, a number of rows, or using table statistics. Estimates are performed for the data only and not for the metadata.
- EXCLUDE can be used to exclude metadata, dependent objects, and data to be exported. To exclude data, you must use data filtering through a **query** and **where** clause. Once an object has been excluded, all of its dependent objects will also be excluded.
- FLASHBACK_SCN and _TIME directs the export to unload data that is consistent with the time or scn listed.
- INCLUDE is used to list metadata objects and dependent data that will be exported. This can include object types and object names. Only objects explicitly listed in the INCLUDE statement will be exported.

- NETWORK_LINK allows an import into a target database directly from a source database rather than from a dump file.
- PARALLEL is a performance option that can be used to specify the maximum number of threads that can be used to speed up an export by running it in parallel.
- PARFILE can be included to point to another file that includes export parameters. Use this when filtering data and metadata using the **exclude**, **include**, or **query** parameters.
- QUERY can be used to apply syntax similar to qualifiers that you would use in a **select…where** clause to filter the rows to be exported.
- TRANSPORT_TABLESPACES (*TTS*) is the parameter used to specify the tablespaces that will have their metadata exported during a transportable tablespace operation. When this is done, the tablespaces in the source database should be placed in read-only mode and their underlying datafiles copied to a new location. The datafile copies are performed at the OS level. The only "export" is that of the metadata. The datafile copies and exported metadata can be used to plug in the tablespaces to a target database. The tablespaces must be a self-contained set and the **transport_full_check** parameter can be used to ensure this is the case.
- ADD_FILE is valuable if an export operation fills the current dump file. When this occurs, you will be prompted to add a new dump file and you are able to do so.
- START_JOB allows you to start a job to which you are attached. This allows you to restart an export after a previous failure and is valuable for long-running jobs.

Examples that use some of these appear in the next section.

Some Export Examples

To perform a full database export using data pump, run the following:

```
expdp system/manager DUMPFILE=expdat.dmp FULL=y LOGFILE=export.log
```

A Schema Level Export of the Sales History (SH) schema can be performed as follows:

```
expdp system/manager DUMPFILE=expdat.dmp SCHEMAS=sh LOGFILE=export.log
```

A single table can be exported, as shown next with the sh.customers table:

```
expdp system/manager DUMPFILE=expdat.dmp TABLES=sh.customers LOGFILE=export.log
```

Here is an example of data filtering where the tables in the SH schema are exported except for the PROMOTIONS table and CUSTOMERS table which has one row exported.

```
expdp sh/sh parfile=exp.par
```

The contents of the exp.par file are shown here:

```
DIRECTORY=DPUMP_DIR
DUMPFILE=testsh.dmp
CONTENT=DATA_ONLY
EXCLUDE=TABLE:"in ('PROMOTIONS')"
QUERY=customers:"where cust_id=1"
```

The Data Pump Export utility is valuable for performing backups of a database or objects in a database, as well as for moving data from one database to another. Experiment with the different parameters and test your exports by performing imports to another database to ensure that the entire export and import stream is working properly.

CRITICAL SKILL 5.7

Work with Oracle Data Pump Import

You've successfully performed exports and they seem to have worked, but that's only half of the job. You now need to perform the ultimate test of whether those exports worked by performing Data Pump Imports.

Imports are performed using the **impdp** command that is new with Oracle Database 10*g*. As with Data Pump Export, this utility has similar functionality with the import utility found in pre–Oracle Database 10*g* versions, but this is a brand new utility. There are five modes for performing the Oracle Data Pump Import. The modes correspond to the export modes, but an import can be run using an export of the exact same mode or an export mode that is a higher level in the hierarchy. For example, a table-mode import can be performed using a source that is a Full, Schema, Tablespace, or Table mode export dump file as well as a Network-Link. These modes are mutually exclusive and are described next.

- **Full Import** The entire database is imported using the FULL parameter. This can be used to completely rebuild the database if needed. This can be run using a source dump file or a source database using a Network_Link.
- **Schema Import** The default mode allows you to import one or more schemas in the database using the SCHEMAS parameter. Objects in other schemas that are dependent on objects in this schema are not imported unless the other schema is also mentioned in the schema list. The source for this can be a Full export dump file or a Schema level export dump file or another database using a Network_Link.

- **Table Import** Allows for the import of tables or partitions and their dependent objects using the **tables** parameter. To import tables that are not in your schema, the **imp_full_database** role must be granted to you. The source for this can be a Full, Schema, Table, or Tablespace level dump file, or another database using a Network_Link.
- **Tablespace Import** Can be used to load all of the tables that have been created in the given tablespace set using the **tablespaces** parameter. The source for this can be a Full, Schema, Table, or Tablespace level dump file, or another database using a Network_Link.
- **Transportable Tablespace (TTS)** Differs from its siblings in that only the metadata is imported to the database for a given tablespace set. This uses the **transport_tablespaces** parameter. The metadata that was exported using a TTS export are imported into the target database and the datafiles need to be copied into the correct location as specified by the metadata (note that the paths can be changed). The source for this can be a transportable tablespace export dump file or a source database.

As with imports, filters can be used on both data and metadata to restrict the rows to be imported. For data, restrictions on the rows to be imported are implemented with the **query** parameter and the filter is executed once per table, per job. For metadata, either the **exclude** or **include** parameters can be used and these are mutually exclusive commands. When filters are applied to metadata, the objects that are included will also have their dependent objects included.

The parameters available with Data Pump Import can be seen using the command **impdp help=y**. A subset of the output from this, which contains the parameters along with a brief description, is shown next.

Import parameters extracted from the command: **impdp help=y**

```
>impdp help=y
Keyword               Description (Default)
------------------------------------------------------------------------------
ATTACH                Attach to existing job, e.g., ATTACH [=job name].
CONTENT               Specifies data to load where the valid keywords are
                      (ALL), DATA_ONLY, and METADATA_ONLY.
DIRECTORY             Directory object to be used for dump, log, and sql files.
DUMPFILE              List of dumpfiles to import from (expdat.dmp),
                      e.g., DUMPFILE=scott1.dmp, scott2.dmp, dmpdir:scott3.dmp.
ESTIMATE              Calculate job estimates where the valid keywords are
                      (BLOCKS), SAMPLING, and STATISTICS.
EXCLUDE               Exclude specific object types, e.g., EXCLUDE=TABLE:EMP.
FLASHBACK_SCN         SCN used to reset the session snapshot.
FLASHBACK_TIME        Time used to get the SCN closest to the specified time.
FULL                  Import everything from source (Y).
HELP                  Display help messages (N).
INCLUDE               Include specific object types, e.g., INCLUDE=TABLE_DATA.
JOB_NAME              Name of import job to create.
LOGFILE               Log file name (import.log).
```

```
NETWORK_LINK          Name of remote database link to the source system.
NOLOGFILE             Do not write logfile.
PARALLEL              Change the number of active workers for current job.
PARFILE               Specify parameter file.
QUERY                 Predicate clause used to import a subset of a table.
REMAP_DATAFILE        Redefine datafile references in all DDL statements.
REMAP_SCHEMA          Objects from one schema are loaded into another schema.
REMAP_TABLESPACE      Tablespace object is remapped to another tablespace.
REUSE_DATAFILES       Tablespace will be initialized if it already exists (N).
SCHEMAS               List of schemas to import.
SKIP_UNUSABLE_INDEXES Skip indexes that were set to the Index Unusable state.
SQLFILE               Write all the SQL DDL to a specified file.
STATUS                Frequency (secs) job status is to be monitored where
                      the default (0) will show new status when available.
TABLE_EXISTS_ACTION   Action to take if imported object already exists.
                      Valid keywords: (SKIP), APPEND, REPLACE, and TRUNCATE.
TABLES                Identifies a list of tables to import.
TABLESPACES           Identifies a list of tablespaces to import.
TRANSFORM             Metadata transform to apply (Y/N) to specific objects.
                      Valid transform keywords: SEGMENT_ATTRIBUTES and STORAGE.
                      e.g., TRANSFORM=SEGMENT_ATTRIBUTES:N:TABLE.
TRANSPORT_DATAFILES   List of datafiles to be imported by transportable mode.
TRANSPORT_FULL_CHECK  Verify storage segments of all tables (N).
TRANSPORT_TABLESPACES List of tablespaces from which metadata will be loaded.
                      Only valid in NETWORK_LINK mode import operations.
VERSION               Version of objects to export where valid keywords are
                      (COMPATIBLE), LATEST, or any valid database version.
                      Only valid for NETWORK_LINK and SQLFILE.
The following commands are valid while in interactive mode.
Command               Description (Default)
------------------------------------------------------------------------------
CONTINUE_CLIENT       Return to logging mode. Job will be re-started if idle.
EXIT_CLIENT           Quit client session and leave job running.
HELP                  Summarize interactive commands.
KILL_JOB              Detach and delete job.
PARALLEL              Change the number of active workers for current job.
                      PARALLEL=<number of workers>.
START_JOB             Start/resume current job.
STATUS                Frequency (secs) job status is to be monitored where
                      the default (0) will show new status when available.
                      STATUS=[interval]
STOP_JOB              Stops job execution and exits the client.
```

The values in brackets in the preceding list are the default values in use for the parameter. Some parameters worth noting are as follows:

- EXCLUDE can be used to exclude metadata and dependent objects and data to be imported. To exclude data only, you must use data filtering through a query. Once an object has been excluded, all of its dependent objects will also be excluded.
- FLASHBACK_SCN and _TIME specify the system change number (scn) or time that the import will use as a point of consistency. In other words, the import will be performed in a manner in which the data is consistent with the time or scn listed. This is only used with a Network_Link, and specifies the scn or time from the source database.

- INCLUDE is used to include metadata objects and dependent data during an import. This can include object types as well as object names. Only objects explicitly listed in the **include** statement will be imported. Employ a **parfile** when using this option.
- NETWORK_LINK allows for an import into a target database directly from a source database rather than from a dump file that was previously exported.
- PARALLEL is a performance option that specifies the maximum number of threads that can be used to speed up an import by running it in parallel.
- PARFILE can be included to point to another file that includes import parameters. Use this when filtering data and metadata using the **exclude**, **include**, or **query** parameters.
- QUERY is used to apply syntax similar to qualifiers that you would use in a **select…where** clause to filter rows to be imported. Use a **parfile** with this parameter.
- Remap parameters: **remap_datafile**, **remap_schema**, **remap_tablespace**, **remap_datafiles**. These allow you to change the names of datafiles, schemas, tablespaces, and datafiles when moving objects from one database to another.
- **reuse_datafiles** should be used with extreme caution. When set to Y, existing datafiles will be used and data will be overwritten when a Create Tablespace operation is performed. The default is N and a **create tablespace** command will fail when a dependent datafile exists.
- SQLFILE names a file where all of the DDL that would be executed will be written. So, rather than executing the DDL, it writes the statements to the SQLFILE named here.
- TRANSPORT_TABLESPACES (TTS) specifies tablespaces that will have their metadata imported during a TTS operation. The datafile copies and previously exported metadata can be used to plug in the tablespaces to a target database.

A Data Pump Export and Import Example

Let's look at an example of data filtering where all data from all tables in the SH schema are exported except for the SALES table. We will then use the dump file created by this export in a separate import job that renames the schema and only imports one table. Here are the export script and parameter files:

```
expdp system/manager parfile=exp.par
```

Contents of the exp.par parameter file are shown here:

```
DIRECTORY=DPUMP_DIR
DUMPFILE=testsh.dmp
SCHEMAS=SH
EXCLUDE=TABLE:"in ('SALES')"
```

An import that uses the preceding dump file is shown next. Notice that we are importing a single table into a different schema **SHNEW** as specified by the **REMAP_SCHEMA** command. If the table already exists, then this will be skipped and the import will continue through the **TABLE_EXISTS_ACTION** parameter. Note that the **SHNEW** schema must already exist in the database with the proper authority to create all of the objects in it since this was a schema level export. In order to create the **SHNEW** schema with Data Pump Import, a full export would need to be run.

```
impdp system/manager parfile=imp.par
```

Contents of the imp.par file are shown here:

```
DIRECTORY=DPUMP_DIR
DUMPFILE=testsh.dmp
REMAP_SCHEMA=SH:SHNEW
TABLES=SH.PRODUCTS
TABLE_EXISTS_ACTION=SKIP
```

Progress Check

1. Describe the data and metadata that is exported with the following command:

   ```
   expdb system/manager dumpfile=testsh.dmp schemas=sh
   logfile=testsh.txt
   ```

2. What is the result of the following export?

   ```
   expdb system/manager dumpfile=testsh.dmp full=Y
   EXCLUDE=TABLE:"LIKE'%'"
   ```

3. Why would you run a Data Pump export or import rather than an original Oracle export?

4. How does a transportable tablespace export and import differ from the others?

5. What makes the metadata export and import so useful and flexible?

CRITICAL SKILL 5.8

Use Traditional Export and Import

The original (non–Data Pump) Export and Import utilities that were used in pre–Oracle10*g* versions can be found in Oracle Database 10*g*. However, we strongly recommend you use the new Data Pump utilities since they support all Oracle Database 10*g* features and will increase performance. Here, we'll review the original Export and Import utilities since you'll be using them with earlier versions of Oracle.

How to Run the Original Utilities

Before running the original export and import, the catexp.sql catalog script needs to be run to prepare Oracle for these utilities, and it is invoked from the catalog.sql script. These scripts can be found in the ORACLE_HOME/rdbms/admin directory.

Once the catalog has been set up for export and import, you are ready to run the utilities. As with Data Pump, these utilities can be run as a command-line interface, by using parameter files or interactive commands.

To run an original export, issue the **exp** executable in a manner similar to using Data Pump. Use the following syntax to run a command-line export or an export using a parameter file or an interactive export, respectively:

```
exp user/password@SID parameter_list
exp PARFILE
exp   (and respond interactively to the export requests)
```

To find all of the export and import syntax, issue the following command:

```
exp help=y
```

Progress Check Answers

1. The entire schema, including metadata and all table data, is exported to file testsh.dmp.

2. Although the FULL=Y option is used, all tables were excluded through the wildcard LIKE '%'. No tables were exported, nor were any table dependencies and metadata.

3. The Data Pump export provides considerable performance enhancements such as parallelism and it supports all Oracle Database 10*g* features.

4. Data is not exported and imported using Transportable Tablespaces (TTS). Rather, all of the metadata associated with the objects are exported from the source database and imported into the target. The datafiles in the source database are placed in read-only mode and the files are copied to the target location before the TTS Import step begins.

5. The metadata is retrieved in XML format that can be used in many different ways. The **remap_schema** parameter facilitates object renames.

To run an original import, issue the **imp** executable in a manner similar to using Data Pump. Use the same syntax as for export in the previous example, except that the utility to be run is imp. The three types of import can be run as shown next:

```
imp user/password@SID parameter_list
imp PARFILE
imp   (and respond interactively to the export requests)
```

To find all of the export syntax, issue the following command:

```
imp help=y
```

The parameters for export and import are a little different than the Data Pump ones, but as with Data Pump, these can be run in different, mutually exclusive, modes. They are

- Full export and import
- User export and import
- Table export and import
- **transportable_tablespace** export and import

These utilities can also be run in Direct-Path or Conventional-Path mode. Conventional Path performs the utilities as SQL statements that are more versatile than Direct-Path exports. These can be used to move data across different server platform types or different Oracle versions. Direct path exports and imports are much faster than conventional ones but are less versatile. A direct path export and import needs to be run on the same Oracle version and the same server platform. Conventional is the default and Direct is run with the DIRECT=Y parameter.

Examples Using Original Export and Import

Let's look at a few examples using the original export and import. The first example is a full export with all grants, rows, constraints, and triggers being exported. This is a conventional export rather than Direct-Path and is being run in consistent mode. This **consistent** parameter is important and means that all data exported will be consistent as of the beginning scn of the export run. Undo/rollback segments will be used to ensure that this consistency is met. The buffer parameter is used to increase the performance of conventional exports and imports. A log file of the export will be created and the compress option will be used to combine all of the extents of an object into a single extent.

```
exp system/manager full=y grants=y rows=y triggers=y buffer=10000000 direct=n
consistent=Y constraints=Y compress=Y file=shexp.dmp log=shexp.log
```

This can be transformed to a *user* export by replacing **full=y** with the **owner** parameter:

```
exp system/manager OWNER=SH grants=y rows=y triggers=y buffer=10000000 direct=n
consistent=Y constraints=Y compress=Y file=shexp.dmp log=shexp.log
```

Now let's look at a Table level direct export using a parameter file as specified by the **parfile** parameter. Notice that we have removed the **full=y** parameter used in the preceding example and the buffer parameter which only is used for conventional exports.

```
exp SYSTEM/manager parfile=exp.par
```

The parameter file named **exp.par** contains the following parameters:

```
TABLES=(SH.PRODUCTS) grants=y rows=y triggers=y direct=Y consistent=Y
constraints=Y compress=Y file=shexp.dmp log=shexp.log
```

An example of a user import employing the user export file from the previous example is shown next. Notice that the schema name has been changed to import all of the data into a new schema and the ignore parameter is used to have the import continue if objects already exist. For example, a table may already exist, so the **create table** will fail, but the rows can still be loaded into the table if **ignore=Y** is used. The compile parameter is used to compile all functions, procedures, and packages, and tablespaces will not be overwritten due to the **Destroy=N** parameter. The user **SHNEW** must already exist in order for this user-mode import to run successfully.

```
imp system/manager FROMUSER=SH TOUSER=SHNEW ignore=y compile=y
destroy=n grants=y rows=y buffer=10000000 constraints=y file=shexp.dmp
log=shimp.log
```

CRITICAL SKILL 5.9

Get Started with Recovery Manager

We have seen different ways to provide backup and recovery in this section as a matter of background and completeness. We will now look into the method that Oracle recommends you should be using or at least migrating to. This is *Recovery Manager* (*RMAN*). The RMAN utility has been available since Oracle8*i* and has been improving steadily with each new release. RMAN is an Oracle tool that manages all backup and recovery activities, including backup, copy, restore and recovery of datafiles, control files, and archived redo logs. It is included with the Oracle server at no extra charge, and Enterprise Manager's backup and recovery is

based on RMAN. RMAN provides many benefits over other types of Oracle backup and recovery:

- Can perform full and incremental backups.
- Creates backup scripting and automation.
- Has powerful reporting capabilities.
- You can use either a GUI or command-line mode.
- Compresses backups so that only blocks that have been written to are included.
- Tablespaces are not put into backup mode, so no extra redo is generated.
- Verifies backups and detects corrupt blocks.
- Parallels and verifies backups.
- Backs up data files, control files, archive redo logs, backup pieces, and spfiles (Oracle9*i*).
- Allows online restores of corrupt blocks.

RMAN Architecture

The RMAN architecture includes a target database, repository, and Media Management Layer, as well as Server Processes, Channels, Backup Sets, and Backup Pieces. The target database is the database that is either being backed up or restored. RMAN connects to the target database using server sessions.

The repository is a separate database or schema that contains the metadata about your target database and all of the backup and recovery information for that database for maintenance purposes. It can keep track of all of the information about every backup that you perform, including all of the file information, the time of the backup, and the database *incarnation* (the database version) at the time of the backup. This information can all be used to restore files and recover the database by issuing very simple restore and recovery commands. All of the information needed to complete these operations is stored in the repository. This repository can be implemented in one of two ways:

- By using control files
- As a recovery catalog database

Control files are the default option for implementing a repository since backup information is written to control files making the recovery catalog optional. Using a control file, however, limits the functionality of RMAN, while a recovery catalog

provides you with the use of all RMAN features (this option is strongly recommended by the authors). Some of the advantages that a recovery catalog gives include the following:

- The catalog will store the physical structure of the target database and a log of backups of datafiles, control files, and archive logs.
- You can store scripts of common tasks.
- Multiple databases can be managed from one location.
- Offers complete reporting capabilities.
- Provides access to a longer history of backups and metadata.
- Enables you to perform recovery when control files are lost.
- Gives a complete set of options when you try to restore from previous backup sets.
- Has more recovery flexibility and options.

One disadvantage of using an RMAN recovery is that it needs to be managed itself. However, this is a small database or schema, so maintenance is minimal. Backups can be performed easily through a hot backup or database export. You also need to keep the recovery catalog in sync with the control files and this is performed with the RMAN-provided **resync** command.

TIP
When using RMAN, use the recovery catalog rather than the control file if it provides you with specific needed features that are above and beyond those provided by the control file.

The Media Management Layer (*MML*) is the third-party software that manages the reading, writing, loading, and labeling of backups to tape. This can be integrated with RMAN to streamline the process of backup, restore, and recovery from the database through to the tape library and keeps track of where files are cataloged on tape.

Oracle publishes a media management API that third-party vendors use to build software that works with RMAN. Tapes will, over time, become unavailable to the system after backups have been performed, and the RMAN MML option will perform crosschecks to determine if backup pieces are still available to the system and missing backups will be marked as "Expired". This can be run simply as follows:

```
RMAN> crosscheck backup;
```

The preceding code checks that the RMAN catalog is in sync with the backup files on disk or the media management catalog.

Channels are server processes that are used to read and write backup files, connect to your target database, to the catalog, and to allocate and open an I/O channel for backup or recovery using tape (called *sbt* in RMAN) or disk. Many configuration options can be set up through channels such as implementing a degree of parallelism for a backup operation or configuring default settings to be used for a specific channel. Allocating a channel starts a server process at the target server and establishes a connection between the RMAN and the target. A channel can do things such as determine the maximum size of files, the maximum rate files are read, the max number of files open at one time, the number of processes accessing a device simultaneously, or the type of I/O device disk or sbt_tape. A channel will be allocated for you automatically using default options unless you explicitly allocate a channel and specify overriding options for the channel in effect.

Backup sets are a complete set of backup pieces that constitute a full or incremental backup of the objects specified in the "Backup" command. Each backup creates a backup set that is composed of one or more backup pieces (that is, files) that are in an RMAN proprietary format.

Set Up a Recovery Catalog and Target Database

Setting up a recovery catalog is a very simple process. This can be done through the Enterprise Manager GUI or through some simple commands in SQL*Plus and the RMAN command-line interface. In SQL*Plus, all you need to do is to create a tablespace to store the catalog data in, create an RMAN user and grant the **recovery_catalog_owner** role to the RMAN user. In RMAN, run the **create catalog** statement.

```
SQL>create tablespace rcatts datafile '/u01/oradata/rcatts.dbf' size 10M;
SQL>create user rcat identified by rcat temporary tablespace temp default
tablespace rcatts quota unlimited on rcatts;
SQL>grant connect, resource, recovery_catalog_owner to rcat;
```

In the RMAN command-line interface, log in and create the catalog:

```
$ rman catalog=rmancat/rmancat
RMAN> create catalog
```

Now you need to register the target database in the catalog. To do this, connect to the target and the catalog database and register the target database in the catalog. This can be done from either location. The target connection must have a user ID with sysdba privileges, so an oracle password file must be created using the orapwd utility. You also need to create the Oracle networking configuration using tnsnames or an equivalent for both the target and recovery catalog instances.

```
$ rman
RMAN> connect catalog rmancat/rmancat@sid
RMAN> connect target sys/pwd@sid
RMAN> register database;
```

You are now ready to start using RMAN, but before going too far, let's take a quick tour of some RMAN features.

Key RMAN Features

Stored Scripts

A stored script is a set of RMAN commands that are stored in the recovery catalog. These can be used to perform tasks such as backup restore, recovery, or reporting. This option allows you to develop, test, and save commands, as well as minimize the potential for operator errors. Each script relates to one target database only. The following is a sample stored script that allocates a channel and performs an incremental level 0 full database backup. The current log is archived and all archive logs are then backed up and deleted.

```
RMAN> create script b_whole_10 {
allocate channel c1 type disk;
backup
      incremental level 0
      format /u01/backup/b_t%t_s%s_p%p'
      (database);
sql 'ALTER SYSTEM ARCHIVE LOG CURRENT';
backup (archivelog all delete input);          }
```

Archive Log Management

As shown in the preceding script, RMAN can back up archive logs to tape and then delete the online versions once they have been successfully backed up. This is a great space saver!

Multiplexing Backups

Oracle multiplexes datafile blocks from different data files into the same backup set to control backup and overall system performance. In Oracle Database 10*g*, this is set by the lesser of the number of files in each backup set and the default number of files that RMAN reads in a single channel (which is eight). There are three performance benefits of multiplexed backups:

1. Keeps a high-performance sequential output device streaming by including a sufficient number of datafiles in the backup.
2. Prevents saturating a single datafile with too many read requests.
3. The read rate can be limited with the set limit channel command.

The following example sets the read rate to 50K blocks per second for a named channel:

```
run { allocate channel c1 type disk;
set limit channel c1 readrate=50; …}
```

Backup and Restore Optimization

RMAN can optimize backups so files that have not changed are not backed up. This will save you from performing repeated backups of read-only files. In the same manner, restores are optimized so that online files that have not been changed since the last backup will not be restored. This also allows restores to be restartable.

```
configure backup optimization {ON | OFF | CLEAR}
```

Corruption and Verification Checks

When RMAN moves a backup piece to another location, it verifies that the backup piece is not corrupt. A multiplexed copy will be used if a corruption is found. Archive logs are also checked in the same manner, and another archive log location will be used if a corruption is found. As part of backup, RMAN checks every datafile block, performs verification checks and logs the corrupted blocks. These can be viewed in the views **v$backup_corruption** and **v$copy_corruption**. Each corrupt block encountered is also recorded in the control file and alert log. RMAN will not allow an unusable backup or corrupt restore to be performed.

Configuration and Default Settings

RMAN allows you to set defaults once using the **configure** command to use with all of your backup and recovery jobs. These can be overridden when needed. The configure settings are stored in the control file and recovery catalog once synched. These configuration commands can all be displayed with the **show all** command in RMAN. An example of an extremely valuable setting is the one that follows which directs RMAN to automatically back up the control file after every backup, or every copy in RMAN prompt, or in a Run block.

```
configure controlfile autobackup;
```

Channels can be allocated automatically by RMAN and when configuration defaults are applied to a channel these can also be applied automatically. To configure a channel to have a default file format, a configure command such as the one listed next can be issued:

```
Configure channel 1 device type disk format
'/orarecover/backup/db01/tp_%U';
```

Redundancy vs. Recovery Windows

An important backup management consideration is to determine how long backups should be kept and then to automate the implementation of your policy. RMAN helps you with this through the mutually exclusive commands **redundancy** and **recovery window**. Redundancy specifies the number of backups to be kept before RMAN will start to delete backup files. This is very good for controlling disk space. For example, to start deleting backups after four backups have been taken, issue the following command:

```
configure retention policy to redundancy 4;
```

A recovery window specifies the amount of time that point-in-time recovery should be able to go back to, which is specified in days. To make point-in-time recovery possible up to the last 15 days and make backups taken more than 14 days ago obsolete, issue the following command:

```
configure retention policy to recovery window of 15 days;
```

Block Media Recovery

Individual blocks can now be recovered from backups and this option is only available with RMAN. The database stays up while the blocks are being recovered but the blocks being recovered remain unavailable until the recovery is complete. This speeds up recovery if only a small number of blocks need to be recovered. The DBA specifies which block to recover by entering a corrupt block address that can be found in the v$backup_corruption or v$copy_corruption views, or in the alert log.

Trial Recovery

A trial recovery can be performed which lets you find all of the corrupt blocks in a database. You perform a trial recovery by adding the parameter **test** to the end of a **recover** command.

Reporting

A major advantage of RMAN is that it gives you the ability to run lists and reports on the repository. Lists allow you to display the contents of the RMAN repository such as image copies, incarnations of the database, and backups of data files or archive logs, among other things. Reports provide a more detailed analysis and can help you determine what should be done. These help report on objects that have not been backed up lately, or backups that are obsolete and can be deleted, or data files that are not recoverable, to mention a few. Such reports and lists are valuable in managing your backup and recovery environment.

To list backup sets and their detailed files and pieces, run the following:

```
List backup by file
```

To report on backups that are no longer needed because they exceed the retention policy:

```
Report obsolete
```

Backups

Oracle RMAN backups can be performed as either image copies or as backups. image copies are a complete copy of the binary data files used in the database. These files can be used by both RMAN or user-managed backup and recovery. Backup sets, on the other hand, are in a proprietary RMAN format and each set consists of one or more files called backup pieces. These backups can only be used by RMAN but have the advantage of performing unused block compression and incremental backups. Image copies can only be made to disk, while backup sets can be made to disk or tape.

When performing database backups, RMAN supports both *full* and *incremental* backups. A full backup will copy all used blocks in the data files specified. An incremental backup, on the other hand, only backs up those blocks that have changed since the previous incremental backup. Incrementals require a *level 0* backup, which is similar to a full backup except that it serves as a baseline to allow future incremental backups. Incremental backups can save recovery time when compared to the time that may be needed to apply archive logs and they take up less disk space and network resources than full backups do. There are two types of incremental backups. *differential* incrementals back up all blocks that have changed since the last backup at this level or lower, and *cumulative* incrementals only back up blocks that have changed since the last backup at a level lower than this. So, a differential incremental level 2 backup will back up all blocks changed since the last level 2, 1, or 0 backup where a cumulative incremental level 2 backs up all blocks since the last level 1 or 0. Differential backups have less data to back up while cumulative backups have less data to restore and can result in quicker restores.

Believe it or not, before Oracle Database 10*g,* incremental backups ran as slow or slower than full backups because table scans needed to be performed to find the blocks that had changed. This has changed with Oracle Database 10*g* since a block-change tracking file consisting of bitmaps is used rather than performing full table scans to discover changed blocks.

In order to back up a database, the target database must be either open or mounted so that RMAN can access the control file before performing a backup. If the database is mounted, it needs to have a consistent backup (that is, it must NOT have been abnormally terminated), and the control file must be current. Backups can be performed as either offline or online, and the target database must be placed in archivelog mode to allow you to perform online backups.

- **Offline Backup** Performs an immediate or normal shutdown and then a startup mount. This does not require archivelog mode.
- **Online Backup** For this to be done, the database must be open and in archivelog mode.

To help manage your backup and recovery space, a *Flash Recovery Area* should be created as the storage area for most of your backup and recovery files. Archive logs can be placed here and, if possible, the Flash Recovery Area should be large enough to handle two complete backup cycles for your database, including the archive logs. The backup retention policy of either recovery window or redundancy are used to manage space in the Flash Recovery Area. The Flash Recovery Area is an Oracle-managed area that can be used to store all of the files required for backup and recovery, including RMAN backups.

Now that you're familiar with the options available through RMAN, you're ready to back up a database.

Performing Backups

There are a number of ways that RMAN backups can be performed. In this section, we will cover examples of the basic set of backups. Namely, you will see an example of a database, data file, tablespace, and incremental backup, as well as an image copy.

Database Backup

An RMAN database backup can be as simple or as complex as you want to make it. In its simplest form, you can preconfigure channel defaults as discussed previously, connect to the catalog and the target, and then run the **backup** command:

```
RMAN > connect catalog rmancat/rmancat@test2
RMAN > connect target sys/lexus4me@TEST1
rman> backup database;
```

Datafile Backup

It doesn't get any easier than that! Let's now look at a backup that allocates one channel and backs up three datafiles using multiplexing. The archive logs are then backed up.

```
RMAN > run {
RMAN > allocate channel c1 type disk;
RMAN > allocate channel c2 type disk;
RMAN > allocate channel c3 type disk;
RMAN > backup (datafile 1,2,3 filesperset =3 channel c1)
RMAN > (archivelog all channel c3);}
```

Tablespace Backup

A tablespace backup is performed along with a backup of the control file and archivelog. Of course, the tablespace backup is implemented by RMAN as a series of data file backups.

```
RMAN > backup tablespace EXAMPLE include controlfile plus archivelog;
```

Incremental Backup

We can configure default settings for a channel and then perform an incremental level 1 backup. You need to perform an incremental level 0 backup first to provide a baseline for this incremental to be compared to. If an incremental level 0 does not exist, then this level 1 backup will be changed to level 0. Check the output of your backup run to make sure that the backup ran exactly as you expected it to. Backup optimization will be used to ignore any data files that have not changed since the last backup was performed. A backup script will be used in this example.

```
replace script BackupTEST1 {
configure backup optimization on;
configure channel device type disk;
sql 'alter system archive log current';
backup database incremental 2 cumulative database;
release channel d1;
}
run {execute script BackupTEST1;}
```

Image Copy

An Image Copy can be performed using the RMAN **copy** command. Here is a copy of a System data file to a named location. As you can see, there are no **begin backup** and **end backup** statements. The syntax is simple and RMAN performs the copy without incurring extra logging overhead.

```
RMAN > run { allocate channel c1 type disk;
RMAN > copy datafile 1 to '/u01/back/system.dbf';}
```

We've only done the first part of the job, but as you can see, the commands are relatively simple. We now need to think about how to use these backups in a recovery situation. Fortunately, the RMAN toolset also simplifies our restores and recoveries a great deal! Let's take a look at an example of how we can recover a database with RMAN.

Restore and Recovery

RMAN can automate file restores and can be used to restore data files, control files, and archived redo logs. In this example, you will see a full restore and recovery where the control file is restored from backup and the archive logs that we need are

also restored. We have changed the archive log directory destination to write the archive log restores to. Notice that there is no mention of file names in this script. The recovery catalog has kept track of all of the files for us and if files were stored on tape, the Media Management Layer software may have also assisted with this.

```
RMAN> connect catalog rmancat/rmancat@ora10g
RMAN> connect target sys/change_on_install@ora10g

MAN> replace script fullRestoreTEST1 {
allocate channel ch1 type disk;
# Set a new location for logs
set archivelog destination to '/TD70/sandbox/TEST1/arch';
startup nomount;
restore archivelog from logseq 2123 until logseq 2145;
restore controlfile;
alter database mount;
restore database;
recover database;
alter database open resetlogs;
release channel ch1;
}
host 'echo "start `date`"';
run {execute script fullRestoreTEST1;}
host 'echo "stop `date`"';
exit
```

That's it! This script is simple and very powerful. We've now covered some basic RMAN backup options to give you an overview of how you can use RMAN on your databases. You should now test out various backup and recovery options to see how they function and how well the different options work in your environment. The settings that you use on one set of servers may not be the ones you will use on another, so testing your RMAN backup and recovery setup is essential!

Project 5-1 RMAN End-to-End

This project will take you from start to finish using RMAN. We will first assume that you have two Oracle databases to work with. The target database will be called ora10g in this project and the catalog database will be called oracat. You will first set up the RMAN catalog and then connect to the target database and register that database in the catalog. A full database backup will be performed and once that has been successfully completed, we will use that backup to perform a full database restore using RMAN. Look carefully at the output that RMAN produces to help better understand what is going on behind the scenes. Once you've completed this project, you will have used RMAN from end to end and will be comfortable with basic RMAN functionality.

(continued)

Step by Step

1. In SQL*Plus, create the RMAN tablespace, catalog, and user named **rcat**. Grant the authority that user rcat needs to perform all RMAN operations.

```
> export ORACLE_SID=oracat
SQL> sqlplus /nolog
SQL> connect sys/change_on_install as sysdba
SQL> create tablespace rcatts datafile '/u01/oradata/oracat/rcatts.dbf' size 50M;
SQL> create user rcat identified by rcat temporary tablespace temp default
SQL> tablespace rcatts quota unlimited on rcat;
SQL> grant connect, resource, recovery_catalog_owner to rcat;
SQL> exit
```

2. Your RMAN environment and user have now been created, so you need to go into RMAN to create the recovery catalog. Note that we are using a recovery catalog here rather than the control file and strongly encourage using this approach. We first log in to the catalog, then connect with the rcat user, and run the **create catalog** command.

```
> rman catalog=rcat/rcat@oracat
RMAN> catalog rcat/rcat@oracat
RMAN> create catalog;
RMAN> exit;
```

3. Register the target database ora10g with the RMAN catalog. Once you've completed this, you will be connected to both the target database and a fully functional catalog and will be ready to begin issuing RMAN commands.

```
RMAN> connect catalog rcat/rcat@oracat
RMAN> connect target sys/manager@ora10g
RMAN> register database;
```

4. It's now time to back up your entire database. We'll start by applying a couple of configuration settings to set the default backup device to disk and to state that we always want to back up the control file and spfile with every backup. The spfile is automatically included with control file backups. Once these are configured, we can back up the database, archivelogs, control file, and spfile. This sounds like a lot of work, but just look at how easy this is to do with RMAN!

```
RMAN> configure default device type to disk;
RMAN> configure controlfile autobackup on;
RMAN> backup database plus archivelog;
RMAN> exit;
```

5. Once the backup has completed successfully, we want to set up the environment for a restore. To do this, shut down the database and delete all of the data files, archive logs, control files, and the spfile SPFILEORA10G.ora of the target database.

6. Now for the big test! The database restore and recovery is the one thing that absolutely tests how well we've done everything so far. Once again in RMAN, connect to the catalog and target and then put the database in nomount mode. Once that's done, restore the archive logs and control files, and then mount the database. You should now see these files in their proper location. Restore the database and watch the files being created in another window. Once that's complete, recover the database and open it up.

```
RMAN> connect catalog rcat/rcat@oracat
RMAN> connect target sys/manager@ora10g
RMAN> startup nomount;
RMAN> restore archivelog all;
RMAN> restore controlfile;
RMAN> alter database mount;
RMAN> restore database;
RMAN> recover database;
RMAN> alter database open resetlogs;
```

The resetlogs step at the end, is needed to create new log files. This creates a new incarnation (that is, version) of the database and it should be backed up immediately.

Project Summary

This project has taken you from the very first step of setting up RMAN through a full backup, restore, and recovery. Congratulations! You have successfully completed the RMAN fundamentals and are now ready to explore it further and exploit this powerful tool in your own environment.

☑ Chapter 5 Mastery Check

1. What are some advantages of cold backups, and when would you use them?
2. What are disadvantages of cold backups?
3. Describe the difference between a logical and a physical backup.
4. Name three different types of backups.
5. What is the difference between an RMAN backup and an RMAN image copy?
6. Under what situations should redo logs be restored in a recovery situation?
7. Name three interfaces that can be used to perform a Data Pump Export and Import.
8. List some advantages of using RMAN.

9. Why would RMAN's recovery catalog be used rather than a control file to implement the repository?
10. Are there any disadvantages to an RMAN recovery catalog?
11. How can default settings be set up by you for future runs of RMAN?
12. What is an RMAN backup-set and how does it relate to a backup-piece?
13. Describe the ways in which corrupt blocks can be recovered.
14. What are some advantages to incremental image copies?
15. When performing a recovery from a hot backup, do all files and tablespaces need to be brought forward to the same point in time?