

Oracle Database 10g: Develop PL/SQL Program Units

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Contents

Preface

I Introduction

- Lesson Objectives I-2
- Course Objectives I-3
- Course Agenda I-4
- Human Resources (HR) Schema I-7
- Creating a Modularized and Layered Subprogram Design I-8
- Modularizing Development with PL/SQL Blocks I-9
- Review of Anonymous Blocks I-10
- Introduction to PL/SQL Procedures I-11
- Introduction to PL/SQL Functions I-12
- Introduction to PL/SQL Packages I-13
- Introduction to PL/SQL Triggers I-14
- PL/SQL Execution Environment I-15
- PL/SQL Development Environments I-16
- Coding PL/SQL in *iSQL*Plus* I-17
- Coding PL/SQL in SQL*Plus I-18
- Coding PL/SQL in Oracle JDeveloper I-19
- Summary I-20
- Practice I: Overview I-21

1 Creating Stored Procedures

- Objectives 1-2
- What Is a Procedure? 1-3
- Syntax for Creating Procedures 1-4
- Developing Procedures 1-5
- What Are Parameters? 1-6
- Formal and Actual Parameters 1-7
- Procedural Parameter Modes 1-8
- Using `IN` Parameters: Example 1-9
- Using `OUT` Parameters: Example 1-10
- Viewing `OUT` Parameters with *iSQL*Plus* 1-11
- Calling PL/SQL Using Host Variables 1-12
- Using `IN OUT` Parameters: Example 1-13

Syntax for Passing Parameters	1-14
Parameter Passing: Examples	1-15
Using the <code>DEFAULT</code> Option for Parameters	1-16
Summary of Parameter Modes	1-18
Invoking Procedures	1-19
Handled Exceptions	1-20
Handled Exceptions: Example	1-21
Exceptions Not Handled	1-22
Exceptions Not Handled: Example	1-23
Removing Procedures	1-24
Viewing Procedures in the Data Dictionary	1-25
Benefits of Subprograms	1-26
Summary	1-27
Practice 1: Overview	1-29

2 Creating Stored Functions

Objectives	2-2
Overview of Stored Functions	2-3
Syntax for Creating Functions	2-4
Developing Functions	2-5
Stored Function: Example	2-6
Ways to Execute Functions	2-7
Advantages of User-Defined Functions in SQL Statements	2-8
Function in SQL Expressions: Example	2-9
Locations to Call User-Defined Functions	2-10
Restrictions on Calling Functions from SQL Expressions	2-11
Controlling Side Effects When Calling Functions from SQL Expressions	2-12
Restrictions on Calling Functions from SQL: Example	2-13
Removing Functions	2-14
Viewing Functions in the Data Dictionary	2-15
Procedures Versus Functions	2-16
Summary	2-17
Practice 2: Overview	2-18

3 Creating Packages

Objectives	3-2
PL/SQL Packages: Overview	3-3
Components of a PL/SQL Package	3-4
Visibility of Package Components	3-5
Developing PL/SQL Packages	3-6
Creating the Package Specification	3-7
Example of Package Specification: <code>comm_pkg</code>	3-8
Creating the Package Body	3-9
Example of Package Body: <code>comm_pkg</code>	3-10
Invoking Package Subprograms	3-11
Creating and Using Bodiless Packages	3-12
Removing Packages	3-13
Viewing Packages in the Data Dictionary	3-14
Guidelines for Writing Packages	3-15
Advantages of Using Packages	3-16
Summary	3-18
Practice 3: Overview	3-20

4 Using More Package Concepts

Objectives	4-2
Overloading Subprograms	4-3
Overloading: Example	4-5
Overloading and the <code>STANDARD</code> Package	4-7
Using Forward Declarations	4-8
Package Initialization Block	4-10
Using Package Functions in SQL and Restrictions	4-11
Package Function in SQL: Example	4-12
Persistent State of Packages	4-13
Persistent State of Package Variables: Example	4-14
Persistent State of a Package Cursor	4-15
Executing <code>CURS_PKG</code>	4-16
Using PL/SQL Tables of Records in Packages	4-17
PL/SQL Wrapper	4-18
Running the Wrapper	4-19
Results of Wrapping	4-20
Guidelines for Wrapping	4-21
Summary	4-22
Practice 4: Overview	4-23

5 Using Oracle-Supplied Packages in Application Development

- Objectives 5-2
- Using Oracle-Supplied Packages 5-3
- List of Some Oracle-Supplied Packages 5-4
- How the DBMS_OUTPUT Package Works 5-5
- Interacting with Operating System Files 5-6
- File Processing Using the UTL_FILE Package 5-7
- Exceptions in the UTL_FILE Package 5-8
- FOPEN and IS_OPEN Function Parameters 5-9
- Using UTL_FILE: Example 5-10
- Generating Web Pages with the HTP Package 5-12
- Using the HTP Package Procedures 5-13
- Creating an HTML File with iSQL*Plus 5-14
- Using UTL_MAIL 5-15
- Installing and Using UTL_MAIL 5-16
- Sending E-Mail with a Binary Attachment 5-17
- Sending E-Mail with a Text Attachment 5-19
- DBMS_SCHEDULER Package 5-21
- Creating a Job 5-23
- Creating a Job with In-Line Parameters 5-24
- Creating a Job Using a Program 5-25
- Creating a Job for a Program with Arguments 5-26
- Creating a Job Using a Schedule 5-27
- Setting the Repeat Interval for a Job 5-28
- Creating a Job Using a Named Program and Schedule 5-29
- Managing Jobs 5-30
- Data Dictionary Views 5-31
- Summary 5-32
- Practice 5: Overview 5-33

6 Dynamic SQL and Metadata

- Objectives 6-2
- Execution Flow of SQL 6-3
- Dynamic SQL 6-4
- Native Dynamic SQL 6-5
- Using the EXECUTE IMMEDIATE Statement 6-6
- Dynamic SQL with a DDL Statement 6-7
- Dynamic SQL with DML Statements 6-8
- Dynamic SQL with a Single-Row Query 6-9
- Dynamic SQL with a Multirow Query 6-10

Declaring Cursor Variables	6-11
Dynamically Executing a PL/SQL Block	6-12
Using Native Dynamic SQL to Compile PL/SQL Code	6-13
Using the DBMS_SQL Package	6-14
Using DBMS_SQL with a DML Statement	6-15
Using DBMS_SQL with a Parameterized DML Statement	6-16
Comparison of Native Dynamic SQL and the DBMS_SQL Package	6-17
DBMS_METADATA Package	6-18
Metadata API	6-19
Subprograms in DBMS_METADATA	6-20
FETCH_XXX Subprograms	6-21
SET_FILTER Procedure	6-22
Filters	6-23
Examples of Setting Filters	6-24
Programmatic Use: Example 1	6-25
Programmatic Use: Example 2	6-27
Browsing APIs	6-29
Browsing APIs: Examples	6-30
Summary	6-32
Practice 6: Overview	6-33
7 Design Considerations for PL/SQL Code	
Objectives	7-2
Standardizing Constants and Exceptions	7-3
Standardizing Exceptions	7-4
Standardizing Exception Handling	7-5
Standardizing Constants	7-6
Local Subprograms	7-7
Definer's Rights Versus Invoker's Rights	7-8
Specifying Invoker's Rights	7-9
Autonomous Transactions	7-10
Features of Autonomous Transactions	7-11
Using Autonomous Transactions	7-12
RETURNING Clause	7-13
Bulk Binding	7-14
Using Bulk Binding	7-15
Bulk Binding FORALL: Example	7-16
Using BULK COLLECT INTO with Queries	7-18
Using BULK COLLECT INTO with Cursors	7-19
Using BULK COLLECT INTO with a RETURNING Clause	7-20

Using the `NOCOPY` Hint 7-21
Effects of the `NOCOPY` Hint 7-22
`NOCOPY` Hint Can Be Ignored 7-23
`PARALLEL_ENABLE` Hint 7-24
Summary 7-25
Practice 7: Overview 7-26

8 Managing Dependencies

Objectives 8-2
Understanding Dependencies 8-3
Dependencies 8-4
Local Dependencies 8-5
A Scenario of Local Dependencies 8-7
Displaying Direct Dependencies by Using `USER_DEPENDENCIES` 8-8
Displaying Direct and Indirect Dependencies 8-9
Displaying Dependencies 8-10
Another Scenario of Local Dependencies 8-11
A Scenario of Local Naming Dependencies 8-12
Understanding Remote Dependencies 8-13
Concepts of Remote Dependencies 8-15
`REMOTE_DEPENDENCIES_MODE` Parameter 8-16
Remote Dependencies and Time Stamp Mode 8-17
Remote Procedure B Compiles at 8:00 a.m. 8-19
Local Procedure A Compiles at 9:00 a.m. 8-20
Execute Procedure A 8-21
Remote Procedure B Recompiled at 11:00 a.m. 8-22
Execute Procedure A 8-23
Signature Mode 8-24
Recompiling a PL/SQL Program Unit 8-25
Unsuccessful Recompile 8-26
Successful Recompile 8-27
Recompilation of Procedures 8-28
Packages and Dependencies 8-29
Summary 8-31
Practice 8: Overview 8-32

9 Manipulating Large Objects

- Objectives 9-2
- What Is a LOB? 9-3
- Contrasting LONG and LOB Data Types 9-5
- Anatomy of a LOB 9-6
- Internal LOBs 9-7
- Managing Internal LOBs 9-8
- What Are BFILES? 9-9
- Securing BFILES 9-10
- A New Database Object: DIRECTORY 9-11
- Guidelines for Creating DIRECTORY Objects 9-12
- Managing BFILES 9-13
- Preparing to Use BFILES 9-14
- Populating BFILE Columns with SQL 9-15
- Populating a BFILE Column with PL/SQL 9-16
- Using DBMS_LOB Routines with BFILES 9-17
- Migrating from LONG to LOB 9-18
- DBMS_LOB Package 9-20
- DBMS_LOB.READ and DBMS_LOB.WRITE 9-23
- Initializing LOB Columns Added to a Table 9-24
- Populating LOB Columns 9-25
- Updating LOB by Using DBMS_LOB in PL/SQL 9-26
- Selecting CLOB Values by Using SQL 9-27
- Selecting CLOB Values by Using DBMS_LOB 9-28
- Selecting CLOB Values in PL/SQL 9-29
- Removing LOBs 9-30
- Temporary LOBs 9-31
- Creating a Temporary LOB 9-32
- Summary 9-33
- Practice 9: Overview 9-34

10 Creating Triggers

- Objectives 10-2
- Types of Triggers 10-3
- Guidelines for Designing Triggers 10-4
- Creating DML Triggers 10-5
- Types of DML Triggers 10-6
- Trigger Timing 10-7
- Trigger-Firing Sequence 10-8

Trigger Event Types and Body	10-10
Creating a DML Statement Trigger	10-11
Testing <code>SECURE_EMP</code>	10-12
Using Conditional Predicates	10-13
Creating a DML Row Trigger	10-14
Using <code>OLD</code> and <code>NEW</code> Qualifiers	10-15
Using <code>OLD</code> and <code>NEW</code> Qualifiers: Example Using <code>AUDIT_EMP</code>	10-16
Restricting a Row Trigger: Example	10-17
Summary of the Trigger Execution Model	10-18
Implementing an Integrity Constraint with a Trigger	10-19
<code>INSTEAD OF</code> Triggers	10-20
Creating an <code>INSTEAD OF</code> Trigger	10-21
Comparison of Database Triggers and Stored Procedures	10-24
Comparison of Database Triggers and Oracle Forms Triggers	10-25
Managing Triggers	10-26
Removing Triggers	10-27
Testing Triggers	10-28
Summary	10-29
Practice 10: Overview	10-30

11 Applications for Triggers

Objectives	11-2
Creating Database Triggers	11-3
Creating Triggers on DDL Statements	11-4
Creating Triggers on System Events	11-5
<code>LOGON</code> and <code>LOGOFF</code> Triggers: Example	11-6
<code>CALL</code> Statements	11-7
Reading Data from a Mutating Table	11-8
Mutating Table: Example	11-9
Benefits of Database Triggers	11-11
Managing Triggers	11-12
Business Application Scenarios for Implementing Triggers	11-13
Viewing Trigger Information	11-14
Using <code>USER_TRIGGERS</code>	11-15
Listing the Code of Triggers	11-16
Summary	11-17
Practice 11: Overview	11-18

12 Understanding and Influencing the PL/SQL Compiler

Objectives 12-2

Native and Interpreted Compilation 12-3

Features and Benefits of Native Compilation 12-4

Considerations When Using Native Compilation 12-5

Parameters Influencing Compilation 12-6

Switching Between Native and Interpreted Compilation 12-7

Viewing Compilation Information in the Data Dictionary 12-8

Using Native Compilation 12-9

Compiler Warning Infrastructure 12-10

Setting Compiler Warning Levels 12-11

Guidelines for Using `PLSQL_WARNINGS` 12-12`DBMS_WARNING` Package 12-13Using `DBMS_WARNING` Procedures 12-14Using `DBMS_WARNING` Functions 12-15Using `DBMS_WARNING`: Example 12-16

Summary 12-18

Practice 12: Overview 12-19

Appendix A: Practice Solutions**Appendix B: Table Descriptions and Data****Appendix C: Studies for Implementing Triggers****Appendix D: Review of PL/SQL****Appendix E: JDeveloper****Appendix F: Using SQL Developer****Index****Additional Practices****Additional Practice: Solutions****Additional Practices: Table Descriptions and Data**

Preface

Profile

Before You Begin This Course

Before you begin this course, you should have thorough knowledge of SQL and *iSQL*Plus*, as well as working experience in developing applications. Prerequisites are any of the following Oracle University courses or combinations of courses:

- *Oracle Database 10g: Introduction to SQL*
- *Oracle Database 10g: SQL Fundamentals I* and *Oracle Database 10g: SQL Fundamentals II*
- *Oracle Database 10g: SQL and PL/SQL Fundamentals*
- *Oracle Database 10g: PL/SQL Fundamentals*

How This Course Is Organized

Oracle Database 10g: Develop PL/SQL Program Units is an instructor-led course featuring lectures and hands-on exercises. Online demonstrations and practice sessions reinforce the concepts and skills that are introduced.

Related Publications

Oracle Publications

Title	Part Number
<i>Oracle Database Application Developer's Guide – Fundamentals (10g Release 1)</i>	<i>B10795-01</i>
<i>Oracle Database Application Developer's Guide – Large Objects (10g Release 1)</i>	<i>B10796-01</i>
<i>PL/SQL Packages and Types Reference (10g Release 1)</i>	<i>B10802-01</i>
<i>PL/SQL User's Guide and Reference (10g Release 1)</i>	<i>B10807-01</i>

Additional Publications

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

Typographic Conventions

Typographic Conventions in Text

Convention	Element	Example
Bold	Emphasized words and phrases in Web content only	To navigate within this application, do not click the Back and Forward buttons.
Bold italic	Glossary terms (if there is a glossary)	The <i>algorithm</i> inserts the new key.
Brackets	Key names	Press [Enter].
Caps and lowercase	Buttons, check boxes, triggers, windows	Click the Executable button. Select the Registration Required check box. Assign a When-Validate-Item trigger. Open the Master Schedule window.
Carets	Menu paths	Select File > Save.
Commas	Key sequences	Press and release these keys one at a time: [Alt], [F], [D]

Typographic Conventions (continued)

Typographic Conventions in Text (continued)

Convention	Object or Term	Example
Courier New, case sensitive	Code output, SQL and PL/SQL code elements, Java code elements, directory names, filenames, passwords, pathnames, URLs, user input, usernames	Code output: <code>debug.seti('I', 300);</code> SQL code elements: Use the <code>SELECT</code> command to view information stored in the <code>last_name</code> column of the <code>emp</code> table. Java code elements: Java programming involves the <code>String</code> and <code>StringBuffer</code> classes. Directory names: <code>bin</code> (DOS), <code>\$FMHOME</code> (UNIX) File names: Locate the <code>init.ora</code> file. Passwords: Use <code>tiger</code> as your password. Path names: Open <code>c:\my_docs\projects</code> . URLs: Go to <code>http://www.oracle.com</code> . User input: Enter <code>300</code> . Usernames: Log on as <code>scott</code> .
Initial cap	Graphics labels (unless the term is a proper noun)	Customer address (<i>but</i> Oracle Payables)
Italic	Emphasized words and phrases in print publications, titles of books and courses, variables	Do <i>not</i> save changes to the database. For further information, see <i>Oracle7 Server SQL Language Reference Manual</i> . Enter <u><i>user_id@us.oracle.com</i></u> , where <i>user_id</i> is the name of the user.
Plus signs	Key combinations	Press and hold these keys simultaneously: [Control] + [Alt] + [Delete]
Quotation marks	Lesson and chapter titles in cross references, interface elements with long names that have only initial caps	This subject is covered in Unit II, Lesson 3, “Working with Objects.” Select the “Include a reusable module component” and click Finish. Use the “WHERE clause of query” property.

Typographic Conventions (continued)

Typographic Conventions in Navigation Paths

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

Invoice Batch Summary

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

This simplified path translates to the following sequence of steps:

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

Notation:

(N) = Navigator	(I) = icon
(M) = menu	(H) = hyperlink
(T) = tab	(B) = button

I Introduction

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Lesson Objectives

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

- **Discuss the goals of the course**
- **Identify the modular components of PL/SQL:**
 - **Anonymous blocks**
 - **Procedures and functions**
 - **Packages**
- **Discuss the PL/SQL execution environment**
- **Describe the database schema and tables that are used in the course**
- **List the PL/SQL development environments that are available in the course**

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Lesson Aim

PL/SQL supports many program constructs. In this lesson, you review program units in the form of anonymous blocks, and you are introduced to named PL/SQL blocks. The named PL/SQL blocks are also referred to as subprograms. The named PL/SQL blocks include procedures and functions.

The tables from the Human Resources (HR) schema (which is used for the practices in this course) are briefly discussed. The development tools for writing, testing, and debugging PL/SQL are listed.

Course Objectives

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

- **Create, execute, and maintain:**
 - Procedures and functions with OUT parameters
 - Package constructs
 - Database triggers
- **Manage PL/SQL subprograms and triggers**
- **Use a subset of Oracle-supplied packages to:**
 - Generate screen, file, and Web output
 - Schedule PL/SQL jobs to run independently
- **Build and execute dynamic SQL statements**
- **Manipulate large objects (LOBs)**

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Course Objectives

You can develop modularized applications with database procedures by using database objects such as the following:

- Procedures and functions
- Packages
- Database triggers

Modular applications improve:

- Functionality
- Security
- Overall performance

Course Agenda

Lessons for day 1:

- I. Introduction
 1. Creating Stored Procedures
 2. Creating Stored Functions
 3. Creating Packages
 4. Using More Package Concepts

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Course Agenda

Lessons for day 2:

5. Using Oracle-Supplied Packages in Application Development
6. Dynamic SQL and Metadata
7. Design Considerations for PL/SQL Code
8. Managing Dependencies

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Course Agenda

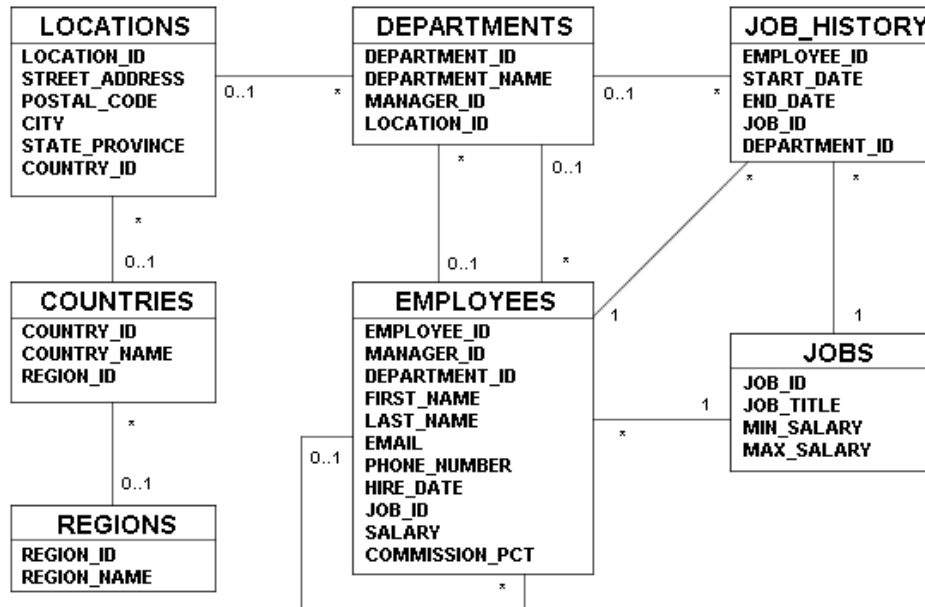
Lessons for day 3:

- 9. Manipulating Large Objects**
- 10. Creating Triggers**
- 11. Applications for Triggers**
- 12. Understanding and Influencing the PL/SQL Compiler**

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Human Resources (HR) Schema



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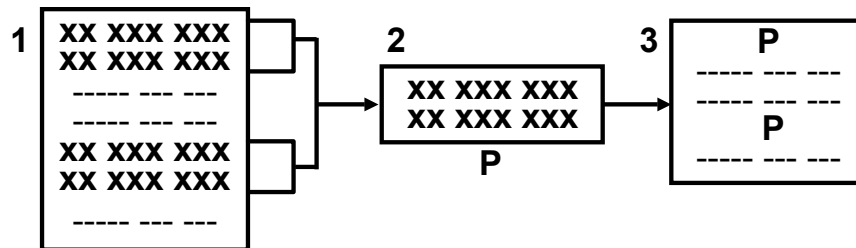
Human Resources (HR) Schema

The Human Resources (HR) schema is part of the Oracle Sample Schemas that can be installed in an Oracle database. The practice sessions in this course use data from the HR schema.

Table Descriptions

- REGIONS contains rows that represent a region such as Americas, Asia, and so on.
- COUNTRIES contains rows for countries, each of which is associated with a region.
- LOCATIONS contains the specific address of a specific office, warehouse, or production site of a company in a particular country.
- DEPARTMENTS shows details about the departments in which employees work. Each department may have a relationship representing the department manager in the EMPLOYEES table.
- EMPLOYEES contains details about each employee working for a department. Some employees may not be assigned to any department.
- JOBS contains the job types that can be held by each employee.
- JOB_HISTORY contains the job history of the employees. If an employee changes departments within a job or changes jobs within a department, then a new row is inserted into this table with the old job information of the employee.

Creating a Modularized and Layered Subprogram Design



- **Modularize code into subprograms.**
 1. Locate code sequences repeated more than once.
 2. Create subprogram P containing the repeated code.
 3. Modify original code to invoke the new subprogram.
- **Create subprogram layers for your application.**
 - Data access subprogram layer with SQL logic
 - Business logic subprogram layer, which may or may not use data access layer

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Creating a Modularized and Layered Subprogram Design

The diagram illustrates the principle of modularization with subprograms: the creation of smaller manageable pieces of flexible and reusable code. Flexibility is achieved by using subprograms with parameters, which in turn makes the same code reusable for different input values. To modularize existing code, perform the following steps:

1. Locate and identify repetitive sequences of code.
2. Move the repetitive code into a PL/SQL subprogram.
3. Replace the original repetitive code with calls to the new PL/SQL subprogram.

Subprogram Layers

Because PL/SQL allows SQL statements to be seamlessly embedded into the logic, it is too easy to have SQL statement spread all over the code. However, it is recommended that you keep the SQL logic separate from the business logic—that is, create a layered application design with a minimum of two layers:

- **Data access layer:** For subroutines to access the data by using SQL statements
- **Business logic layer:** For subprograms to implement the business processing rules, which may or may not call on the data access layer routines

Following this modular and layered approach can help you create code that is easier to maintain, particularly when the business rules change. In addition, keeping the SQL logic simple and free of complex business logic can benefit from the work of Oracle Database Optimizer, which can reuse parsed SQL statements for better use of server-side resources.

Modularizing Development with PL/SQL Blocks

- **PL/SQL is a block-structured language. The PL/SQL code block helps modularize code by using:**
 - Anonymous blocks
 - Procedures and functions
 - Packages
 - Database triggers
- **The benefits of using modular program constructs are:**
 - Easy maintenance
 - Improved data security and integrity
 - Improved performance
 - Improved code clarity

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Modularizing Development with PL/SQL Blocks

A subprogram is based on standard PL/SQL structures. It contains a declarative section, an executable section, and an optional exception-handling section (for example, anonymous blocks, procedures, functions, packages, and triggers). Subprograms can be compiled and stored in the database, providing modularity, extensibility, reusability, and maintainability. Modularization converts large blocks of code into smaller groups of code called modules. After modularization, the modules can be reused by the same program or shared with other programs. It is easier to maintain and debug code that comprises smaller modules than it is to maintain code in a single large program. Modules can be easily extended for customization by incorporating more functionality, if required, without affecting the remaining modules of the program.

Subprograms provide easy maintenance because the code is located in one place and any modifications required to the subprogram can therefore be performed in this single location. Subprograms provide improved data integrity and security. The data objects are accessed through the subprogram, and a user can invoke the subprogram only if the appropriate access privilege is granted to the user.

Note: Knowing how to develop anonymous blocks is a prerequisite for this course. For detailed information about anonymous blocks, see the course titled *Oracle 10g: PL/SQL Fundamentals*.

Review of Anonymous Blocks

Anonymous blocks:

- Form the basic PL/SQL block structure
- Initiate PL/SQL processing tasks from applications
- Can be nested within the executable section of any PL/SQL block

```
[DECLARE      -- Declaration Section (Optional)
  variable declarations; ... ]
BEGIN          -- Executable Section (Mandatory)
  SQL or PL/SQL statements;
[EXCEPTION    -- Exception Section (Optional)
  WHEN exception THEN statements; ]
END;          -- End of Block (Mandatory)
```

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Review of Anonymous Blocks

Anonymous blocks are typically used for:

- Writing trigger code for Oracle Forms components
- Initiating calls to procedures, functions, and package constructs
- Isolating exception handling within a block of code
- Nesting inside other PL/SQL blocks for managing code flow control

The DECLARE keyword is optional, but it is required if you declare variables, constants, and exceptions to be used within the PL/SQL block.

BEGIN and END are mandatory and require at least one statement between them, either SQL, PL/SQL, or both.

The exception section is optional and is used to handle errors that occur within the scope of the PL/SQL block. Exceptions can be propagated to the caller of the anonymous block by excluding an exception handler for the specific exception, thus creating what is known as an *unhandled* exception.

Introduction to PL/SQL Procedures

Procedures are named PL/SQL blocks that perform a sequence of actions.

```
CREATE PROCEDURE getemp IS -- header
  emp_id  employees.employee_id%type;
  lname   employees.last_name%type;
BEGIN
  emp_id := 100;
  SELECT last_name INTO lname
  FROM EMPLOYEES
  WHERE employee_id = emp_id;
  DBMS_OUTPUT.PUT_LINE('Last name: ' || lname);
END;
/
```

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Introduction to PL/SQL Procedures

A procedure is a named PL/SQL block that is created by using a CREATE PROCEDURE statement. When called or invoked, a procedure performs a sequence of actions. The anatomy of the procedure includes:

- **The header:** “PROCEDURE getemp IS”
- **The declaration section:** With variable declarations emp_id and lname
- **The executable section:** Contains the PL/SQL and SQL statements used to obtain the last name of employee 100. The executable section makes use of the DBMS_OUTPUT package to print the last name of the employee.
- **The exception section:** Optional and not used in the example

Note: Hard-coding the value of 100 for emp_id is inflexible. The procedure would be more reusable if used as a parameter to obtain the employee ID value. Using parameters is covered in the lesson titled “Creating Stored Procedures.”

To call a procedure by using an anonymous block, use the following:

```
BEGIN
  getemp;
END;
```

Introduction to PL/SQL Functions

Functions are named PL/SQL blocks that perform a sequence of actions and return a value. A function can be invoked from:

- **Any PL/SQL block**
- **A SQL statement (subject to some restrictions)**

```
CREATE FUNCTION avg_salary RETURN NUMBER IS
    avg_sal employees.salary%type;
BEGIN
    SELECT AVG(salary) INTO avg_sal
    FROM EMPLOYEES;
    RETURN avg_sal;
END;
/
```

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Introduction to PL/SQL Functions

A function is a named PL/SQL block that is created with a CREATE FUNCTION statement. Functions are used to compute a value that must be returned to the caller.

PL/SQL functions follow the same block structure as procedures. However, the header starts with the keyword FUNCTION followed by the function name. The header includes the return data type after the function name (using the keyword RETURN followed by the data type). The example declares a variable called avg_sal in the declaration section, and uses the RETURN statement to return the value retrieved from the SELECT statement. The value returned represents the average salary for all employees.

A function can be called from:

- Another PL/SQL block where its return value can be stored in a variable or supplied as a parameter to a procedure
- A SQL statement, subject to restrictions (This topic is covered in the lesson titled “Creating Stored Functions.”)

To call a function from an anonymous block, use the following:

```
BEGIN
    dbms_output.put_line('Average Salary: ' ||
        avg_salary);
END;
```


Introduction to PL/SQL Packages

PL/SQL packages have a specification and an optional body. Packages group related subprograms together.

```
CREATE PACKAGE emp_pkg IS
  PROCEDURE getemp;
  FUNCTION avg_salary RETURN NUMBER;
END emp_pkg;
/
CREATE PACKAGE BODY emp_pkg IS
  PROCEDURE getemp IS ...
  BEGIN ... END;

  FUNCTION avg_salary RETURN NUMBER IS ...
  BEGIN ... RETURN avg_sal; END;
END emp_pkg;
/
```

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Introduction to PL/SQL Packages

A PL/SQL package is typically made up of two parts:

- A package specification declaring the public (accessible) components of the package
- A package body that implements public and private components of the package

A package is used to group related PL/SQL code and constructs together. This helps developers manage and maintain related code in one place. Packages are powerful constructs and provide a way to logically modularize code into application-specific or functional groups.

The example declares a package called `emp_package` that comprises a procedure `getemp` and a function `avg_salary`. The specification defines the procedure and function heading. The package body provides the full implementation of the procedure and function declared in the package specification. The example is incomplete but provides an introduction to the concept of a PL/SQL package. The details about PL/SQL packages are covered in the lesson titled “Creating Packages.”

To call the package procedure from an anonymous block, use the following:

```
BEGIN
  emp_pkg.getemp;
END;
```

Introduction to PL/SQL Triggers

PL/SQL triggers are code blocks that execute when a specified application, database, or table event occurs.

- Oracle Forms application triggers are standard anonymous blocks.
- Oracle database triggers have a specific structure.

```
CREATE TRIGGER check_salary
BEFORE INSERT OR UPDATE ON employees
FOR EACH ROW
DECLARE
  c_min constant number(8,2) := 1000.0;
  c_max constant number(8,2) := 500000.0;
BEGIN
  IF :new.salary > c_max OR
     :new.salary < c_min THEN
    RAISE_APPLICATION_ERROR(-20000,
      'New salary is too small or large');
  END IF;
END;
/
```

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Introduction to PL/SQL Triggers

A trigger is a PL/SQL block that executes when a particular event occurs.

A PL/SQL trigger has two forms:

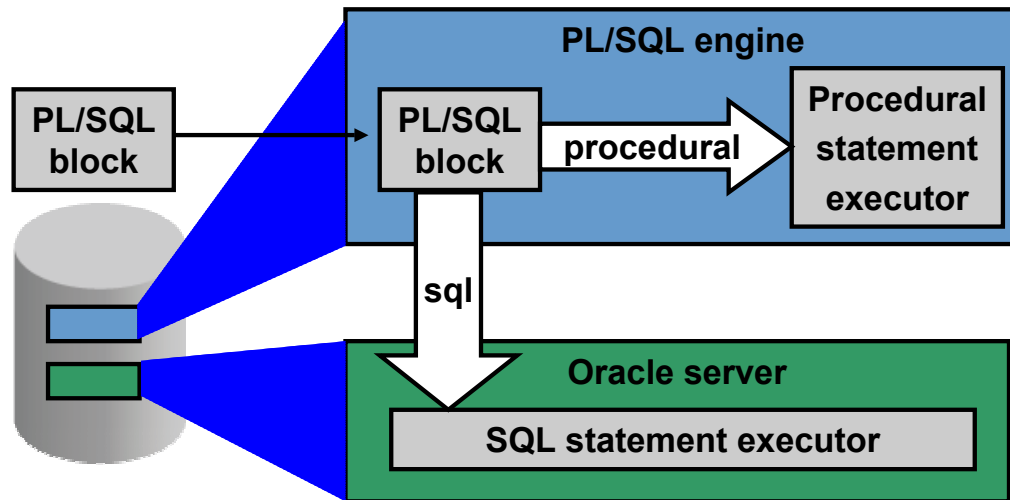
- **Application trigger:** Block of code that executes when a nominated application event occurs in an Oracle Forms execution environment
- **Database trigger:** Named block of code that is associated and executes when a nominated database or table event occurs

The `check_salary` trigger example shows a database trigger that executes before either an `INSERT` or an `UPDATE` operation occurs on the `EMPLOYEES` table. The trigger code checks whether the `salary` column value is within an acceptable range. If the value is outside the specified range, the code uses the `RAISE_APPLICATION_ERROR` built-in procedure to fail the operation. The `:new` syntax, which is used in the example, is a special bind/host variable that can be used in row-level triggers.

Triggers are covered in detail in the lesson titled “Creating Triggers.”

PL/SQL Execution Environment

The PL/SQL run-time architecture:



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PL/SQL Execution Environment

The diagram shows a PL/SQL block being executed by the PL/SQL engine. The PL/SQL engine resides in:

- The Oracle database for executing stored subprograms
- The Oracle Forms client when running client/server applications, or in the Oracle Application Server when using Oracle Forms Services to run Forms on the Web

Irrespective of the PL/SQL run-time environment, the basic architecture remains the same. Therefore, all PL/SQL statements are processed in the Procedural Statement Executor, and all SQL statements must be sent to the SQL Statement Executor for processing by the Oracle server processes.

The PL/SQL engine is a virtual machine that resides in memory and processes the PL/SQL m-code instructions. When the PL/SQL engine encounters a SQL statement, a context switch is made to pass the SQL statement to the Oracle server processes. The PL/SQL engine waits for the SQL statement to complete and for the results to be returned before it continues to process subsequent statements in the PL/SQL block.

The Oracle Forms PL/SQL engine runs in the client for the client/server implementation, and in the application server for the Forms Services implementation. In either case, SQL statements are typically sent over a network to an Oracle server for processing.

PL/SQL Development Environments

This course provides the following tools for developing PL/SQL code:

- **Oracle SQL*Plus (GUI or command-line versions)**
- **Oracle iSQL*Plus (used from a browser)**
- **Oracle JDeveloper IDE**

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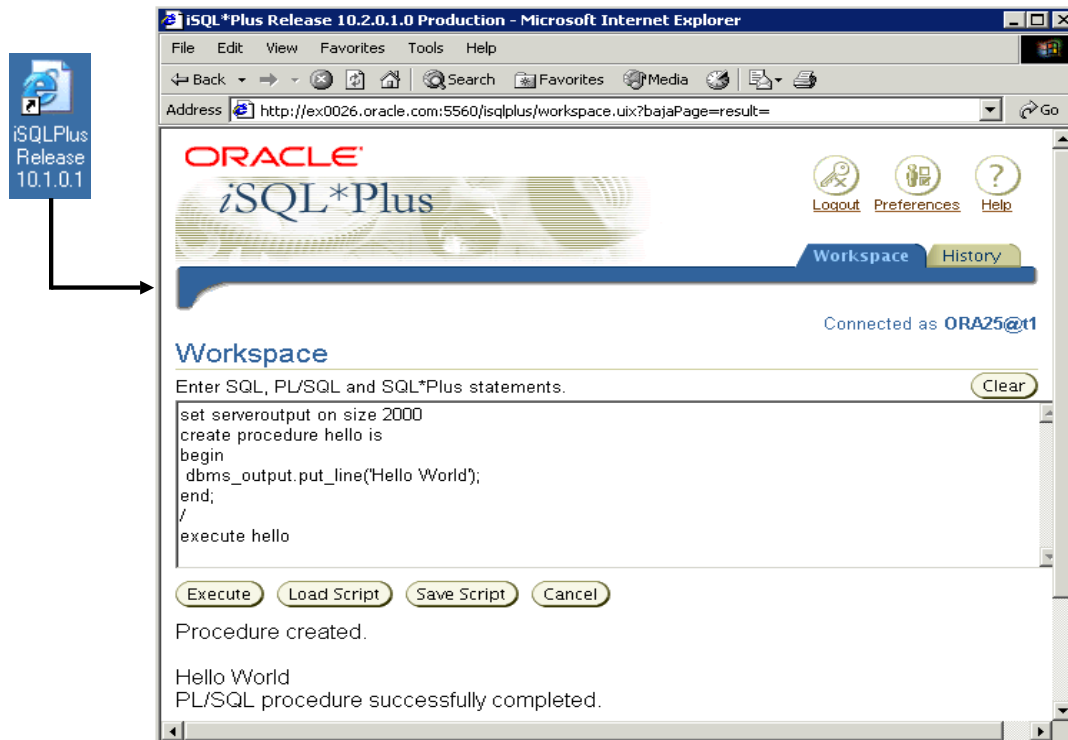
PL/SQL Development Environments

There are many tools that provide an environment for developing PL/SQL code. Oracle provides several tools that can be used to write PL/SQL code. Some of the development tools that are available for use in this course are:

- Oracle iSQL*Plus: A browser-based application
- Oracle SQL*Plus: A window or command-line application
- Oracle JDeveloper: A window-based integrated development environment (IDE)

Note: The code and screen examples presented in the course notes were generated from output in the iSQL*Plus environment.

Coding PL/SQL in *iSQL*Plus*



Coding PL/SQL in *iSQL*Plus*

Oracle *iSQL*Plus* is a Web application that allows you to submit SQL statements and PL/SQL blocks for execution and receive the results in a standard Web browser.

*iSQL*Plus* is:

- Shipped with the database
- Installed in the middle tier
- Accessed from a Web browser by using a URL format that is similar to the following example:

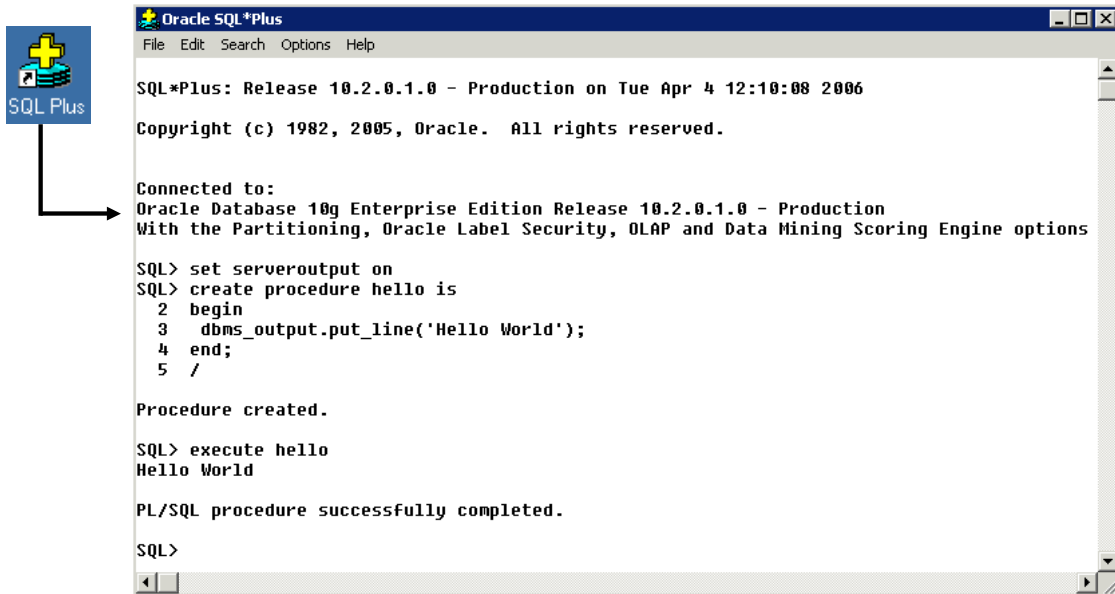
`http://host:port/isqlplus`

The host and port are for the Web server name and HTTP listener port.

When coding PL/SQL subprograms in the *iSQL*Plus* tool, consider the following:

- You create subprograms by using the `CREATE SQL` statement.
- You execute subprograms by using either an anonymous PL/SQL block or the `EXECUTE` command.
- If you use the `DBMS_OUTPUT` package procedures to print text to the screen, you must first execute the `SET SERVEROUTPUT ON` command in your session.

Coding PL/SQL in SQL*Plus



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Coding PL/SQL in SQL*Plus

Oracle SQL*Plus is a graphical user interface (GUI) or command-line application that enables you to submit SQL statements and PL/SQL blocks for execution and receive the results in an application or command window.

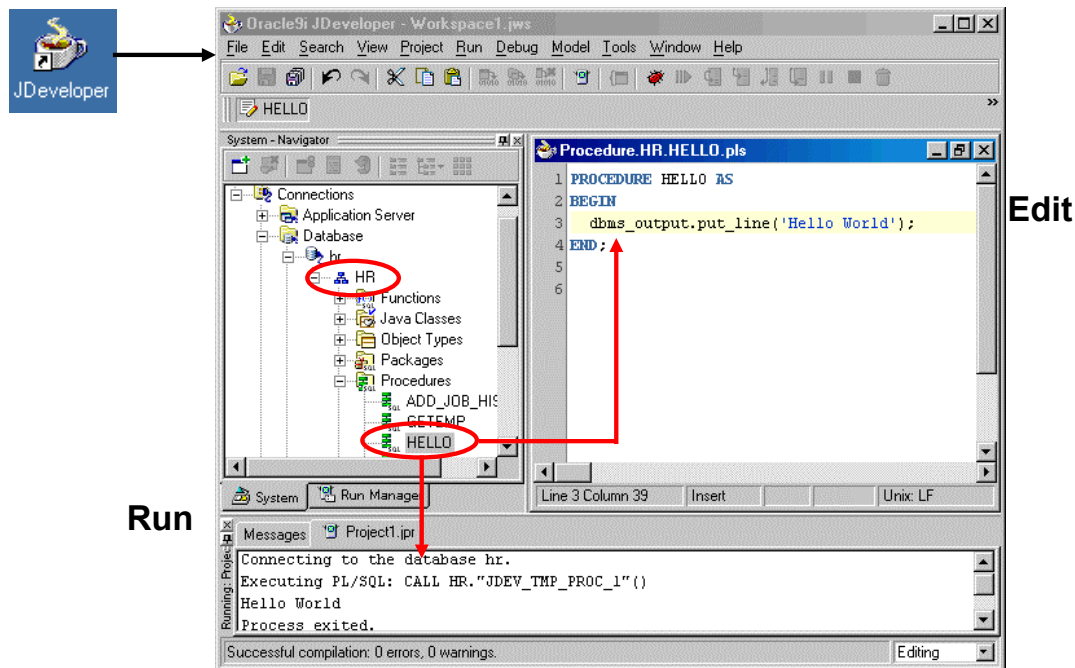
SQL*Plus is:

- Shipped with the database
- Installed on a client and on the database server system
- Accessed from an icon or the command line

When coding PL/SQL subprograms using SQL*Plus, consider the following:

- You create subprograms by using the CREATE SQL statement.
- You execute subprograms by using either an anonymous PL/SQL block or the EXECUTE command.
- If you use the DBMS_OUTPUT package procedures to print text to the screen, you must first execute the SET SERVEROUTPUT ON command in your session.

Coding PL/SQL in Oracle JDeveloper



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Coding PL/SQL in Oracle JDeveloper

Oracle JDeveloper allows developers to create, edit, test, and debug PL/SQL code by using a sophisticated GUI. Oracle JDeveloper is a part of Oracle Developer Suite and is also available as a separate product.

When coding PL/SQL in JDeveloper, consider the following:

- You first create a database connection to enable JDeveloper to access a database schema owner for the subprograms.
- You can then use the JDeveloper context menus on the Database connection to create a new subprogram construct using the built-in JDeveloper Code Editor. The JDeveloper Code Editor provides an excellent environment for PL/SQL development, with features such as the following:
 - Different colors for syntactical components of the PL/SQL language
 - Code insight to rapidly locate procedures and functions in supplied packages
- You invoke a subprogram by using a Run command on the context menu for the named subprogram. The output appears in the JDeveloper Log Message window, as shown in the lower portion of the screenshot.

Note: JDeveloper provides color-coding syntax in the JDeveloper Code Editor and is sensitive to PL/SQL language constructs and statements.

Summary

In this lesson, you should have learned how to:

- **Declare named PL/SQL blocks, including procedures, functions, packages, and triggers**
- **Use anonymous (unnamed) PL/SQL blocks to invoke stored procedures and functions**
- **Use *iSQL*Plus* or *SQL*Plus* to develop PL/SQL code**
- **Explain the PL/SQL execution environment:**
 - **The client-side PL/SQL engine for executing PL/SQL code in Oracle Forms and Oracle Reports**
 - **The server-side PL/SQL engine for executing PL/SQL code stored in an Oracle database**

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Summary

The PL/SQL language provides different program constructs for blocks of reusable code. Unnamed or anonymous PL/SQL blocks can be used to invoke SQL and PL/SQL actions, procedures, functions, and package components. Named PL/SQL blocks, otherwise known as subprograms, include:

- Procedures
- Functions
- Package procedures and functions
- Triggers

Oracle supplies several tools to develop your PL/SQL functionality. Oracle provides a client-side or middle-tier PL/SQL run-time environment for Oracle Forms and Oracle Reports, and provides a PL/SQL run-time engine inside the Oracle database. Procedures and functions inside the database can be invoked from any application code that can connect to an Oracle database and execute PL/SQL code.

Practice I: Overview

This practice covers the following topics:

- **Browsing the HR tables**
- **Creating a simple PL/SQL procedure**
- **Creating a simple PL/SQL function**
- **Using an anonymous block to execute the PL/SQL procedure and function**

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Practice I: Overview

In this practice, you use *iSQL*Plus* to execute SQL statements to examine data in the HR schema. You also create a simple procedure and function that you invoke by using an anonymous block or the EXECUTE command in *iSQL*Plus*. Optionally, you can experiment by creating and executing the PL/SQL code in SQL*Plus.

Note: All written practices use *iSQL*Plus* as the development environment. However, you can use any of the tools that are provided in your course environment.

Practice I

1. Launch *iSQL*Plus* using the icon that is provided on your desktop.
 - a. Log in to the database by using the username and database connect string details provided by your instructor (you may optionally write the information here for your records):
Username: **ora**____
Password: **oracle**
Database Connect String/Tnsname: **T**____
 - b. Execute basic `SELECT` statements to query the data in the `DEPARTMENTS`, `EMPLOYEES`, and `JOBS` tables. Take a few minutes to familiarize yourself with the data, or consult Appendix B, which provides a description and some data from each table in the Human Resources schema.
2. Create a procedure called `HELLO` to display the text `Hello World`.
 - a. Create a procedure called `HELLO`.
 - b. In the executable section, use the `DBMS_OUTPUT.PUT_LINE` procedure to print the text `Hello World`, and save the code in the database.
Note: If you get compile-time errors, correct the PL/SQL code and replace the `CREATE` keyword with the text `CREATE OR REPLACE`.
 - c. Execute the `SET SERVEROUTPUT ON` command to ensure that the output from the `DBMS_OUTPUT.PUT_LINE` procedure is displayed in *iSQL*Plus*.
 - d. Create an anonymous block to invoke the stored procedure.
3. Create a function called `TOTAL_SALARY` to compute the sum of all employee salaries.
 - a. Create a function called `TOTAL_SALARY` that returns a `NUMBER`.
 - b. In the executable section, execute a query to store the total salary of all employees in a local variable that you declare in the declaration section. Return the value stored in the local variable. Save and compile the code.
 - c. Use an anonymous block to invoke the function. To display the result computed by the function, use the `DBMS_OUTPUT.PUT_LINE` procedure.
Hint: Either nest the function call inside the `DBMS_OUTPUT.PUT_LINE` parameter, or store the function result in a local variable of the anonymous block and use the local variable in the `DBMS_OUTPUT.PUT_LINE` procedure.

If you have time, complete the following exercise:

4. Launch *SQL*Plus* using the icon that is provided on your desktop.
 - a. Invoke the procedure and function that you created in exercises 2 and 3.
 - b. Create a new procedure called `HELLO_AGAIN` to print `Hello World` again.
 - c. Invoke the `HELLO_AGAIN` procedure with an anonymous block.

1

Creating Stored Procedures

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Objectives

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

- **Describe and create a procedure**
- **Create procedures with parameters**
- **Differentiate between formal and actual parameters**
- **Use different parameter-passing modes**
- **Invoke a procedure**
- **Handle exceptions in procedures**
- **Remove a procedure**

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Lesson Aim

In this lesson, you learn to create, execute, and remove procedures with or without parameters. Procedures are the foundation of modular programming in PL/SQL. To make procedures more flexible, it is important that varying data is either calculated or passed into a procedure by using input parameters. Calculated results can be returned to the caller of a procedure by using OUT parameters.

To make your programs robust, you should always manage exception conditions by using the exception-handling features of PL/SQL.

What Is a Procedure?

A procedure:

- **Is a type of subprogram that performs an action**
- **Can be stored in the database as a schema object**
- **Promotes reusability and maintainability**

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Definition of a Procedure

A procedure is a named PL/SQL block that can accept parameters (sometimes referred to as arguments). Generally, you use a procedure to perform an action. It has a header, a declaration section, an executable section, and an optional exception-handling section. A procedure is invoked by using the procedure name in the execution section of another PL/SQL block.

A procedure is compiled and stored in the database as a schema object. If you are using the procedures with Oracle Forms and Reports, then they can be compiled within the Oracle Forms or Oracle Reports executables.

Procedures promote reusability and maintainability. When validated, they can be used in any number of applications. If the requirements change, only the procedure needs to be updated.

Syntax for Creating Procedures

- Use **CREATE PROCEDURE** followed by the name, optional parameters, and keyword **IS** or **AS**.
- Add the **OR REPLACE** option to overwrite an existing procedure.
- Write a **PL/SQL block** containing local variables, a **BEGIN** statement, and an **END** statement (or **END procedure_name**).

```
CREATE [OR REPLACE] PROCEDURE procedure_name
  [(parameter1 [mode] datatype1,
    parameter2 [mode] datatype2, ...)]
IS|AS
  [local_variable_declarations; ...]
BEGIN
  -- actions;
END [procedure_name];
```

→ PL/SQL Block

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Syntax for Creating Procedures

You create new procedures with the **CREATE PROCEDURE** statement, which may declare a list of parameters and must define the actions to be performed by the standard PL/SQL block. The **CREATE** clause enables you to create stand-alone procedures that are stored in an Oracle database.

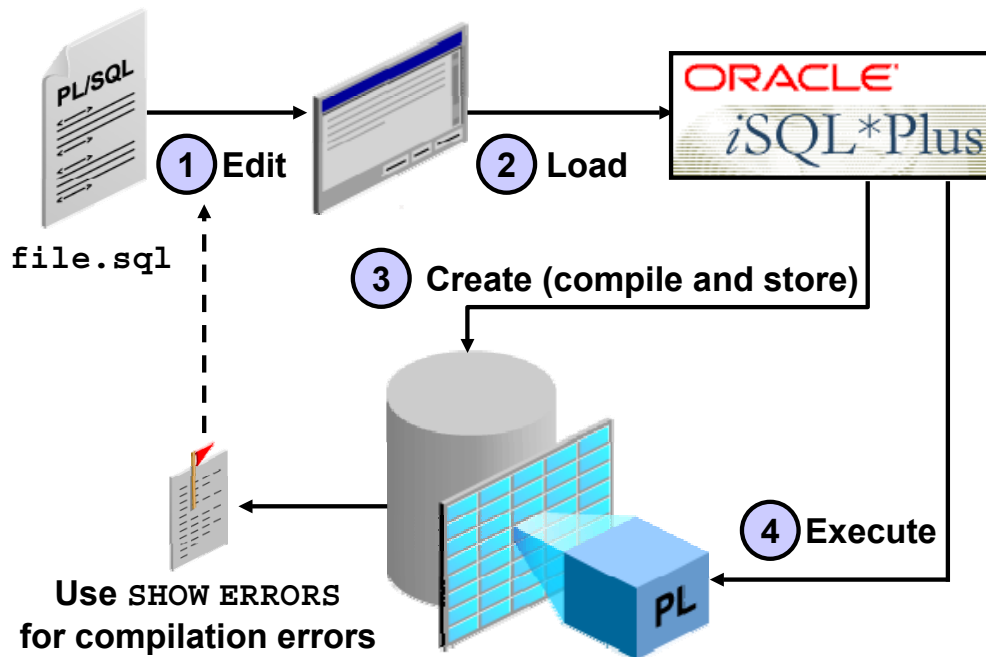
- PL/SQL blocks start with **BEGIN**, optionally preceded by the declaration of local variables. PL/SQL blocks end with either **END** or **END procedure_name**.
- The **REPLACE** option indicates that if the procedure exists, it is dropped and replaced with the new version created by the statement.

Other Syntactic Elements

- *parameter1* represents the name of a parameter.
- The *mode* option defines how a parameter is used: **IN** (default), **OUT**, or **IN OUT**.
- *datatype1* specifies the parameter data type, without any precision.

Note: Parameters can be considered as local variables. Substitution and host (bind) variables cannot be referenced anywhere in the definition of a PL/SQL stored procedure. The **OR REPLACE** option does not require any change in object security, as long as you own the object and have the **CREATE [ANY] PROCEDURE** privilege.

Developing Procedures



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Developing Procedures

To develop a stored procedure, perform the following steps:

1. Write the code to create a procedure in an editor or a word processor, and then save it as a SQL script file (typically with an `.sql` extension).
2. Load the code into one of the development tools such as SQL*Plus or *iSQL*Plus*.
3. Create the procedure in the database. The `CREATE PROCEDURE` statement compiles and stores source code and the compiled *m-code* in the database. If compilation errors exist, then the *m-code* is not stored and you must edit the source code to make corrections. You cannot invoke a procedure that contains compilation errors. To view the compilation errors in SQL*Plus or *iSQL*Plus*, use:
 - `SHOW ERRORS` for the most recently (last) compiled procedure
 - `SHOW ERRORS PROCEDURE procedure_name` for any procedure compiled previously
4. After successful compilation, execute the procedure to perform the desired action. Use the `EXECUTE` command from *iSQL*Plus* or an anonymous PL/SQL block from environments that support PL/SQL.

Note: If compilation errors occur, use a `CREATE OR REPLACE PROCEDURE` statement to overwrite the existing code if you previously used a `CREATE PROCEDURE` statement. Otherwise, `DROP` the procedure first and then execute the `CREATE PROCEDURE` statement.

What Are Parameters?

Parameters:

- **Are declared after the subprogram name in the PL/SQL header**
- **Pass or communicate data between the caller and the subprogram**
- **Are used like local variables but are dependent on their parameter-passing mode:**
 - **An IN parameter (the default) provides values for a subprogram to process.**
 - **An OUT parameter returns a value to the caller.**
 - **An IN OUT parameter supplies an input value, which may be returned (output) as a modified value.**

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What Are Parameters?

Parameters are used to transfer data values to and from the calling environment and the procedure (or subprogram). Parameters are declared in the subprogram header, after the name and before the declaration section for local variables.

Parameters are subject to one of the three parameter-passing modes: IN, OUT, or IN OUT.

- An IN parameter passes a constant value from the calling environment into the procedure.
- An OUT parameter passes a value from the procedure to the calling environment.
- An IN OUT parameter passes a value from the calling environment to the procedure and a possibly different value from the procedure back to the calling environment using the same parameter.

Parameters can be thought of as a special form of local variable, whose input values are initialized by the calling environment when the subprogram is called, and whose output values are returned to the calling environment when the subprogram returns control to the caller.

Formal and Actual Parameters

- **Formal parameters:** Local variables declared in the parameter list of a subprogram specification

Example:

```
CREATE PROCEDURE raise_sal(id NUMBER,sal NUMBER) IS
BEGIN ...
END raise_sal;
```

- **Actual parameters:** Literal values, variables, and expressions used in the parameter list of the called subprogram

Example:

```
emp_id := 100;
raise_sal(emp_id, 2000)
```

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Formal and Actual Parameters

Formal parameters are local variables that are declared in the parameter list of a subprogram specification. In the first example, in the `raise_sal` procedure, the variable `id` and `sal` identifiers represent the formal parameters.

The actual parameters can be literal values, variables, and expressions that are provided in the parameter list of a called subprogram. In the second example, a call is made to `raise_sal`, where the `emp_id` variable provides the actual parameter value for the `id` formal parameter and `2000` is supplied as the actual parameter value for `sal`. Actual parameters:

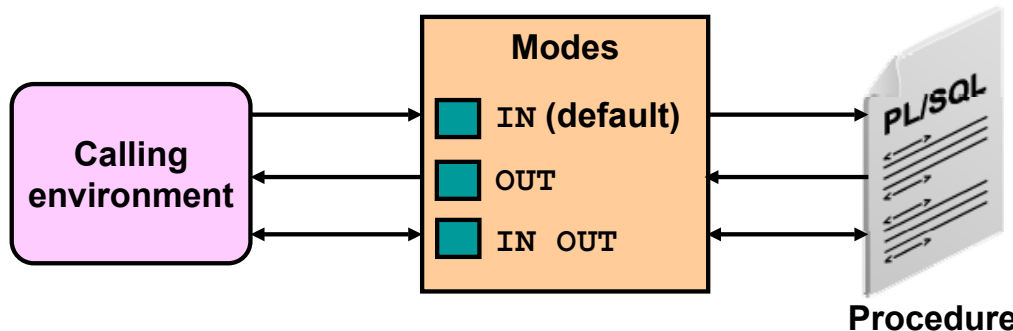
- Are associated with formal parameters during the subprogram call
- Can also be expressions, as in the following example:
`raise_sal(emp_id, raise+100);`

The formal and actual parameters should be of compatible data types. If necessary, before assigning the value, PL/SQL converts the data type of the actual parameter value to that of the formal parameter.

Procedural Parameter Modes

- Parameter modes are specified in the formal parameter declaration, after the parameter name and before its data type.
- The **IN** mode is the default if no mode is specified.

```
CREATE PROCEDURE procedure(param [mode] datatype)  
...
```



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Procedural Parameter Modes

When you create the procedure, the formal parameter defines a variable name whose value is used in the executable section of the PL/SQL block. The actual parameter is used when invoking the procedure to provide input values or receive output results.

The parameter mode **IN** is the default passing mode—that is, if no mode is specified with a parameter declaration, the parameter is considered to be an **IN** parameter. The parameter modes **OUT** and **IN OUT** must be explicitly specified in their parameter declarations.

The *datatype* parameter is specified without a size specification. It can be specified:

- As an explicit data type
- Using the `%TYPE` definition
- Using the `%ROWTYPE` definition

Note: One or more formal parameters can be declared, with each separated by a comma.

Using IN Parameters: Example

```
CREATE OR REPLACE PROCEDURE raise_salary
(id      IN employees.employee_id%TYPE,
 percent IN NUMBER)
IS
BEGIN
    UPDATE employees
    SET    salary = salary * (1 + percent/100)
    WHERE employee_id = id;
END raise_salary;
/
```

```
EXECUTE raise_salary(176,10)
```

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Using IN Parameters: Example

The example shows a procedure with two IN parameters. Running this first statement in *iSQL*Plus* creates the `raise_salary` procedure in the database. The second example invokes `raise_salary` and provides the first parameter value of 176 for the employee ID, and a percentage salary increase of 10 percent for the second parameter value.

To invoke a procedure in *iSQL*Plus*, use the following EXECUTE command:

```
EXECUTE raise_salary (176, 10)
```

To invoke a procedure from another procedure, use a direct call inside an executable section of the calling block. At the location of calling the new procedure, enter the procedure name and actual parameters. For example:

```
...
BEGIN
    raise_salary (176, 10);
END;
```

Note: IN parameters are passed as read-only values from the calling environment into the procedure. Attempts to change the value of an IN parameter result in a compile-time error.

Using OUT Parameters: Example

```
CREATE OR REPLACE PROCEDURE query_emp
(id      IN  employees.employee_id%TYPE,
 name    OUT employees.last_name%TYPE,
 salary  OUT employees.salary%TYPE) IS
BEGIN
  SELECT  last_name, salary INTO name, salary
  FROM    employees
  WHERE   employee_id = id;
END query_emp;
```

```
DECLARE
  emp_name employees.last_name%TYPE;
  emp_sal  employees.salary%TYPE;
BEGIN
  query_emp(171, emp_name, emp_sal); ...
END;
```

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Using OUT Parameters: Example

In this example, you create a procedure with OUT parameters to retrieve information about an employee. The procedure accepts the value 171 for employee ID and retrieves the name and salary of the employee with ID 171 into the two OUT parameters. The `query_emp` procedure has three formal parameters. Two of them are OUT parameters that return values to the calling environment, shown in the code box in the lower portion of the slide. The procedure accepts an employee ID value through the `id` parameter. The `emp_name` and `emp_salary` variables are populated with the information retrieved from the query into their two corresponding OUT parameters.

If you print the values returned into PL/SQL variables of the calling block shown in the second block of code, then the variables contain the following:

- `emp_name` holds the value Smith.
- `emp_salary` holds the value 7600.

Note: Make sure that the data type for the actual parameter variables used to retrieve values from OUT parameters has a size sufficient to hold the data values being returned.

Attempting to use or read OUT parameters inside the procedure that declares them results in a compilation error. The OUT parameters can be assigned values only in the body of the procedure in which they are declared.

Viewing OUT Parameters with *iSQL*Plus*

- Use PL/SQL variables that are printed with calls to the `DBMS_OUTPUT.PUT_LINE` procedure.

```
SET SERVEROUTPUT ON
DECLARE
    emp_name employees.last_name%TYPE;
    emp_sal   employees.salary%TYPE;
BEGIN
    query_emp(171, emp_name, emp_sal);
    DBMS_OUTPUT.PUT_LINE('Name: ' || emp_name);
    DBMS_OUTPUT.PUT_LINE('Salary: ' || emp_sal);
END;
```

- Use *iSQL*Plus* host variables, execute `QUERY_EMP` using host variables, and print the host variables.

```
VARIABLE name VARCHAR2(25)
VARIABLE sal NUMBER
EXECUTE query_emp(171, :name, :sal)
PRINT name sal
```

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Viewing OUT Parameters with *iSQL*Plus*

The examples show two ways to view the values returned from OUT parameters.

- The first technique uses PL/SQL variables in an anonymous block to retrieve the OUT parameter values. The `DBMS_OUTPUT.PUT_LINE` procedure is called to print the values held in the PL/SQL variables. The `SET SERVEROUTPUT` must be ON.
- The second technique shows how to use *iSQL*Plus* variables that are created using the `VARIABLE` command. The *iSQL*Plus* variables are external to the PL/SQL block and are known as host or bind variables. To reference host variables from a PL/SQL block, you must prefix their names with a colon (:). To display the values stored in the host variables, you must use the *iSQL*Plus* `PRINT` command followed by the name of the *iSQL*Plus* variable (without the colon because this is not a PL/SQL command or context).

To use *iSQL*Plus* and host variables when calling a procedure with OUT parameters, perform the following steps:

1. Create an *iSQL*Plus* script file by using an editor.
2. Add commands to create the variables, execute the procedure, and print the variables.
3. Load and execute the *iSQL*Plus* script file.

Note: For details about the `VARIABLE` command, see the *iSQL*Plus* Command Reference.

Calling PL/SQL Using Host Variables

A host variable (also known as a *bind* or a *global* variable):

- **Is declared and exists externally to the PL/SQL subprogram. A host variable can be created in:**
 - *iSQL*Plus* by using the `VARIABLE` command
 - Oracle Forms internal and UI variables
 - Java variables
- **Is preceded by a colon (:) when referenced in PL/SQL code**
- **Can be referenced in an anonymous block but not in a stored subprogram**
- **Provides a value to a PL/SQL block and receives a value from a PL/SQL block**

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Calling PL/SQL Using Host Variables

The PL/SQL code that is stored in the database can be called from a variety of environments, such as:

- SQL*Plus or *iSQL*Plus*
- Oracle Forms and Oracle Reports
- Java and C applications

Each of the preceding environments provides ways to declare variables to store data in memory. The variable values in these applications are defined and held external to stored PL/SQL code. Each environment provides a way to pass the variable data to PL/SQL and receive updated values from the PL/SQL code. In general, most languages host calls to PL/SQL blocks or subprograms. The PL/SQL engine uses a technique called binding to associate values supplied from external locations to PL/SQL variables or parameters declared in the PL/SQL subprograms.

Unlike in Java, PL/SQL recognizes host variables by the presence of a colon prefixed to the external variable name when it is used in a PL/SQL block.

You cannot store PL/SQL code with host variables because the compiler cannot resolve references to host variables. The binding process is done at run time.

Using IN OUT Parameters: Example

Calling environment

phone_no (before the call)	phone_no (after the call)
'8006330575'	'(800)633-0575'

```
CREATE OR REPLACE PROCEDURE format_phone
(phone_no IN OUT VARCHAR2) IS
BEGIN
    phone_no := '(' || SUBSTR(phone_no,1,3) ||
                ')' || SUBSTR(phone_no,4,3) ||
                '-' || SUBSTR(phone_no,7);
END format_phone;
/
```

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Using IN OUT Parameters: Example

Using an IN OUT parameter, you can pass a value into a procedure that can be updated. The actual parameter value supplied from the calling environment can return as either of the following:

- The original unchanged value
- A new value that is set within the procedure

Note: An IN OUT parameter acts as an initialized variable.

The example in the slide creates a procedure with an IN OUT parameter to accept a 10-character string containing digits for a phone number. The procedure returns the phone number formatted with parentheses around the first three characters and a hyphen after the sixth digit—for example, the phone string 8006330575 is returned as (800)633-0575.

The following code uses the phone_no host variable of iSQL*Plus to provide the input value passed to the FORMAT_PHONE procedure. The procedure is executed and returns an updated string in the phone_no host variable.

```
VARIABLE phone_no VARCHAR2(15)
EXECUTE :phone_no := '8006330575'
PRINT phone_no
EXECUTE format_phone (:phone_no)
PRINT phone_no
```

Syntax for Passing Parameters

- **Positional:**
 - Lists the actual parameters in the same order as the formal parameters
- **Named:**
 - Lists the actual parameters in arbitrary order and uses the association operator (`=>`) to associate a named formal parameter with its actual parameter
- **Combination:**
 - Lists some of the actual parameters as positional and some as named

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Syntax for Passing Parameters

For a procedure that contains multiple parameters, you can use a number of methods to specify the values of the parameters. The methods are:

- **Positional:** Lists the actual parameter values in the order in which the formal parameters are declared
- **Named:** Lists the actual values in arbitrary order and uses the association operator to associate each actual parameter with its formal parameter by name. The PL/SQL association operator is an “equal” sign followed by an “is greater than” sign, without spaces: `=>`.
- **Combination:** Lists the first parameter values by their position and the remainder by using the special syntax of the named method

The next page shows some examples of the first two methods.

Parameter Passing: Examples

```
CREATE OR REPLACE PROCEDURE add_dept(  
    name IN departments.department_name%TYPE,  
    loc  IN departments.location_id%TYPE) IS  
BEGIN  
    INSERT INTO departments(department_id,  
                           department_name, location_id)  
    VALUES (departments_seq.NEXTVAL, name, loc);  
END add_dept;  
/
```

- **Passing by positional notation:**

```
EXECUTE add_dept ('TRAINING', 2500)
```

- **Passing by named notation:**

```
EXECUTE add_dept (loc=>2400, name=>'EDUCATION')
```

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Parameter Passing: Examples

In the example, the `add_dept` procedure declares two `IN` parameters: `name` and `loc`. The values of these parameters are used in the `INSERT` statement to set the `department_name` and `location_id` columns, respectively.

Passing parameters by position is shown in the first call to execute `add_dept` below the procedure definition. The first actual parameter supplies the value `TRAINING` for the `name` parameter. The second actual parameter value of `2500` is assigned by position to the `loc` parameter.

Passing parameters using the named notation is shown in the last example. Here, the `loc` parameter, which is declared as the second formal parameter, is referenced by name in the call, where it is associated to the actual value of `2400`. The `name` parameter is associated to the value `EDUCATION`. The order of the actual parameters is irrelevant if all parameter values are specified.

Note: You must provide a value for each parameter unless the formal parameter is assigned a default value. Specifying default values for formal parameters is discussed next.

Using the DEFAULT Option for Parameters

- Defines default values for parameters:

```
CREATE OR REPLACE PROCEDURE add_dept(  
  name departments.department_name%TYPE := 'Unknown',  
  loc  departments.location_id%TYPE DEFAULT 1700)  
IS  
BEGIN  
  INSERT INTO departments (...)  
  VALUES (departments_seq.NEXTVAL, name, loc);  
END add_dept;
```

- Provides flexibility by combining the positional and named parameter-passing syntax:

```
EXECUTE add_dept  
EXECUTE add_dept ('ADVERTISING', loc => 1200)  
EXECUTE add_dept (loc => 1200)
```

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Using the DEFAULT Option for Parameters

The code examples in the slide show two ways of assigning a default value to an IN parameter. The two ways shown use:

- The assignment operator (: =), as shown for the name parameter
- The DEFAULT option, as shown for the loc parameter

When default values are assigned to formal parameters, you can call the procedure without supplying an actual parameter value for the parameter. Thus, you can pass different numbers of actual parameters to a subprogram, either by accepting or by overriding the default values as required. It is recommended that you declare parameters without default values first. Then, you can add formal parameters with default values without having to change every call to the procedure.

Note: You cannot assign default values to OUT and IN OUT parameters.

The slide shows three ways of invoking the add_dept procedure:

- The first example assigns the default values for each parameter.
- The second example illustrates a combination of position and named notation to assign values. In this case, using named notation is presented as an example.
- The last example uses the default value for the name parameter and the supplied value for the loc parameter.

Using the DEFAULT Option for Parameters (continued)

Usually, you can use named notation to override the default values of formal parameters. However, you cannot skip providing an actual parameter if there is no default value provided for a formal parameter.

Note: All the positional parameters should precede the named parameters in a subprogram call. Otherwise, you receive an error message, as shown in the following example:

```
EXECUTE add_dept(name=>'new dept', 'new location')
```

The following error message is generated:

```
ERROR at line 1:
ORA-06550: line 1, column 34:
PLS-00312: a positional parameter association may not follow a named association
ORA-06550: line 1, column 7:
PL/SQL: Statement ignored
```

Summary of Parameter Modes

IN	OUT	IN OUT
Default mode	Must be specified	Must be specified
Value is passed into subprogram	Returned to calling environment	Passed into subprogram; returned to calling environment
Formal parameter acts as a constant	Uninitialized variable	Initialized variable
Actual parameter can be a literal, expression, constant, or initialized variable	Must be a variable	Must be a variable
Can be assigned a default value	Cannot be assigned a default value	Cannot be assigned a default value

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Summary of Parameter Modes

The IN parameter mode is the default mode if no mode is specified in the declaration. The OUT and IN OUT parameter modes must be explicitly specified with the parameter declaration.

A formal parameter of IN mode cannot be assigned a value and cannot be modified in the body of the procedure. By default, the IN parameter is passed by reference. An IN parameter can be assigned a default value in the formal parameter declaration, in which case the caller need not provide a value for the parameter if the default applies.

An OUT or IN OUT parameter must be assigned a value before returning to the calling environment. The OUT and IN OUT parameters cannot be assigned default values. To improve performance with OUT and IN OUT parameters, the NOCOPY compiler hint can be used to request to pass by reference.

Note: Using NOCOPY is discussed later in this course.

Invoking Procedures

You can invoke procedures by:

- Using anonymous blocks
- Using another procedure, as in the following example:

```
CREATE OR REPLACE PROCEDURE process_employees
IS
    CURSOR emp_cursor IS
        SELECT employee_id
        FROM   employees;
BEGIN
    FOR emp_rec IN emp_cursor
    LOOP
        raise_salary(emp_rec.employee_id, 10);
    END LOOP;
    COMMIT;
END process_employees;
/
```

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Invoking Procedures

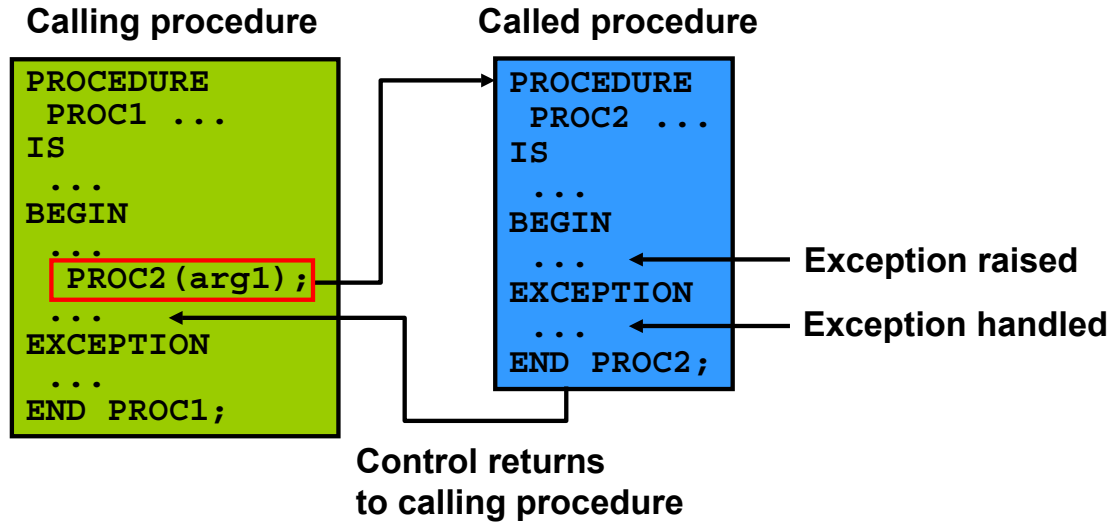
You can invoke procedures by using:

- Anonymous blocks
- Another procedure or PL/SQL subprogram

Examples on the preceding pages have illustrated how to use anonymous blocks (or the EXECUTE command in *iSQL*Plus*).

This example shows you how to invoke a procedure from another stored procedure. The PROCESS_EMPLOYEES stored procedure uses a cursor to process all the records in the EMPLOYEES table and passes each employee's ID to the RAISE_SALARY procedure, which results in a 10% salary increase across the company.

Handled Exceptions



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Handled Exceptions

When you develop procedures that are called from other procedures, you should be aware of the effects that handled and unhandled exceptions have on the transaction and the calling procedure.

When an exception is raised in a called procedure, the control immediately goes to the exception section of that block. An exception is considered handled if the exception section provides a handler for the exception raised.

When an exception occurs and is handled, the following code flow takes place:

1. The exception is raised.
2. Control is transferred to the exception handler.
3. The block is terminated.
4. The calling program/block continues to execute as if nothing has happened.

If a transaction was started (that is, if any data manipulation language [DML] statements executed before executing the procedure in which the exception was raised), then the transaction is unaffected. A DML operation is rolled back if it was performed within the procedure before the exception.

Note: You can explicitly end a transaction by executing a COMMIT or ROLLBACK operation in the exception section.

Handled Exceptions: Example

```
CREATE PROCEDURE add_department(  
    name VARCHAR2, mgr NUMBER, loc NUMBER) IS  
BEGIN  
    INSERT INTO DEPARTMENTS (department_id,  
        department_name, manager_id, location_id)  
    VALUES (DEPARTMENTS_SEQ.NEXTVAL, name, mgr, loc);  
    DBMS_OUTPUT.PUT_LINE('Added Dept: ' || name);  
EXCEPTION  
    WHEN OTHERS THEN  
        DBMS_OUTPUT.PUT_LINE('Err: adding dept: ' || name);  
END;
```

```
CREATE PROCEDURE create_departments IS  
BEGIN  
    add_department('Media', 100, 1800);  
    add_department('Editing', 99, 1800);  
    add_department('Advertising', 101, 1800);  
END;
```

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Handled Exceptions: Example

The two procedures in the example are the following:

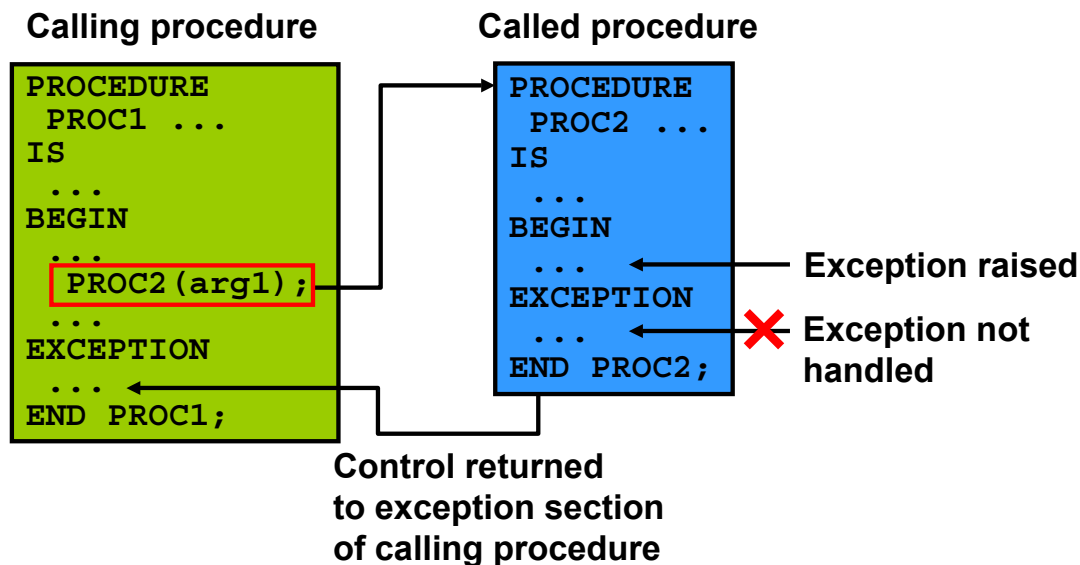
- The `add_department` procedure creates a new department record by allocating a new department number from an Oracle sequence, and sets the `department_name`, `manager_id`, and `location_id` column values using the `name`, `mgr`, and `loc` parameters, respectively.
- The `create_departments` procedure creates more than one department by using calls to the `add_department` procedure.

The `add_department` procedure catches all raised exceptions in its own handler. When `create_departments` is executed, the following output is generated:

```
Added Dept: Media  
Err: Adding Dept: Editing  
Added Dept: Advertising
```

The `Editing` department with `manager_id` of 99 is not inserted because of a foreign key integrity constraint violation on the `manager_id`. Because the exception was handled in the `add_department` procedure, the `create_department` procedure continues to execute. A query on the `DEPARTMENTS` table where the `location_id` is 1800 shows that `Media` and `Advertising` are added but the `Editing` record is not.

Exceptions Not Handled



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Exceptions Not Handled

As discussed, when an exception is raised in a called procedure, control immediately goes to the exception section of that block. If the exception section does not provide a handler for the raised exception, then it is not handled. The following code flow occurs:

1. The exception is raised.
2. The block terminates because no exception handler exists; any DML operations performed within the procedure are rolled back.
3. The exception propagates to the exception section of the calling procedure—that is, control is returned to the exception section of the calling block, if one exists.

If an exception is not handled, then all the DML statements in the calling procedure and the called procedure are rolled back along with any changes to any host variables. The DML statements that are not affected are statements that were executed before calling the PL/SQL code whose exceptions are not handled.

Exceptions Not Handled: Example

```
SET SERVEROUTPUT ON
CREATE PROCEDURE add_department_noex(
    name VARCHAR2, mgr NUMBER, loc NUMBER) IS
BEGIN
    INSERT INTO DEPARTMENTS (department_id,
        department_name, manager_id, location_id)
    VALUES (DEPARTMENTS_SEQ.NEXTVAL, name, mgr, loc);
    DBMS_OUTPUT.PUT_LINE('Added Dept: ' || name);
END;
```

```
CREATE PROCEDURE create_departments_noex IS
BEGIN
    add_department_noex('Media', 100, 1800);
    add_department_noex('Editing', 99, 1800);
    add_department_noex('Advertising', 101, 1800);
END;
```

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Exceptions Not Handled: Example

The code example in the slide shows `add_department_noex`, which does not have an exception section. In this case, the exception occurs when the `Editing` department is added. Because of the lack of exception handling in either of the subprograms, no new department records are added into the `DEPARTMENTS` table. Executing the `create_departments_noex` procedure produces a result that is similar to the following:

```
Added Dept: Media
BEGIN create_departments_noex; END;

*
ERROR at line 1:
ORA-02291: integrity constraint (ORA1.DEPT_MGR_FK)
violated - parent key not
found
ORA-06512: at "ORA1.ADD_DEPARTMENT_NOEX", line 4
ORA-06512: at "ORA1.CREATE_DEPARTMENTS_NOEX", line 4
ORA-06512: at line 1
```

Although the results show that the `Media` department was added, its operation is rolled back because the exception was not handled in either of the subprograms invoked.

Removing Procedures

You can remove a procedure that is stored in the database.

- **Syntax:**

```
DROP PROCEDURE procedure_name
```

- **Example:**

```
DROP PROCEDURE raise_salary;
```

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Removing Procedures

When a stored procedure is no longer required, you can use the DROP PROCEDURE SQL statement to remove it.

Note: Whether successful or not, executing a data definition language (DDL) command such as DROP PROCEDURE commits any pending transactions that cannot be rolled back.

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- **View source code in the `USER_SOURCE` table to view the subprograms that you own, or the `ALL_SOURCE` table for procedures that are owned by others who have granted you the `EXECUTE` privilege.**

- **View the names of procedures in USER OBJECTS.**

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Viewing Procedures in the Data Dictionary

- The USER_SOURCE table to display PL/SQL code that you own
- The ALL_SOURCE table to display PL/SQL code to which you have been granted the EXECUTE right by the owner of that subprogram code

- The **TEXT** column holds a line of PL/SQL source code.
- The **NAME** column holds the name of the subprogram in uppercase text.
- The **TYPE** column holds the subprogram type, such as **PROCEDURE** or **FUNCTION**.
- The **LINE** column stores the line number for each source code line.

Note: You cannot display the source code for Oracle PL/SQL built-in packages, or PL/SQL whose source code has been wrapped by using a WRAP utility. The WRAP utility converts the PL/SQL source code into a form that cannot be deciphered by humans.

Benefits of Subprograms

- **Easy maintenance**
- **Improved data security and integrity**
- **Improved performance**
- **Improved code clarity**

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Benefits of Subprograms

Procedures and functions have many benefits due to the modularizing of the code:

- **Easy maintenance** is realized because subprograms are located in one place. Modifications need to be done in only one place to affect multiple applications and minimize excessive testing.
- **Improved data security** can be achieved by controlling indirect access to database objects from nonprivileged users with security privileges. The subprograms are by default executed with definer's right. The execute privilege does not allow a calling user direct access to objects that are accessible to the subprogram.
- **Data integrity** is managed by having related actions performed together or not at all.
- **Improved performance** can be realized from reuse of parsed PL/SQL code that becomes available in the shared SQL area of the server. Subsequent calls to the subprogram avoid parsing the code again. Because PL/SQL code is parsed at compile time, the parsing overhead of SQL statements is avoided at run time. Code can be written to reduce the number of network calls to the database, and therefore, decrease network traffic.
- **Improved code clarity** can be attained by using appropriate names and conventions to describe the action of the routines, thereby reducing the need for comments and enhancing the clarity of the code.

Summary

In this lesson, you should have learned how to:

- **Write a procedure to perform a task or an action**
- **Create, compile, and save procedures in the database by using the `CREATE PROCEDURE SQL` command**
- **Use parameters to pass data from the calling environment to the procedure by using three different parameter modes: `IN` (the default), `OUT`, and `IN OUT`**
- **Recognize the effect of handling and not handling exceptions on transactions and calling procedures**

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Summary

A procedure is a subprogram that performs a specified action. You can compile and save a procedure as a stored procedure in the database. A procedure can return zero or more values through its parameters to its calling environment. There are three parameter modes: `IN`, `OUT`, and `IN OUT`.

You should be able to handle and not handle exceptions, and you should understand how managing exceptions affects transactions and calling procedures. The exceptions are handled in the exception section of a subprogram.

Summary

In this lesson, you should have learned how to:

- **Remove procedures from the database by using the `DROP PROCEDURE SQL` command**
- **Modularize your application code by using procedures as building blocks**

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Summary (continued)

You can modify and remove procedures. Procedures are modular components that form the building blocks of an application. You can also create client-side procedures that can be used by client-side applications.

Practice 1: Overview

This practice covers the following topics:

- **Creating stored procedures to:**
 - Insert new rows into a table using the supplied parameter values
 - Update data in a table for rows that match the supplied parameter values
 - Delete rows from a table that match the supplied parameter values
 - Query a table and retrieve data based on supplied parameter values
- **Handling exceptions in procedures**
- **Compiling and invoking procedures**

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Practice 1: Overview

In this practice, you create procedures that issue DML and query commands.

If you encounter compilation errors when you are using *iSQL*Plus*, use the `SHOW ERRORS` command.

If you correct any compilation errors in *iSQL*Plus*, do so in the original script file (rather than in the buffer) and then rerun the new version of the file. This saves a new version of the procedure to the data dictionary.

Note: It is recommended to use *iSQL*Plus* for this practice.

Practice 1

Note: You can find table descriptions and sample data in Appendix B, “Table Descriptions and Data.” Click the Save Script button to save your subprograms as .sql files in your local file system.

Remember to enable SERVEROUTPUT if you have previously disabled it.

1. Create and invoke the ADD_JOB procedure and consider the results.
 - a. Create a procedure called ADD_JOB to insert a new job into the JOBS table. Provide the ID and title of the job using two parameters.
 - b. Compile the code; invoke the procedure with IT_DBA as job ID and Database Administrator as job title. Query the JOBS table to view the results.

JOB_ID	JOB_TITLE	MIN_SALARY	MAX_SALARY
IT_DBA	Database Administrator		

- c. Invoke your procedure again, passing a job ID of ST_MAN and a job title of Stock Manager. What happens and why?

2. Create a procedure called UPD_JOB to modify a job in the JOBS table.
 - a. Create a procedure called UPD_JOB to update the job title. Provide the job ID and a new title using two parameters. Include the necessary exception handling if no update occurs.
 - b. Compile the code; invoke the procedure to change the job title of the job ID IT_DBA to Data Administrator. Query the JOBS table to view the results.

JOB_ID	JOB_TITLE	MIN_SALARY	MAX_SALARY
IT_DBA	Data Administrator		

Also check the exception handling by trying to update a job that does not exist. (You can use the job ID IT_WEB and the job title Web Master.)

3. Create a procedure called DEL_JOB to delete a job from the JOBS table.
 - a. Create a procedure called DEL_JOB to delete a job. Include the necessary exception handling if no job is deleted.
 - b. Compile the code; invoke the procedure using the job ID IT_DBA. Query the JOBS table to view the results.

no rows selected

Also, check the exception handling by trying to delete a job that does not exist. (Use the IT_WEB job ID.) You should get the message that you used in the exception-handling section of the procedure as output.

Practice 1 (continued)

4. Create a procedure called GET_EMPLOYEE to query the EMPLOYEES table, retrieving the salary and job ID for an employee when provided with the employee ID.
 - a. Create a procedure that returns a value from the SALARY and JOB_ID columns for a specified employee ID. Compile the code and remove the syntax errors.
 - b. Execute the procedure using host variables for the two OUT parameters—one for the salary and the other for the job ID. Display the salary and job ID for employee ID 120.

SALARY	
	8000

JOB	
ST_MAN	

- c. Invoke the procedure again, passing an EMPLOYEE_ID of 300. What happens and why?

2

Creating Stored Functions

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Objectives

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

- **Describe the uses of functions**
- **Create stored functions**
- **Invoke a function**
- **Remove a function**
- **Differentiate between a procedure and a function**

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Lesson Aim

In this lesson, you learn how to create and invoke functions.

Overview of Stored Functions

A function:

- **Is a named PL/SQL block that returns a value**
- **Can be stored in the database as a schema object for repeated execution**
- **Is called as part of an expression or is used to provide a parameter value**

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Overview of Stored Functions

A function is a named PL/SQL block that can accept parameters, be invoked, and return a value. In general, you use a function to compute a value. Functions and procedures are structured alike. A function must return a value to the calling environment, whereas a procedure returns zero or more values to its calling environment. Like a procedure, a function has a header, a declarative section, an executable section, and an optional exception-handling section. A function must have a RETURN clause in the header and at least one RETURN statement in the executable section.

Functions can be stored in the database as schema objects for repeated execution. A function that is stored in the database is referred to as a stored function. Functions can also be created on client-side applications.

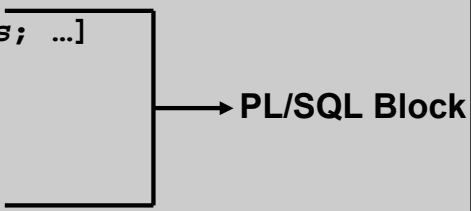
Functions promote reusability and maintainability. When validated, they can be used in any number of applications. If the processing requirements change, only the function needs to be updated.

A function may also be called as part of a SQL expression or as part of a PL/SQL expression. In the context of a SQL expression, a function must obey specific rules to control side effects. In a PL/SQL expression, the function identifier acts like a variable whose value depends on the parameters passed to it.

Syntax for Creating Functions

The PL/SQL block must have at least one RETURN statement.

```
CREATE [OR REPLACE] FUNCTION function_name
[(parameter1 [mode1] datatype1, ...)]
RETURN datatype IS|AS
  [local_variable_declarations; ...]
BEGIN
  -- actions;
  RETURN expression;
END [function_name];
```



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Syntax for Creating Functions

A function is a PL/SQL block that returns a value. A RETURN statement must be provided to return a value with a data type that is consistent with the function declaration.

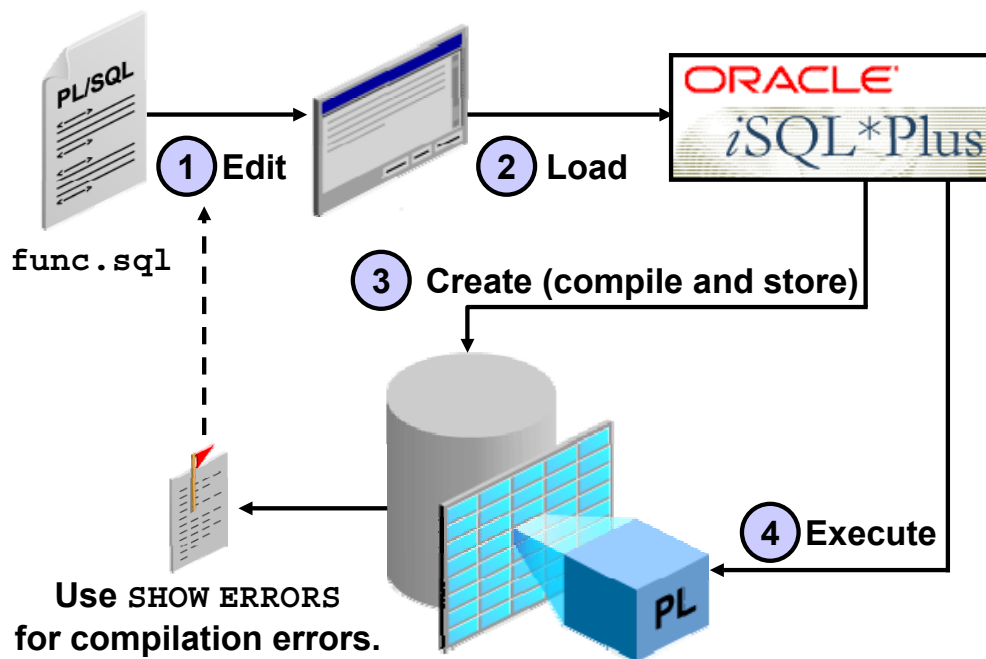
You create new functions with the CREATE FUNCTION statement, which may declare a list of parameters, must return one value, and must define the actions to be performed by the standard PL/SQL block.

You should consider the following points about the CREATE FUNCTION statement:

- The REPLACE option indicates that if the function exists, it is dropped and replaced with the new version that is created by the statement.
- The RETURN data type must not include a size specification.
- The PL/SQL block starts with a BEGIN after the declaration of any local variables and ends with an END, optionally followed by the *function_name*.
- There must be at least one RETURN *expression* statement.
- You cannot reference host or bind variables in the PL/SQL block of a stored function.

Note: Although the OUT and IN OUT parameter modes can be used with functions, it is not good programming practice to use them with functions. However, if you need to return more than one value from a function, consider returning the values in a composite data structure such as a PL/SQL record or a PL/SQL table.

Developing Functions



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How to Develop Stored Functions

The diagram illustrates the basic steps involved in developing a stored function. To develop a stored function, perform the following steps:

1. Create a file by using your favorite text or code editor to edit the function syntax, and saving the code in a file typically with a .sql extension.
2. Load the function code from the file into the buffer by using iSQL*Plus as the PL/SQL development environment.
3. Execute the CREATE FUNCTION statement to compile and store the function in the database.
4. After successful compilation, invoke the function from a PL/SQL environment or application.

Returning a Value

- Add a RETURN clause with the data type in the header of the function.
- Include one RETURN statement in the executable section.

Multiple RETURN statements are allowed in a function (usually within an IF statement). Only one RETURN statement is executed because after the value is returned, processing of the block ceases.

Use the SHOW ERRORS or SHOW ERRORS FUNCTION function_name iSQL*Plus commands to view compilation errors.

Stored Function: Example

- **Create the function:**

```
CREATE OR REPLACE FUNCTION get_sal
(id employees.employee_id%TYPE) RETURN NUMBER IS
    sal employees.salary%TYPE := 0;
BEGIN
    SELECT salary
    INTO    sal
    FROM    employees
    WHERE   employee_id = id;
    RETURN sal;
END get_sal;
/
```

- **Invoke the function as an expression or as a parameter value:**

```
EXECUTE dbms_output.put_line(get_sal(100))
```

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Stored Function: Example

The `get_sal` function is created with a single input parameter and returns the salary as a number. Execute the command as shown, or save it in a script file and run the script to create the `get_sal` function.

The `get_sal` function follows a common programming practice of using a single `RETURN` statement that returns a value assigned to a local variable. If your function has an exception section, then it may also contain a `RETURN` statement.

Invoke a function as part of a PL/SQL expression because the function will return a value to the calling environment. The second code box uses the `iSQL*Plus` `EXECUTE` command to call the `DBMS_OUTPUT.PUT_LINE` procedure whose argument is the return value from the function `get_sal`. In this case, `get_sal` is invoked first to calculate the salary of the employee with ID 100. The salary value returned is supplied as the value of the `DBMS_OUTPUT.PUT_LINE` parameter, which displays the result (if you have executed a `SET SERVEROUTPUT ON`).

Note: A function must always return a value. The example does not return a value if a row is not found for a given `id`. Ideally, create an exception handler to return a value as well.

Ways to Execute Functions

- **Invoke as part of a PL/SQL expression**
 - Using a host variable to obtain the result:

```
VARIABLE salary NUMBER
EXECUTE :salary := get_sal(100)
```

- Using a local variable to obtain the result:

```
DECLARE sal employees.salary%type;
BEGIN
    sal := get_sal(100); ...
END;
```

- **Use as a parameter to another subprogram**

```
EXECUTE dbms_output.put_line(get_sal(100))
```

- **Use in a SQL statement (subject to restrictions)**

```
SELECT job_id, get_sal(employee_id) FROM employees;
```

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Ways to Execute Functions

If functions are designed thoughtfully, they can be powerful constructs. Functions can be invoked in the following ways:

- **As part of PL/SQL expressions:** You can use host or local variables to hold the returned value from a function. The first example in the slide uses a host variable and the second example uses a local variable in an anonymous block.
- **As a parameter to another subprogram:** The third example in the slide demonstrates this usage. The `get_sal` function with all its arguments is nested in the parameter required by the `DBMS_OUTPUT.PUT_LINE` procedure. This comes from the concept of nesting functions as discussed in the course titled *Oracle Database 10g: SQL Fundamentals I*.
- **As an expression in a SQL statement:** The last example shows how a function can be used as a single-row function in a SQL statement.

Note: The benefits and restrictions that apply to functions when used in a SQL statement are discussed in the next few pages.

Advantages of User-Defined Functions in SQL Statements

- Can extend SQL where activities are too complex, too awkward, or unavailable with SQL
- Can increase efficiency when used in the WHERE clause to filter data, as opposed to filtering the data in the application
- Can manipulate data values

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Advantages of User-Defined Functions in SQL Statements

SQL statements can reference PL/SQL user-defined functions anywhere a SQL expression is allowed. For example, a user-defined function can be used anywhere that a built-in SQL function, such as UPPER () , can be placed.

Advantages

- Permits calculations that are too complex, awkward, or unavailable with SQL
- Increases data independence by processing complex data analysis within the Oracle server, rather than by retrieving the data into an application
- Increases efficiency of queries by performing functions in the query rather than in the application
- Manipulates new types of data (for example, latitude and longitude) by encoding character strings and using functions to operate on the strings

Function in SQL Expressions: Example

```
CREATE OR REPLACE FUNCTION tax(value IN NUMBER)
  RETURN NUMBER IS
BEGIN
  RETURN (value * 0.08);
END tax;
/
SELECT employee_id, last_name, salary, tax(salary)
FROM   employees
WHERE  department_id = 100;
```

Function created.

EMPLOYEE_ID	LAST_NAME	SALARY	TAX(SALARY)
108	Greenberg	12000	960
109	Faviet	9000	720
110	Chen	8200	656
111	Sciarra	7700	616
112	Urman	7800	624
113	Popp	6900	552

6 rows selected.

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Function in SQL Expressions: Example

The example in the slide shows how to create a `tax` function to calculate income tax. The function accepts a `NUMBER` parameter and returns the calculated income tax based on a simple flat tax rate of 8%.

In *iSQL*Plus*, the `tax` function is invoked as an expression in the `SELECT` clause along with the employee ID, last name, and salary for employees in a department with ID 100. The return result from the `tax` function is displayed with the regular output from the query.

Locations to Call User-Defined Functions

User-defined functions act like built-in single-row functions and can be used in:

- The **SELECT** list or clause of a query
- Conditional expressions of the **WHERE** and **HAVING** clauses
- The **CONNECT BY**, **START WITH**, **ORDER BY**, and **GROUP BY** clauses of a query
- The **VALUES** clause of the **INSERT** statement
- The **SET** clause of the **UPDATE** statement

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Locations to Call User-Defined Functions

A PL/SQL user-defined function can be called from any SQL expression where a built-in single-row function can be called.

Example:

```
SELECT employee_id, tax(salary)
FROM   employees
WHERE  tax(salary) > (SELECT MAX(tax(salary))
                     FROM employees
                     WHERE department_id = 30)
ORDER BY tax(salary) DESC;
```

EMPLOYEE_ID	TAX(SALARY)
100	1920
101	1360
102	1360
145	1120
146	1080
...	...

10 rows selected.

Restrictions on Calling Functions from SQL Expressions

- **User-defined functions that are callable from SQL expressions must:**
 - Be stored in the database
 - Accept only **IN** parameters with valid SQL data types, not PL/SQL-specific types
 - Return valid SQL data types, not PL/SQL-specific types
- **When calling functions in SQL statements:**
 - Parameters must be specified with positional notation
 - You must own the function or have the **EXECUTE** privilege

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Restrictions on Calling Functions from SQL Expressions

The user-defined PL/SQL functions that are callable from SQL expressions must meet the following requirements:

- The function must be stored in the database.
- The function parameters must be input only and valid SQL data types.
- The functions must return data types that are valid SQL data types. They cannot be PL/SQL-specific data types such as **BOOLEAN**, **RECORD**, or **TABLE**. The same restriction applies to the parameters of the function.

The following restrictions apply when calling a function in a SQL statement:

- Parameters must use positional notation. Named notation is not supported.
- You must own or have the **EXECUTE** privilege on the function.

Other restrictions on a user-defined function include the following:

- It cannot be called from the **CHECK** constraint clause of a **CREATE TABLE** or **ALTER TABLE** statement.
- It cannot be used to specify a default value for a column.

Note: Only stored functions are callable from SQL statements. Stored procedures cannot be called unless invoked from a function that meets the preceding requirements.

Controlling Side Effects When Calling Functions from SQL Expressions

Functions called from:

- **A SELECT statement cannot contain DML statements**
- **An UPDATE or DELETE statement on a table T cannot query or contain DML on the same table T**
- **SQL statements cannot end transactions (that is, cannot execute COMMIT or ROLLBACK operations)**

Note: Calls to subprograms that break these restrictions are also not allowed in the function.

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Controlling Side Effects When Calling Functions from SQL Expressions

To execute a SQL statement that calls a stored function, the Oracle server must know whether the function is free of specific side effects. The side effects are unacceptable changes to database tables.

Additional restrictions apply when a function is called in expressions of SQL statements:

- When a function is called from a SELECT statement or a parallel UPDATE or DELETE statement, the function cannot modify database tables.
- When a function is called from an UPDATE or DELETE statement, the function cannot query or modify database tables modified by that statement.
- When a function is called from a SELECT, INSERT, UPDATE, or DELETE statement, the function cannot execute directly or indirectly through another subprogram or SQL transaction control statements such as:
 - A COMMIT or ROLLBACK statement
 - A session control statement (such as SET ROLE)
 - A system control statement (such as ALTER SYSTEM)
 - Any DDL statements (such as CREATE) because they are followed by an automatic commit

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Oracle Database 10g: Develop PL/SQL Program Units 2-13

Removing Functions

Removing a stored function:

- You can drop a stored function by using the following syntax:

```
DROP FUNCTION function_name
```

Example:

```
DROP FUNCTION get_sal;
```

- All the privileges that are granted on a function are revoked when the function is dropped.
- The CREATE OR REPLACE syntax is equivalent to dropping a function and re-creating it. Privileges granted on the function remain the same when this syntax is used.

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Removing Functions

When a stored function is no longer required, you can use a SQL statement in *iSQL*Plus* to drop it. To remove a stored function by using *iSQL*Plus*, execute the DROP FUNCTION SQL command.

CREATE OR REPLACE Versus DROP and CREATE

The REPLACE clause in the CREATE OR REPLACE syntax is equivalent to dropping a function and re-creating it. When you use the CREATE OR REPLACE syntax, the privileges granted on this object to other users remain the same. When you DROP a function and then re-create it, all the privileges granted on this function are automatically revoked.

Viewing Functions in the Data Dictionary

Information for PL/SQL functions is stored in the following Oracle data dictionary views:

- You can view source code in the **USER_SOURCE** table for subprograms that you own, or the **ALL_SOURCE** table for functions owned by others who have granted you the **EXECUTE** privilege.

```
SELECT text
FROM   user_source
WHERE  type = 'FUNCTION'
ORDER BY line;
```

- You can view the names of functions by using **USER_OBJECTS**.

```
SELECT object_name
FROM   user_objects
WHERE  object_type = 'FUNCTION';
```

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Viewing Functions in the Data Dictionary

The source code for PL/SQL functions is stored in the data dictionary tables. The source code is accessible for PL/SQL functions that are successfully or unsuccessfully compiled. To view the PL/SQL function code stored in the data dictionary, execute a **SELECT** statement on the following tables where the **TYPE** column value is **FUNCTION**:

- The **USER_SOURCE** table to display the PL/SQL code that you own
- The **ALL_SOURCE** table to display the PL/SQL code to which you have been granted the **EXECUTE** right by the owner of that subprogram code

The first query example shows how to display the source code for all the functions in your schema. The second query, which uses the **USER_OBJECTS** data dictionary view, lists the names of all functions that you own.

Procedures Versus Functions

Procedures	Functions
Execute as a PL/SQL statement	Invoke as part of an expression
Do not contain RETURN clause in the header	Must contain a RETURN clause in the header
Can return values (if any) in output parameters	Must return a single value
Can contain a RETURN statement without a value	Must contain at least one RETURN statement

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How Procedures and Functions Differ

You create a procedure to store a series of actions for later execution. A procedure can contain zero or more parameters that can be transferred to and from the calling environment, but a procedure does not have to return a value. A procedure can call a function to assist with its actions.

Note: A procedure containing a single OUT parameter would be better rewritten as a function returning the value.

You create a function when you want to compute a value that must be returned to the calling environment. A function can contain zero or more parameters that are transferred from the calling environment. Functions typically return only a single value, and the value is returned through a RETURN statement. The functions used in SQL statements should not use OUT or IN OUT mode parameters. Although a function using output parameters can be used in a PL/SQL procedure or block, it cannot be used in SQL statements.

Summary

In this lesson, you should have learned how to:

- **Write a PL/SQL function to compute and return a value by using the CREATE FUNCTION SQL statement**
- **Invoke a function as part of a PL/SQL expression**
- **Use stored PL/SQL functions in SQL statements**
- **Remove a function from the database by using the DROP FUNCTION SQL statement**

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Summary

A function is a named PL/SQL block that must return a value. Generally, you create a function to compute and return a value, and you create a procedure to perform an action.

A function can be created or dropped.

A function is invoked as a part of an expression.

Practice 2: Overview

This practice covers the following topics:

- **Creating stored functions:**
 - To query a database table and return specific values
 - To be used in a SQL statement
 - To insert a new row, with specified parameter values, into a database table
 - Using default parameter values
- **Invoking a stored function from a SQL statement**
- **Invoking a stored function from a stored procedure**

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Practice 2: Overview

If you encounter compilation errors when using *iSQL*Plus*, use the `SHOW ERRORS` command.

If you correct any compilation errors in *iSQL*Plus*, do so in the original script file, not in the buffer, and then rerun the new version of the file. This saves a new version of the program unit to the data dictionary.

Note: It is recommended to use *iSQL*Plus* for this practice.

Practice 2

1. Create and invoke the GET_JOB function to return a job title.
 - a. Create and compile a function called GET_JOB to return a job title.
 - b. Create a VARCHAR2 host variable called TITLE, allowing a length of 35 characters. Invoke the function with SA_REP job ID to return the value in the host variable. Print the host variable to view the result.

TITLE
Sales Representative

2. Create a function called GET_ANNUAL_COMP to return the annual salary computed from an employee's monthly salary and commission passed as parameters.
 - a. Develop and store the GET_ANNUAL_COMP function, accepting parameter values for monthly salary and commission. Either or both values passed can be NULL, but the function should still return a non-NULL annual salary. Use the following basic formula to calculate the annual salary:
$$(\text{salary} * 12) + (\text{commission_pct} * \text{salary} * 12)$$
 - b. Use the function in a SELECT statement against the EMPLOYEES table for employees in department 30.

EMPLOYEE_ID	LAST_NAME	Annual Compensation
114	Raphaely	132000
115	Khoo	37200
116	Baida	34800
117	Tobias	33600
118	Himuro	31200
119	Colmenares	30000

6 rows selected.

3. Create a procedure, ADD_EMPLOYEE, to insert a new employee into the EMPLOYEES table. The procedure should call a VALID_DEPTID function to check whether the department ID specified for the new employee exists in the DEPARTMENTS table.
 - a. Create a function VALID_DEPTID to validate a specified department ID and return a BOOLEAN value of TRUE if the department exists.
 - b. Create the ADD_EMPLOYEE procedure to add an employee to the EMPLOYEES table. The row should be added to the EMPLOYEES table if the VALID_DEPTID function returns TRUE; otherwise, alert the user with an appropriate message. Provide the following parameters (with defaults specified in parentheses): first_name, last_name, email, job (SA_REP), mgr (145), sal (1000), comm (0), and deptid (30). Use the EMPLOYEES_SEQ sequence to set the employee_id column, and set hire_date to TRUNC(SYSDATE).
 - c. Call ADD_EMPLOYEE for the name Jane Harris in department 15, leaving other parameters with their default values. What is the result?
 - d. Add another employee named Joe Harris in department 80, leaving remaining parameters with their default values. What is the result?

3

Creating Packages

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Objectives

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

- **Describe packages and list their components**
- **Create a package to group together related variables, cursors, constants, exceptions, procedures, and functions**
- **Designate a package construct as either public or private**
- **Invoke a package construct**
- **Describe the use of a bodiless package**

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Lesson Aim

In this lesson, you learn what a package is and what its components are. You also learn how to create and use packages.

PL/SQL Packages: Overview

PL/SQL packages:

- **Group logically related components:**
 - PL/SQL types
 - Variables, data structures, and exceptions
 - Subprograms: Procedures and functions
- **Consist of two parts:**
 - A specification
 - A body
- **Enable the Oracle server to read multiple objects into memory at once**



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PL/SQL Packages: Overview

PL/SQL packages enable you to bundle related PL/SQL types, variables, data structures, exceptions, and subprograms into one container. For example, a Human Resources package can contain hiring and firing procedures, commission and bonus functions, and tax exemption variables.

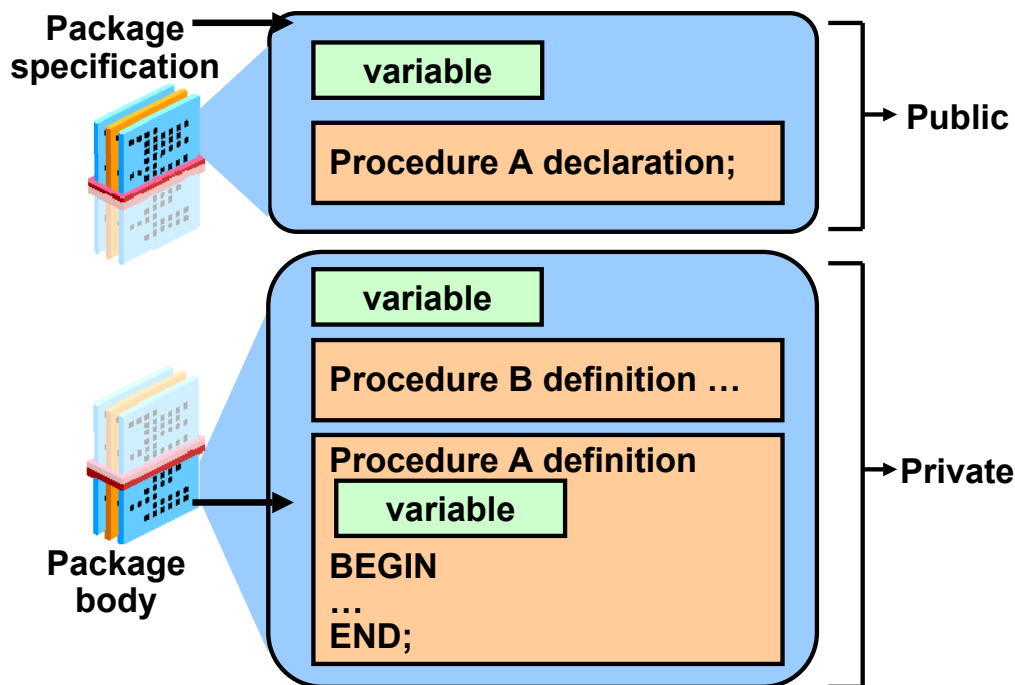
A package usually consists of two parts stored separately in the database:

- A specification
- A body (optional)

The package itself cannot be called, parameterized, or nested. After writing and compiling, the contents can be shared with many applications.

When a PL/SQL-packaged construct is referenced for the first time, the whole package is loaded into memory. Subsequent access to constructs in the same package do not require disk input/output (I/O).

Components of a PL/SQL Package



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Components of a PL/SQL Package

You create a package in two parts:

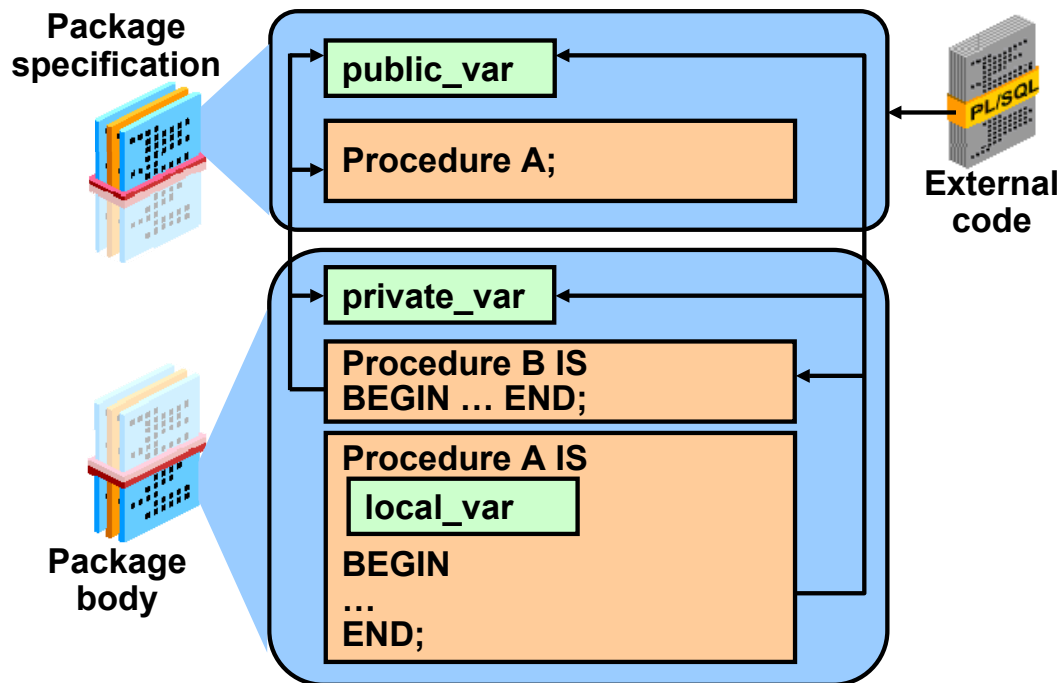
- The **package specification** is the interface to your applications. It declares the public types, variables, constants, exceptions, cursors, and subprograms available for use. The package specification may also include PRAGMAS, which are directives to the compiler.
- The **package body** defines its own subprograms and must fully implement subprograms declared in the specification part. The package body may also define PL/SQL constructs, such as types, variables, constants, exceptions, and cursors.

Public components are declared in the package specification. The specification defines a public application programming interface (API) for users of package features and functionality—that is, public components can be referenced from any Oracle server environment that is external to the package.

Private components are placed in the package body and can be referenced only by other constructs within the same package body. Private components can reference the package public components.

Note: If a package specification does not contain subprogram declarations, then there is no requirement for a package body.

Visibility of Package Components



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Visibility of Package Components

The *visibility* of a component describes whether that component can be seen, that is, referenced and used by other components or objects. The visibility of components depends on whether they are locally or globally declared.

Local components are visible within the structure in which they are declared, such as the following:

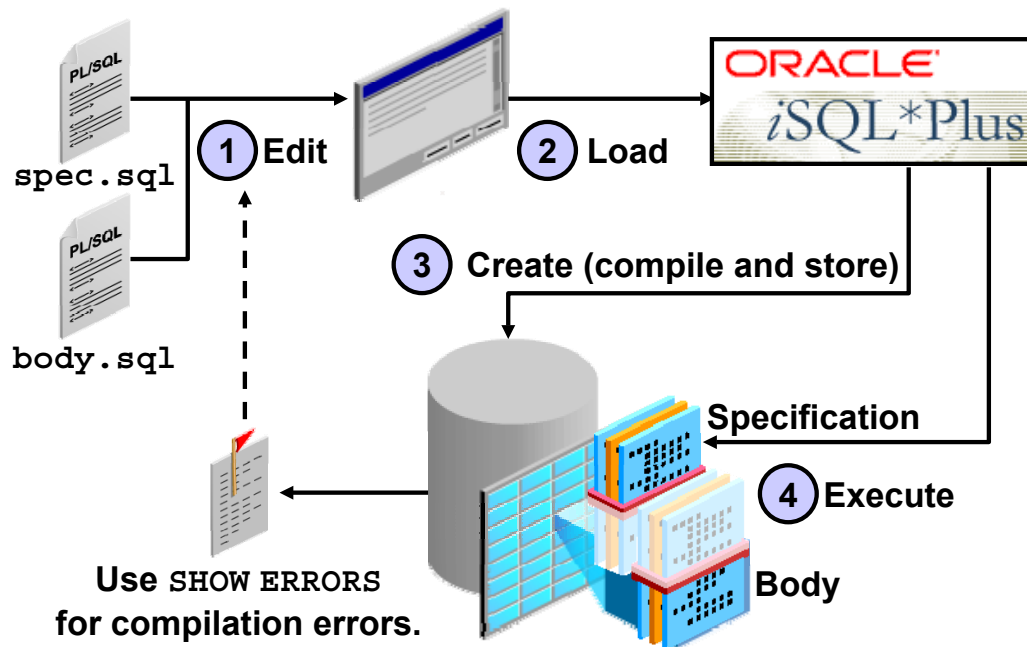
- Variables defined in a subprogram can be referenced within that subprogram, and are not visible to external components—for example, `local_var` can be used in procedure A.
- Private package variables, which are declared in a package body, can be referenced by other components in the same package body. They are not visible to any subprograms or objects that are outside the package. For example, `private_var` can be used by procedures A and B within the package body, but not outside the package.

Globally declared components are visible internally and externally to the package, such as:

- A public variable, which is declared in a package specification, can be referenced and changed outside the package (for example, `public_var` can be referenced externally).
- A package subprogram in the specification can be called from external code sources (for example, procedure A can be called from an environment external to the package).

Note: Private subprograms, such as procedure B, can be invoked only with public subprograms, such as procedure A, or other private package constructs.

Developing PL/SQL Packages



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Developing PL/SQL Packages

To develop a package, perform the following steps:

1. Edit the text for the specification by using the `CREATE PACKAGE` statement within a SQL script file. Edit the text for the body (only if required; see the guidelines below) by using the `CREATE PACKAGE BODY` statement within a SQL script file.
2. Load the script files into a tool such as *iSQL*Plus*.
3. Execute the script files to create (that is, to compile and store) the package and package body in the database.
4. Execute any public construct within the package specification from an Oracle server environment.

Guidelines for Developing Packages

- Consider saving the text for a package specification and a package body in two different script files to facilitate easier modifications to the package or its body.
- A package specification can exist without a package body—that is, when the package specification does not declare subprograms, a body is not required. However, a package body cannot exist without a package specification.

Note: The Oracle server stores the specification and body of a package separately. This enables you to change the implementation of a program construct in the package body without invalidating other schema objects that call or reference the program construct.

Creating the Package Specification

Syntax:

```
CREATE [OR REPLACE] PACKAGE package_name IS | AS
    public type and variable declarations
    subprogram specifications
END [package_name];
```

- The **OR REPLACE** option drops and re-creates the package specification.
- Variables declared in the package specification are initialized to **NULL** by default.
- All the constructs declared in a package specification are visible to users who are granted privileges on the package.

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Creating the Package Specification

To create packages, you declare all public constructs within the package specification.

- Specify the **OR REPLACE** option, if overwriting an existing package specification.
- Initialize a variable with a constant value or formula within the declaration, if required; otherwise, the variable is initialized implicitly to **NULL**.

The following are definitions of items in the package syntax:

- **package_name** specifies a name for the package that must be unique among objects within the owning schema. Including the package name after the **END** keyword is optional.
- **public type and variable declarations** declares public variables, constants, cursors, exceptions, user-defined types, and subtypes.
- **subprogram specification** specifies the public procedure or function declarations.

Note: The package specification should contain procedure and function headings terminated by a semicolon, without the **IS** (or **AS**) keyword and its PL/SQL block. The implementation of a procedure or function that is declared in a package specification is done in the package body.

Example of Package Specification: `comm_pkg`

```
CREATE OR REPLACE PACKAGE comm_pkg IS
  std_comm NUMBER := 0.10;  --initialized to 0.10
  PROCEDURE reset_comm(new_comm NUMBER);
END comm_pkg;
/
```

- **STD_COMM** is a global variable initialized to 0.10.
- **RESET_COMM** is a public procedure used to reset the standard commission based on some business rules. It is implemented in the package body.

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Example of Package Specification: `comm_pkg`

The example in the slide creates a package called `comm_pkg` used to manage business processing rules for commission calculations.

The `std_comm` public (global) variable is declared to hold a maximum allowable percentage commission for the user session, and it is initialized to 0.10 (that is, 10%).

The `reset_comm` public procedure is declared to accept a new commission percentage that updates the standard commission percentage if the commission validation rules are accepted. The validation rules for resetting the commission are not made public and do not appear in the package specification. The validation rules are managed by using a private function in the package body.

Creating the Package Body

Syntax:

```
CREATE [OR REPLACE] PACKAGE BODY package_name IS | AS
    private type and variable declarations
    subprogram bodies
    [BEGIN initialization statements]
END [package_name];
```

- The **OR REPLACE** option drops and re-creates the package body.
- Identifiers defined in the package body are private and not visible outside the package body.
- All private constructs must be declared before they are referenced.
- Public constructs are visible to the package body.

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Creating the Package Body

Create a package body to define and implement all public subprograms and supporting private constructs. When creating a package body, perform the following steps:

- Specify the **OR REPLACE** option to overwrite an existing package body.
- Define the subprograms in an appropriate order. The basic principle is that you must declare a variable or subprogram before it can be referenced by other components in the same package body. It is common to see all private variables and subprograms defined first and the public subprograms defined last in the package body.
- Complete the implementation for all procedures or functions declared in the package specification within the package body.

The following are definitions of items in the package body syntax:

- **package_name** specifies a name for the package that must be the same as its package specification. Using the package name after the **END** keyword is optional.
- **private type and variable declarations** declares private variables, constants, cursors, exceptions, user-defined types, and subtypes.
- **subprogram specification** specifies the full implementation of any private and/or public procedures or functions.
- **[BEGIN initialization statements]** is an optional block of initialization code that executes when the package is first referenced.

Example of Package Body: comm_pkg

```
CREATE OR REPLACE PACKAGE BODY comm_pkg IS
  FUNCTION validate(comm NUMBER) RETURN BOOLEAN IS
    max_comm employees.commission_pct%type;
  BEGIN
    SELECT MAX(commission_pct) INTO max_comm
    FROM   employees;
    RETURN (comm BETWEEN 0.0 AND max_comm);
  END validate;
  PROCEDURE reset_comm (new_comm NUMBER) IS BEGIN
    IF validate(new_comm) THEN
      std_comm := new_comm; -- reset public var
    ELSE RAISE_APPLICATION_ERROR(
      -20210, 'Bad Commission');
    END IF;
  END reset_comm;
END comm_pkg;
```

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Example of Package Body: comm_pkg

The slide shows the complete package body for comm_pkg, with a private function called validate to check for a valid commission. The validation requires that the commission be positive and lesser than the highest commission among existing employees. The reset_comm procedure invokes the private validation function before changing the standard commission in std_comm. In the example, note the following:

- The std_comm variable referenced in the reset_comm procedure is a public variable. Variables declared in the package specification, such as std_comm, can be directly referenced without qualification.
- The reset_comm procedure implements the public definition in the specification.
- In the comm_pkg body, the validate function is private and is directly referenced from the reset_comm procedure without qualification.

Note: The validate function appears before the reset_comm procedure because the reset_comm procedure references the validate function. It is possible to create forward declarations for subprograms in the package body if their order of appearance needs to be changed. If a package specification declares only types, constants, variables, and exceptions without any subprogram specifications, then the package body is unnecessary. However, the body can be used to initialize items declared in the package specification.

Invoking Package Subprograms

- **Invoke a function within the same package:**

```
CREATE OR REPLACE PACKAGE BODY comm_pkg IS ...  
  PROCEDURE reset_comm(new_comm NUMBER) IS  
  BEGIN  
    IF validate(new_comm) THEN  
      std_comm := new_comm;  
    ELSE ...  
    END IF;  
  END reset_comm;  
END comm_pkg;
```

- **Invoke a package procedure from *iSQL*Plus*:**

```
EXECUTE comm_pkg.reset_comm(0.15)
```

- **Invoke a package procedure in a different schema:**

```
EXECUTE scott.comm_pkg.reset_comm(0.15)
```

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Invoking Package Subprograms

After the package is stored in the database, you can invoke public or private subprograms within the same package, or public subprograms if external to the package. Fully qualify the subprogram with its package name when invoked externally from the package. Use the `package_name.subprogram` syntax.

Fully qualifying a subprogram when invoked within the same package is optional.

Example 1: Invokes the `validate` function from the `reset_comm` procedure within the same package. The package name prefix is not required; it is optional.

Example 2: Calls the `reset_comm` procedure from *iSQL*Plus* (an environment external to the package) to reset the prevailing commission to 0.15 for the user session.

Example 3: Calls the `reset_comm` procedure that is owned in a schema user called SCOTT. Using *iSQL*Plus*, the qualified package procedure is prefixed with the schema name. This can be simplified by using a synonym that references the `schema.package_name`.

Assume that a database link named NY has been created for a remote database in which the `reset_comm` package procedure is created. To invoke the remote procedure, use:

```
EXECUTE comm_pkg.reset_comm@NY(0.15)
```

Creating and Using Bodiless Packages

```
CREATE OR REPLACE PACKAGE global_consts IS
    mile_2_kilo      CONSTANT  NUMBER  :=  1.6093;
    kilo_2_mile      CONSTANT  NUMBER  :=  0.6214;
    yard_2_meter     CONSTANT  NUMBER  :=  0.9144;
    meter_2_yard     CONSTANT  NUMBER  :=  1.0936;
END global_consts;
```

```
BEGIN  DBMS_OUTPUT.PUT_LINE('20 miles = ' ||
    20 * global_consts.mile_2_kilo || ' km');
END;
```

```
CREATE FUNCTION mtr2yrd(m NUMBER) RETURN NUMBER IS
BEGIN
    RETURN (m * global_consts.meter_2_yard);
END mtr2yrd;
/
EXECUTE DBMS_OUTPUT.PUT_LINE(mtr2yrd(1))
```

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Creating and Using Bodiless Packages

The variables and constants declared within stand-alone subprograms exist only for the duration that the subprogram executes. To provide data that exists for the duration of the user session, create a package specification containing public (global) variables and constant declarations. In this case, create a package specification without a package body, known as a *bodiless package*. As discussed earlier in this lesson, if a specification declares only types, constants, variables, and exceptions, then the package body is unnecessary.

Examples

The first code box in the slide creates a bodiless package specification with several constants to be used for conversion rates. A package body is not required to support this package specification.

The second code box references the `mile_2_kilo` constant in the `global_consts` package by prefixing the package name to the identifier of the constant.

The third example creates a stand-alone function `mtr2yrd` to convert meters to yards, and uses the constant conversion rate `meter_2_yard` declared in the `global_consts` package. The function is invoked in a `DBMS_OUTPUT.PUT_LINE` parameter.

Rule to be followed: When referencing a variable, cursor, constant, or exception from outside the package, you must qualify it with the name of the package.

Removing Packages

- To remove the package specification and the body, use the following syntax:

```
DROP PACKAGE package_name;
```

- To remove the package body, use the following syntax:

```
DROP PACKAGE BODY package_name;
```

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Removing Packages

When a package is no longer required, you can use a SQL statement in *iSQL*Plus* to remove it. A package has two parts; therefore, you can remove the whole package, or you can remove only the package body and retain the package specification.

Viewing Packages in the Data Dictionary

The source code for PL/SQL packages is maintained and is viewable through the `USER_SOURCE` and `ALL_SOURCE` tables in the data dictionary.

- To view the package specification, use:

```
SELECT text
FROM   user_source
WHERE  name = 'COMM_PKG' AND type = 'PACKAGE';
```

- To view the package body, use:

```
SELECT text
FROM   user_source
WHERE  name = 'COMM_PKG' AND type = 'PACKAGE BODY';
```

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Viewing Packages in the Data Dictionary

The source code for PL/SQL packages is also stored in the data dictionary tables such as stand-alone procedures and functions. The source code is viewable in the data dictionary when you execute a `SELECT` statement on the `USER_SOURCE` and `ALL_SOURCE` tables.

When querying the package, use a condition in which the `TYPE` column is:

- Equal to 'PACKAGE' to display the source code for the package specification
- Equal to 'PACKAGE BODY' to display the source code for the package body

Note: The values of the `NAME` and `TYPE` columns must be uppercase.

Guidelines for Writing Packages

- **Construct packages for general use.**
- **Define the package specification before the body.**
- **The package specification should contain only those constructs that you want to be public.**
- **Place items in the declaration part of the package body when you must maintain them throughout a session or across transactions.**
- **Changes to the package specification require recompilation of each referencing subprogram.**
- **The package specification should contain as few constructs as possible.**

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Guidelines for Writing Packages

Keep your packages as general as possible, so that they can be reused in future applications. Also, avoid writing packages that duplicate features provided by the Oracle server.

Package specifications reflect the design of your application, so define them before defining the package bodies. The package specification should contain only those constructs that must be visible to the users of the package. Thus, other developers cannot misuse the package by basing code on irrelevant details.

Place items in the declaration part of the package body when you must maintain them throughout a session or across transactions. For example, declare a variable called `NUMBER_EMPLOYED` as a private variable if each call to a procedure that uses the variable needs to be maintained. When declared as a global variable in the package specification, the value of that global variable is initialized in a session the first time a construct from the package is invoked.

Changes to the package body do not require recompilation of dependent constructs, whereas changes to the package specification require recompilation of every stored subprogram that references the package. To reduce the need for recompiling when code is changed, place as few constructs as possible in a package specification.

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Oracle Database 10g: Develop PL/SQL Program Units 3-16

Advantages of Using Packages

- **Added functionality: Persistency of variables and cursors**
- **Better performance:**
 - The entire package is loaded into memory when the package is first referenced.
 - There is only one copy in memory for all users.
 - The dependency hierarchy is simplified.
- **Overloading: Multiple subprograms of the same name**

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Advantages of Using Packages (continued)

Added functionality: Packaged public variables and cursors persist for the duration of a session. Thus, they can be shared by all subprograms that execute in the environment. They also enable you to maintain data across transactions without having to store it in the database. Private constructs also persist for the duration of the session but can be accessed only within the package.

Better performance: When you call a packaged subprogram the first time, the entire package is loaded into memory. Later calls to related subprograms in the package therefore require no further disk I/O. Packaged subprograms also stop cascading dependencies and thus avoid unnecessary compilation.

Overloading: With packages, you can overload procedures and functions, which means you can create multiple subprograms with the same name in the same package, each taking parameters of different number or data type.

Note: Dependencies are covered in detail in the lesson titled “Managing Dependencies.”

Summary

In this lesson, you should have learned how to:

- **Improve code organization, management, security, and performance by using packages**
- **Create and remove package specifications and bodies**
- **Group related procedures and functions together in a package**
- **Encapsulate the code in a package body**
- **Define and use components in bodiless packages**
- **Change a package body without affecting a package specification**

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Summary

You group related procedures and function together in a package. Packages improve organization, management, security, and performance.

A package consists of a package specification and a package body. You can change a package body without affecting its package specification.

Packages enable you to hide source code from users. When you invoke a package for the first time, the entire package is loaded into memory. This reduces the disk access for subsequent calls.

Summary

Command	Task
CREATE [OR REPLACE] PACKAGE	Create (or modify) an existing package specification.
CREATE [OR REPLACE] PACKAGE BODY	Create (or modify) an existing package body.
DROP PACKAGE	Remove both the package specification and package body.
DROP PACKAGE BODY	Remove only the package body.

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Summary (continued)

You can create, delete, and modify packages. You can remove both package specification and body by using the **DROP PACKAGE** command. You can drop the package body without affecting its specification.

Practice 3: Overview

This practice covers the following topics:

- **Creating packages**
- **Invoking package program units**

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Practice 3: Overview

In this practice, you create package specifications and package bodies. You invoke the constructs in the packages by using sample data.

Note: If you are using SQL Developer, your compile time errors are displayed in the Message Log. If you are using SQL*Plus or iSQL*Plus to create your stored code, use the `SHOW ERRORS` to view compile errors.

Practice 3

1. Create a package specification and body called JOB_PKG, containing a copy of your ADD_JOB, UPD_JOB, and DEL_JOB procedures as well as your GET_JOB function.
Tip: Consider saving the package specification and body in two separate files (for example, p3q1_s.sql and p3q1_b.sql for the package specification and body, respectively). Include a SHOW ERRORS after the CREATE PACKAGE statement in each file. Alternatively, place all code in one file.

Note: Use the code in your previously saved script files when creating the package.

- a. Create the package specification including the procedures and function headings as public constructs.
Note: Consider whether you still need the stand-alone procedures and functions you just packaged.
- b. Create the package body with the implementations for each of the subprograms.
- c. Invoke your ADD_JOB package procedure by passing the values IT_SYSAN and SYSTEMS ANALYST as parameters.
- d. Query the JOBS table to see the result.

JOB_ID	JOB_TITLE	MIN_SALARY	MAX_SALARY
IT_SYSAN	Systems Analyst		

2. Create and invoke a package that contains private and public constructs.
 - a. Create a package specification and package body called EMP_PKG that contains your ADD_EMPLOYEE and GET_EMPLOYEE procedures as public constructs, and include your VALID_DEPTID function as a private construct.
 - b. Invoke the EMP_PKG.ADD_EMPLOYEE procedure, using department ID 15 for employee Jane Harris with the e-mail ID JAHARRIS. Because department ID 15 does not exist, you should get an error message as specified in the exception handler of your procedure.
 - c. Invoke the ADD_EMPLOYEE package procedure by using department ID 80 for employee David Smith with the e-mail ID DASMITH.

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Using More Package Concepts

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Objectives

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

- **Overload package procedures and functions**
- **Use forward declarations**
- **Create an initialization block in a package body**
- **Manage persistent package data states for the life of a session**
- **Use PL/SQL tables and records in packages**
- **Wrap source code stored in the data dictionary so that it is not readable**

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Lesson Aim

This lesson introduces the more advanced features of PL/SQL, including overloading, forward referencing, one-time-only procedures, and the persistency of variables, constants, exceptions, and cursors. It also explains the effect of packaging functions that are used in SQL statements.

Overloading Subprograms

The overloading feature in PL/SQL:

- Enables you to create two or more subprograms with the same name
- Requires that the subprogram's formal parameters differ in number, order, or data type family
- Enables you to build flexible ways for invoking subprograms with different data
- Provides a way to extend functionality without loss of existing code

Note: Overloading can be done with local subprograms, package subprograms, and type methods, but not with stand-alone subprograms.

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Overloading Subprograms

The overloading feature in PL/SQL enables you to develop two or more packaged subprograms with the same name. Overloading is useful when you want a subprogram to accept similar sets of parameters that have different data types. For example, the TO_CHAR function has more than one way to be called, enabling you to convert a number or a date to a character string.

PL/SQL allows overloading of package subprogram names and object type methods.

The key rule is that you can use the same name for different subprograms as long as their formal parameters differ in number, order, or data type family.

Consider using overloading when:

- Processing rules for two or more subprograms are similar, but the type or number of parameters used varies
- Providing alternative ways for finding different data with varying search criteria. For example, you may want to find employees by their employee ID and also provide a way to find employees by their last name. The logic is intrinsically the same, but the parameters or search criteria differ.
- Extending functionality when you do not want to replace existing code

Note: Stand-alone subprograms cannot be overloaded. Writing local subprograms in object type methods is not discussed in this course.

Overloading Subprograms (continued)

Restrictions

You cannot overload:

- Two subprograms if their formal parameters differ only in data type and the different data types are in the same family (NUMBER and DECIMAL belong to the same family.)
- Two subprograms if their formal parameters differ only in subtype and the different subtypes are based on types in the same family (VARCHAR and STRING are PL/SQL subtypes of VARCHAR2.)
- Two functions that differ only in return type, even if the types are in different families

You get a run-time error when you overload subprograms with the preceding features.

Note: The preceding restrictions apply if the names of the parameters are also the same. If you use different names for the parameters, you can invoke the subprograms by using named notation for the parameters.

Resolving Calls

The compiler tries to find a declaration that matches the call. It searches first in the current scope and then, if necessary, in successive enclosing scopes. The compiler stops searching if it finds one or more subprogram declarations in which the name matches the name of the called subprogram. For similarly named subprograms at the same level of scope, the compiler needs an exact match in number, order, and data type between the actual and formal parameters.

Overloading: Example

```
CREATE OR REPLACE PACKAGE dept_pkg IS
  PROCEDURE add_department(deptno NUMBER,
    name VARCHAR2 := 'unknown', loc NUMBER := 1700);
  PROCEDURE add_department(
    name VARCHAR2 := 'unknown', loc NUMBER := 1700);
END dept_pkg;
/
```

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Overloading: Example

The slide shows the dept_pkg package specification with an overloaded procedure called add_department. The first declaration takes three parameters that are used to provide data for a new department record inserted into the department table. The second declaration takes only two parameters because this version internally generates the department ID through an Oracle sequence.

Note: The example uses basic data types for its arguments to ensure that the example fits in the space provided. It is better to specify data types using the %TYPE attribute for variables that are used to populate columns in database tables, as in the following example:

```
PROCEDURE add_department
(deptno departments.department_id%TYPE,
 name departments.department_name%TYPE := 'unknown',
 loc departments.location_id%TYPE := 1700);
```

Overloading: Example

```
CREATE OR REPLACE PACKAGE BODY dept_pkg IS
  PROCEDURE add_department (deptno NUMBER,
    name VARCHAR2:='unknown', loc NUMBER:=1700) IS
  BEGIN
    INSERT INTO departments(department_id,
      department_name, location_id)
    VALUES (deptno, name, loc);
  END add_department;

  PROCEDURE add_department (
    name VARCHAR2:='unknown', loc NUMBER:=1700) IS
  BEGIN
    INSERT INTO departments (department_id,
      department_name, location_id)
    VALUES (departments_seq.NEXTVAL, name, loc);
  END add_department;
END dept_pkg;
/
```

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Overloading: Example (continued)

If you call `add_department` with an explicitly provided department ID, then PL/SQL uses the first version of the procedure. Consider the following example:

```
EXECUTE dept_pkg.add_department(980, 'Education', 2500)
SELECT * FROM departments
WHERE department_id = 980;
```

DEPARTMENT_ID	DEPARTMENT_NAME	MANAGER_ID	LOCATION_ID
980	Education		2500

If you call `add_department` with no department ID, PL/SQL uses the second version:

```
EXECUTE dept_pkg.add_department ('Training', 2400)
SELECT * FROM departments
WHERE department_name = 'Training';
```

DEPARTMENT_ID	DEPARTMENT_NAME	MANAGER_ID	LOCATION_ID
320	Training		2400

Overloading and the STANDARD Package

- A package named **STANDARD** defines the PL/SQL environment and built-in functions.
- Most built-in functions are overloaded. An example is the **TO_CHAR** function:

```
FUNCTION TO_CHAR (p1 DATE) RETURN VARCHAR2;  
FUNCTION TO_CHAR (p2 NUMBER) RETURN VARCHAR2;  
FUNCTION TO_CHAR (p1 DATE, P2 VARCHAR2) RETURN  
VARCHAR2;  
FUNCTION TO_CHAR (p1 NUMBER, P2 VARCHAR2) RETURN  
VARCHAR2;
```

- A PL/SQL subprogram with the same name as a built-in subprogram overrides the standard declaration in the local context, unless you qualify the built-in subprogram with its package name.

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Overloading and the STANDARD Package

A package named **STANDARD** defines the PL/SQL environment and globally declares types, exceptions, and subprograms that are available automatically to PL/SQL programs. Most of the built-in functions that are found in the **STANDARD** package are overloaded. For example, the **TO_CHAR** function has four different declarations, as shown in the slide. The **TO_CHAR** function can take either the **DATE** or the **NUMBER** data type and convert it to the character data type. The format to which the date or number has to be converted can also be specified in the function call.

If you redeclare a built-in subprogram in another PL/SQL program, then your local declaration overrides the standard or built-in subprogram. To be able to access the built-in subprogram, you must qualify it with its package name. For example, if you redeclare the **TO_CHAR** function to access the built-in function, then you refer to it as **STANDARD.TO_CHAR**.

If you redeclare a built-in subprogram as a stand-alone subprogram, then to access your subprogram you must qualify it with your schema name: for example, **SCOTT.TO_CHAR**.

Using Forward Declarations

- **Block-structured languages (such as PL/SQL) must declare identifiers before referencing them.**
- **Example of a referencing problem:**

```
CREATE OR REPLACE PACKAGE BODY forward_pkg IS
  PROCEDURE award_bonus(. . .) IS
  BEGIN
    calc_rating (. . .);    --illegal reference
  END;

  PROCEDURE calc_rating (. . .) IS
  BEGIN
    ...
  END;
END forward_pkg;
/
```

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Using Forward Declarations

In general, PL/SQL is like other block-structured languages and does not allow forward references. You must declare an identifier before using it. For example, a subprogram must be declared before you can call it.

Coding standards often require that subprograms be kept in alphabetical sequence to make them easy to find. In this case, you may encounter problems, as shown in the slide example, where the `calc_rating` procedure cannot be referenced because it has not yet been declared.

You can solve the illegal reference problem by reversing the order of the two procedures. However, this easy solution does not work if the coding rules require subprograms to be declared in alphabetical order.

The solution in this case is to use forward declarations provided in PL/SQL. A forward declaration enables you to declare the heading of a subprogram, that is, the subprogram specification terminated by a semicolon.

Note: The compilation error for `calc_rating` occurs only if `calc_rating` is a private packaged procedure. If `calc_rating` is declared in the package specification, it is already declared as if it was a forward declaration, and its reference can be resolved by the compiler.

Using Forward Declarations

In the package body, a forward declaration is a private subprogram specification terminated by a semicolon.

```
CREATE OR REPLACE PACKAGE BODY forward_pkg IS
→ PROCEDURE calc_rating (...); -- forward declaration
    -- Subprograms defined in alphabetical order

    PROCEDURE award_bonus(...) IS
    BEGIN
        calc_rating (...);          -- reference resolved!
        . . .
    END;

    PROCEDURE calc_rating (...) IS -- implementation
    BEGIN
        . . .
    END;
END forward_pkg;
```

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Using Forward Declarations (continued)

As previously mentioned, PL/SQL enables you to create a special subprogram declaration called a forward declaration. A forward declaration may be required for private subprograms in the package body, and consists of the subprogram specification terminated by a semicolon. Forward declarations help to:

- Define subprograms in logical or alphabetical order
- Define mutually recursive subprograms. Mutually recursive programs are programs that call each other directly or indirectly.
- Group and logically organize subprograms in a package body

When creating a forward declaration:

- The formal parameters must appear in both the forward declaration and the subprogram body
- The subprogram body can appear anywhere after the forward declaration, but both must appear in the same program unit

Forward Declarations and Packages

Typically, the subprogram specifications go in the package specification, and the subprogram bodies go in the package body. The public subprogram declarations in the package specification do not require forward declarations.

Package Initialization Block

The block at the end of the package body executes once and is used to initialize public and private package variables.

```
CREATE OR REPLACE PACKAGE taxes IS
  tax    NUMBER;
  ... -- declare all public procedures/functions
END taxes;
/
CREATE OR REPLACE PACKAGE BODY taxes IS
  ... -- declare all private variables
  ... -- define public/private procedures/functions
  BEGIN
    SELECT    rate_value INTO tax
    FROM      tax_rates
    WHERE     rate_name = 'TAX';
  END taxes;
/
```

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Package Initialization Block

The first time a component in a package is referenced, the entire package is loaded into memory for the user session. By default, the initial value of variables is NULL (if not explicitly initialized). To initialize package variables, you can:

- Use assignment operations in their declarations for simple initialization tasks
- Add code block to the end of a package body for more complex initialization tasks

Consider the block of code at the end of a package body as a package initialization block that executes once, when the package is first invoked within the user session.

The example in the slide shows the `tax` public variable being initialized to the value in the `tax_rates` table the first time the `taxes` package is referenced.

Note: If you initialize the variable in the declaration by using an assignment operation, it is overwritten by the code in the initialization block at the end of the package body. The initialization block is terminated by the `END` keyword for the package body.

Using Package Functions in SQL and Restrictions

- **Package functions can be used in SQL statements.**
- **Functions called from:**
 - **A query or DML statement must not end the current transaction, create or roll back to a savepoint, or alter the system or session**
 - **A query or a parallelized DML statement cannot execute a DML statement or modify the database**
 - **A DML statement cannot read or modify the table being changed by that DML statement**

Note: A function calling subprograms that break the preceding restrictions is not allowed.

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Using Package Functions in SQL and Restrictions

When executing a SQL statement that calls a stored function, the Oracle server must know the purity level of stored functions, that is, whether the functions are free of the restrictions listed in the slide. In general, restrictions are changes to database tables or public package variables (those declared in a package specification). Restrictions can delay the execution of a query, yield order-dependent (therefore indeterminate) results, or require that the package state variables be maintained across user sessions. Various restrictions are not allowed when a function is called from a SQL query or a DML statement. Therefore, the following restrictions apply to stored functions called from SQL expressions:

- A function called from a query or DML statement cannot end the current transaction, create or roll back to a savepoint, or alter the system or session.
- A function called from a query statement or from a parallelized DML statement cannot execute a DML statement or otherwise modify the database.
- A function called from a DML statement cannot read or modify the particular table being modified by that DML statement.

Note: Prior to Oracle8i, the purity level was checked at compilation time by including `PRAGMA RESTRICT_REFERENCES` in the package specification. Since Oracle8i, the purity level of functions is checked at run time.

Package Function in SQL: Example

```
CREATE OR REPLACE PACKAGE taxes_pkg IS
  FUNCTION tax (value IN NUMBER) RETURN NUMBER;
END taxes_pkg;
/
CREATE OR REPLACE PACKAGE BODY taxes_pkg IS
  FUNCTION tax (value IN NUMBER) RETURN NUMBER IS
    rate NUMBER := 0.08;
  BEGIN
    RETURN (value * rate);
  END tax;
END taxes_pkg;
/
```

```
SELECT taxes_pkg.tax(salary), salary, last_name
FROM   employees;
```

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Package Function in SQL: Example

The first code box shows how to create the package specification and the body encapsulating the tax function in the `taxes_pkg` package. The second code box shows how to call the packaged tax function in the `SELECT` statement. The output results are similar to:

TAXES_PACK.TAX(SALARY)	SALARY	LAST_NAME
1920	24000	King
1360	17000	Kochhar
1360	17000	De Haan
720	9000	Hunold
480	6000	Ernst
422.4	5280	Austin
422.4	5280	Pataballa
369.6	4620	Lorentz
960	12000	Greenberg

■ ■ ■

109 rows selected.

Note: If you are using Oracle versions prior to 8i, then you must assert the purity level of the function in the package specification by using `PRAGMA RESTRICT_REFERENCES`. If this is not specified, you get an error message saying that the `TAX` function does not guarantee that it will not update the database while invoking the package function in a query.

Persistent State of Packages

The collection of package variables and the values define the package state. The package state is:

- **Initialized when the package is first loaded**
- **Persistent (by default) for the life of the session**
 - **Stored in the User Global Area (UGA)**
 - **Unique to each session**
 - **Subject to change when package subprograms are called or public variables are modified**
- **Not persistent for the session but persistent for the life of a subprogram call when using `PRAGMA SERIALLY_REUSABLE` in the package specification**

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Persistent State of Packages

The collection of public and private package variables represents the package state for the user session. That is, the package state is the set of values stored in all the package variables at a given point in time. In general, the package state exists for the life of the user session.

Package variables are initialized the first time a package is loaded into memory for a user session. The package variables are, by default, unique to each session and hold their values until the user session is terminated. In other words, the variables are stored in the UGA memory allocated by the database for each user session.

The package state changes when a package subprogram is invoked and its logic modifies the variable state. Public package state can be directly modified by operations appropriate to its type.

Note: If you add `PRAGMA SERIALLY_REUSABLE` to the package specification, then the database stores package variables in the System Global Area (SGA) shared across user sessions. In this case, the package state is maintained for the life of a subprogram call or a single reference to a package construct. The `SERIALLY_REUSABLE` directive is useful if you want to conserve memory and if the package state does not need to persist for each user session.

Persistent State of Package Variables: Example

		State for: -Scott-		-Jones-	
Time	Events	STD	MAX	STD	MAX
9:00	Scott> EXECUTE comm_pkg.reset_comm(0.25)	0.10 0.25	0.4	-	0.4
9:30	Jones> INSERT INTO employees(last_name,commission_pct) VALUES('Madonna', 0.8);	0.25	0.4		0.8
9:35	Jones> EXECUTE comm_pkg.reset_comm(0.5)	0.25	0.4	0.1 0.5	0.8
10:00	Scott> EXECUTE comm_pkg.reset_comm(0.6) Err -20210 'Bad Commission'	0.25	0.4	0.5	0.8
11:00	Jones> ROLLBACK;	0.25	0.4	0.5	0.4
11:01	EXIT ...	0.25	0.4	-	0.4
12:00	EXEC comm_pkg.reset_comm(0.2)	0.25	0.4	0.2	0.4

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Persistent State of Package Variables: Example

The slide sequence is based on two different users, Scott and Jones, executing `comm_pkg` (covered in the lesson titled “Creating Packages”), in which the `reset_comm` procedure invokes the `validate` function to check the new commission. The example shows how the persistent state of the `std_comm` package variable is maintained in each user session.

At 9:00: Scott calls `reset_comm` with a new commission value of 0.25, the package state for `std_comm` is initialized to 0.10 and then set to 0.25, which is validated because it is less than the database maximum value of 0.4.

At 9:30: Jones inserts a new row into the `EMPLOYEES` table with a new maximum `commission_pct` value of 0.8. This is not committed, so it is visible to Jones only. Scott’s state is unaffected.

At 9:35: Jones calls `reset_comm` with a new commission value of 0.5. The state for Jones’s `std_comm` is first initialized to 0.10 and then set to the new value 0.5 that is valid for his session with the database maximum value of 0.8.

At 10:00: Scott calls with `reset_comm` with a new commission value of 0.6, which is greater than the maximum database commission visible to his session, that is, 0.4 (Jones did not commit the 0.8 value.)

Between 11:00 and 12:00: Jones rolls back the transaction and exits the session. Jones logs in at 11:45 and successfully executes the procedure, setting his state to 0.2.

Persistent State of a Package Cursor

```
CREATE OR REPLACE PACKAGE BODY curs_pkg IS
  CURSOR c IS SELECT employee_id FROM employees;
  PROCEDURE open IS
  BEGIN
    IF NOT c%ISOPEN THEN OPEN c; END IF;
  END open;
  FUNCTION next(n NUMBER := 1) RETURN BOOLEAN IS
    emp_id employees.employee_id%TYPE;
  BEGIN
    FOR count IN 1 .. n LOOP
      FETCH c INTO emp_id;
      EXIT WHEN c%NOTFOUND;
      DBMS_OUTPUT.PUT_LINE('Id: ' || (emp_id));
    END LOOP;
    RETURN c%FOUND;
  END next;
  PROCEDURE close IS BEGIN
    IF c%ISOPEN THEN CLOSE c; END IF;
  END close;
END curs_pkg;
```

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Persistent State of a Package Cursor

The code in the slide shows the package body for CURS_PKG to support the following package specification:

```
CREATE OR REPLACE PACKAGE curs_pkg IS
  PROCEDURE open;
  FUNCTION next(n NUMBER := 1) RETURN BOOLEAN;
  PROCEDURE close;
END curs_pkg;
```

To use this package, perform the following steps to process the rows:

- Call the open procedure to open the cursor.
- Call the next procedure to fetch one or a specified number of rows. If you request more rows than actually exist, the procedure successfully handles termination. It returns TRUE if more rows need to be processed; otherwise it returns FALSE.
- Call the close procedure to close the cursor, before or at the end of processing the rows.

Note: The cursor declaration is private to the package. Therefore the cursor state can be influenced by invoking the package procedure and functions listed in the slide.

Executing CURS_PKG

```
SET SERVEROUTPUT ON
EXECUTE curs_pkg.open
DECLARE
    more BOOLEAN := curs_pkg.next(3);
BEGIN
    IF NOT more THEN
        curs_pkg.close;
    END IF;
END;
/
RUN -- repeats execution on the anonymous block
EXECUTE curs_pkg.close
```

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Executing CURS_PKG

Recall that the state of a package variable or cursor persists across transactions within a session. However, the state does not persist across different sessions for the same user. The database tables hold data that persists across sessions and users. The SET SERVEROUTPUT ON command prepares iSQL*Plus to display output results. The call to curs_pkg.open opens the cursor, which remains open until the session is terminated, or the cursor is explicitly closed. The anonymous block executes the next function in the Declaration section, initializing the BOOLEAN variable more to TRUE, as there are more than three rows in the employees table. The block checks for the end of the result set and closes the cursor, if appropriate. When the block executes, it displays the first three rows:

```
Id :100
Id :101
Id :102
```

The RUN command executes the anonymous block again, and the next three rows are displayed:

```
Id :103
Id :104
Id :105
```

The EXECUTE curs_pkg.close command closes the cursor in the package.

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```
CREATE OR REPLACE PACKAGE BODY emp_pkg IS
    PROCEDURE get_employees(emps OUT emp_table_type) IS
        i BINARY_INTEGER := 0;
    BEGIN
        FOR emp_record IN (SELECT * FROM employees)
        LOOP
            emps(i) := emp_record;
            i := i+1;
        END LOOP;
    END get_employees;
END emp_pkg;
/
```

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PL/SQL Wrapper

- **The PL/SQL wrapper is a stand-alone utility that hides application internals by converting PL/SQL source code into portable object code.**
- **Wrapping has the following features:**
 - **Platform independence**
 - **Dynamic loading**
 - **Dynamic binding**
 - **Dependency checking**
 - **Normal importing and exporting when invoked**

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PL/SQL Wrapper

The PL/SQL wrapper is a stand-alone utility that converts PL/SQL source code into portable object code. Using it, you can deliver PL/SQL applications without exposing your source code, which may contain proprietary algorithms and data structures. The wrapper converts the readable source code into unreadable code. By hiding application internals, it prevents misuse of your application.

Wrapped code, such as PL/SQL stored programs, has several features:

- It is platform independent, so you do not need to deliver multiple versions of the same compilation unit.
- It permits dynamic loading, so users need not shut down and relink to add a new feature.
- It permits dynamic binding, so external references are resolved at load time.
- It offers strict dependency checking, so that invalidated program units are recompiled automatically when they are invoked.
- It supports normal importing and exporting, so the import/export utility can process wrapped files.

Running the Wrapper

The command-line syntax is:

```
WRAP INAME=input_file_name [ONAME=output_file_name]
```

- The **INAME** argument is required.
- The default extension for the input file is **.sql**, unless it is specified with the name.
- The **ONAME** argument is optional.
- The default extension for output file is **.plb**, unless specified with the **ONAME** argument.

Examples:

```
WRAP INAME=demo_04_hello.sql  
WRAP INAME=demo_04_hello  
WRAP INAME=demo_04_hello.sql ONAME=demo_04_hello.plb
```

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Running the Wrapper

The wrapper is an operating system executable called WRAP. To run the wrapper, enter the following command at your operating system prompt:

```
WRAP INAME=input_file_name [ONAME=output_file_name]
```

Each of the examples shown in the slide takes a file called `demo_04_hello.sql` as input and creates an output file called `demo_04_hello.plb`.

After the wrapped file is created, execute the `.plb` file from *iSQL*Plus* to compile and store the wrapped version of the source code, as you would execute SQL script files.

Note

- Only the **INAME** argument is required. If the **ONAME** argument is not specified, then the output file acquires the same name as the input file with an extension of **.plb**.
- The input file can have any extension, but the default is **.sql**.
- Case sensitivity of the **INAME** and **ONAME** values depends on the operating system.
- Generally, the output file is much larger than the input file.
- Do not put spaces around the equal signs in the **INAME** and **ONAME** arguments and values.

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- ```
CREATE PACKAGE banking IS
 min_bal := 100;
 no_funds EXCEPTION;
...
END banking;
/
```

- ```
CREATE PACKAGE banking
wrapped
012abc463e ...
/
```

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The input file can contain any combination of SQL statements. However, the PL/SQL wrapper wraps only the following CREATE statements:

- All other SQL CREATE statements are passed intact to the output file.

Guidelines for Wrapping

- **You must wrap only the package body, not the package specification.**
- **The wrapper can detect syntactic errors but cannot detect semantic errors.**
- **The output file should not be edited. You maintain the original source code and wrap again as required.**

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Guidelines for Wrapping

Guidelines include the following:

- When wrapping a package or object type, wrap only the body, not the specification. Thus, you give other developers the information they need to use the package without exposing its implementation.
- If your input file contains syntactic errors, the PL/SQL wrapper detects and reports them. However, the wrapper cannot detect semantic errors because it does not resolve external references. For example, the wrapper does not report an error if the table or view `amp` does not exist:

```
CREATE PROCEDURE raise_salary (emp_id INTEGER, amount
NUMBER) AS
BEGIN
    UPDATE emp    -- should be emp
    SET sal = sal + amount WHERE empno = emp_id;
END;
```

However, the PL/SQL compiler resolves external references. Therefore, semantic errors are reported when the wrapper output file (`.plb` file) is compiled.

- Because its contents are not readable, the output file should not be edited. To change a wrapped object, you need to modify the original source code and wrap the code again.

Summary

In this lesson, you should have learned how to:

- **Create and call overloaded subprograms**
- **Use forward declarations for subprograms**
- **Write package initialization blocks**
- **Maintain persistent package state**
- **Use the PL/SQL wrapper to wrap code**

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Summary

Overloading is a feature that enables you to define different subprograms with the same name. It is logical to give two subprograms the same name when the processing in both the subprograms is the same but the parameters passed to them vary.

PL/SQL permits a special subprogram declaration called a forward declaration. A forward declaration enables you to define subprograms in logical or alphabetical order, define mutually recursive subprograms, and group subprograms in a package.

A package initialization block is executed only when the package is first invoked within the other user session. You can use this feature to initialize variables only once per session.

You can keep track of the state of a package variable or cursor, which persists throughout the user session, from the time the user first references the variable or cursor to the time the user disconnects.

Using the PL/SQL wrapper, you can obscure the source code stored in the database to protect your intellectual property.

Practice 4: Overview

This practice covers the following topics:

- **Using overloaded subprograms**
- **Creating a package initialization block**
- **Using a forward declaration**
- **Using the `WRAP` utility to prevent the source code from being deciphered by humans**

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Practice 4: Overview

In this practice, you modify an existing package to contain overloaded subprograms and you use forward declarations. You also create a package initialization block within a package body to populate a PL/SQL table. You use the `WRAP` command-line utility to prevent the source code from being readable in the data dictionary tables.

Practice 4

1. Copy and modify the code for the EMP_PKG package that you created in Practice 3, Exercise 2, and overload the ADD_EMPLOYEE procedure.
 - a. In the package specification, add a new procedure called ADD_EMPLOYEE that accepts three parameters: the first name, last name, and department ID. Save and compile the changes.
 - b. Implement the new ADD_EMPLOYEE procedure in the package body so that it formats the e-mail address in uppercase characters, using the first letter of the first name concatenated with the first seven letters of the last name. The procedure should call the existing ADD_EMPLOYEE procedure to perform the actual INSERT operation using its parameters and formatted e-mail to supply the values. Save and compile the changes.
 - c. Invoke the new ADD_EMPLOYEE procedure using the name Samuel Joplin to be added to department 30.
2. In the EMP_PKG package, create two overloaded functions called GET_EMPLOYEE.
 - a. In the specification, add a GET_EMPLOYEE function that accepts the parameter called emp_id based on the employees.employee_id%TYPE type, and a second GET_EMPLOYEE function that accepts the parameter called family_name of type employees.last_name%TYPE. Both functions should return an EMPLOYEES%ROWTYPE. Save and compile the changes.
 - b. In the package body, implement the first GET_EMPLOYEE function to query an employee by his or her ID, and the second to use the equality operator on the value supplied in the family_name parameter. Save and compile the changes.
 - c. Add a utility procedure PRINT_EMPLOYEE to the package that accepts an EMPLOYEES%ROWTYPE as a parameter and displays the department_id, employee_id, first_name, last_name, job_id, and salary for an employee on one line, using DBMS_OUTPUT. Save and compile the changes.
 - d. Use an anonymous block to invoke the EMP_PKG.GET_EMPLOYEE function with an employee ID of 100 and family name of 'Joplin'. Use the PRINT_EMPLOYEE procedure to display the results for each row returned.
3. Because the company does not frequently change its departmental data, you improve performance of your EMP_PKG by adding a public procedure INIT_DEPARTMENTS to populate a private PL/SQL table of valid department IDs. Modify the VALID_DEPTID function to use the private PL/SQL table contents to validate department ID values.
 - a. In the package specification, create a procedure called INIT_DEPARTMENTS with no parameters.
 - b. In the package body, implement the INIT_DEPARTMENTS procedure to store all department IDs in a private PL/SQL index-by table named valid_departments containing BOOLEAN values. Use the department_id column value as the index to create the entry in the index-by table to indicate its presence, and assign the entry a value of TRUE. Declare the valid_departments variable and its type definition boolean_tabtype before all procedures in the body.

Practice 4 (continued)

- c. In the body, create an initialization block that calls the `INIT_DEPARTMENTS` procedure to initialize the table. Save and compile the changes.
4. Change `VALID_DEPTID` validation processing to use the private PL/SQL table of department IDs.
 - a. Modify `VALID_DEPTID` to perform its validation by using the PL/SQL table of department ID values. Save and compile the changes.
 - b. Test your code by calling `ADD_EMPLOYEE` using the name James Bond in department 15. What happens?
 - c. Insert a new department with ID 15 and name Security, and commit the changes.
 - d. Test your code again, by calling `ADD_EMPLOYEE` using the name James Bond in department 15. What happens?
 - e. Execute the `EMP_PKG.INIT_DEPARTMENTS` procedure to update the internal PL/SQL table with the latest departmental data.
 - f. Test your code by calling `ADD_EMPLOYEE` using the employee name James Bond, who works in department 15. What happens?
 - g. Delete employee James Bond and department 15 from their respective tables, commit the changes, and refresh the department data by invoking the `EMP_PKG.INIT_DEPARTMENTS` procedure.
5. Reorganize the subprograms in the package specification and the body so that they are in alphabetical sequence.
 - a. Edit the package specification and reorganize subprograms alphabetically. In *iSQL*Plus*, load and compile the package specification. What happens?
 - b. Edit the package body and reorganize all subprograms alphabetically. In *iSQL*Plus*, load and compile the package specification. What happens?
 - c. Fix the compilation error using a forward declaration in the body for the offending subprogram reference. Load and re-create the package body. What happens? Save the package code in a script file.

If you have time, complete the following exercise:

6. Wrap the `EMP_PKG` package body and re-create it.
 - a. Query the data dictionary to view the source for the `EMP_PKG` body.
 - b. Start a command window and execute the `WRAP` command-line utility to wrap the body of the `EMP_PKG` package. Give the output file name a `.plb` extension.
Hint: Copy the file (which you saved in step 5c) containing the package body to a file called `emp_pkb_b.sql`.
 - c. Using *iSQL*Plus*, load and execute the `.plb` file containing the wrapped source.
 - d. Query the data dictionary to display the source for the `EMP_PKG` package body again. Are the original source code lines readable?

5

Using Oracle-Supplied Packages in Application Development

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Objectives

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

- **Describe how the DBMS_OUTPUT package works**
- **Use UTL_FILE to direct output to operating system files**
- **Use the HTP package to generate a simple Web page**
- **Describe the main features of UTL_MAIL**
- **Call the DBMS_SCHEDULER package to schedule PL/SQL code for execution**

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Lesson Aim

In this lesson, you learn how to use some of the Oracle-supplied packages and their capabilities. This lesson focuses on the packages that generate text-based and Web-based output, e-mail processing, and the provided scheduling capabilities.

Using Oracle-Supplied Packages

The Oracle-supplied packages:

- Are provided with the Oracle server
- Extend the functionality of the database
- Enable access to certain SQL features that are normally restricted for PL/SQL

For example, the `DBMS_OUTPUT` package was originally designed to debug PL/SQL programs.

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Using Oracle-Supplied Packages

Packages are provided with the Oracle server to allow either of the following:

- PL/SQL access to certain SQL features
- The extension of the functionality of the database

You can use the functionality provided by these packages when creating your application, or you may simply want to use these packages as ideas when you create your own stored procedures.

Most of the standard packages are created by running `catproc.sql`. The `DBMS_OUTPUT` package is the one that you will be most familiar with during this course. You should know about this package if you attended the course *Oracle Database 10g: PL/SQL Fundamentals*.

List of Some Oracle-Supplied Packages

Here is an abbreviated list of some Oracle-supplied packages:

- DBMS_ALERT
- DBMS_LOCK
- DBMS_SESSION
- DBMS_OUTPUT
- HTP
- UTL_FILE
- UTL_MAIL
- DBMS_SCHEDULER

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List of Some Oracle-Supplied Packages

The list of PL/SQL packages provided with an Oracle database grows with the release of new versions. It would be impossible to cover the exhaustive set of packages and their functionality in this course. For more information, refer to the *PL/SQL Packages and Types Reference 10g* (previously known as the *PL/SQL Supplied Packages Reference*). This lesson covers the last five packages in this list.

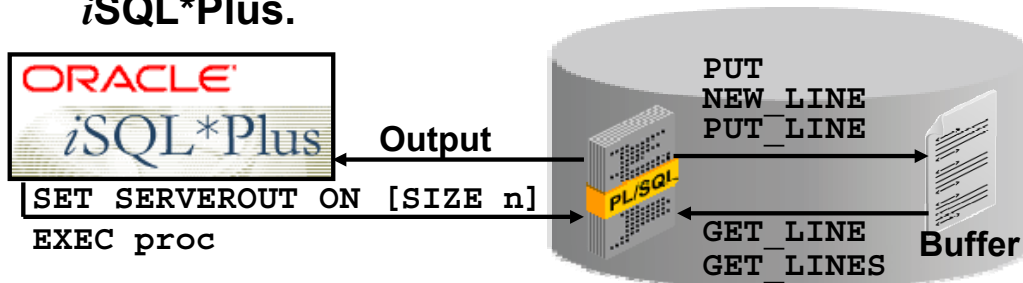
The following is a brief description about all the listed packages:

- DBMS_ALERT supports asynchronous notification of database events. Messages or alerts are sent on a COMMIT command.
- DBMS_LOCK is used to request, convert, and release locks through Oracle Lock Management services.
- DBMS_SESSION enables programmatic use of the ALTER SESSION SQL statement and other session-level commands.
- DBMS_OUTPUT provides debugging and buffering of text data.
- HTP package writes HTML-tagged data into database buffers.
- UTL_FILE enables reading and writing of operating system text files.
- UTL_MAIL enables composing and sending of e-mail messages.
- DBMS_SCHEDULER enables scheduling and automated execution of PL/SQL blocks, stored procedures, and external procedures and executables.

How the DBMS_OUTPUT Package Works

The DBMS_OUTPUT package enables you to send messages from stored subprograms and triggers.

- PUT and PUT_LINE place text in the buffer.
- GET_LINE and GET_LINES read the buffer.
- Messages are not sent until the sender completes.
- Use SET SERVEROUTPUT ON to display messages in iSQL*Plus.



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How the DBMS_OUTPUT Package Works

The DBMS_OUTPUT package sends textual messages from any PL/SQL block into a buffer in the database. Procedures provided by the package include the following:

- PUT appends text from the procedure to the current line of the line output buffer.
- NEW_LINE places an end-of-line marker in the output buffer.
- PUT_LINE combines the action of PUT and NEW_LINE (to trim leading spaces).
- GET_LINE retrieves the current line from the buffer into a procedure variable.
- GET_LINES retrieves an array of lines into a procedure-array variable.
- ENABLE/DISABLE enables and disables calls to DBMS_OUTPUT procedures.

The buffer size can be set by using:

- The SIZE n option appended to the SET SERVEROUTPUT ON command, where n is between 2,000 (the default) and 1,000,000 (1 million characters)
- An integer parameter between 2,000 and 1,000,000 in the ENABLE procedure

Practical Uses

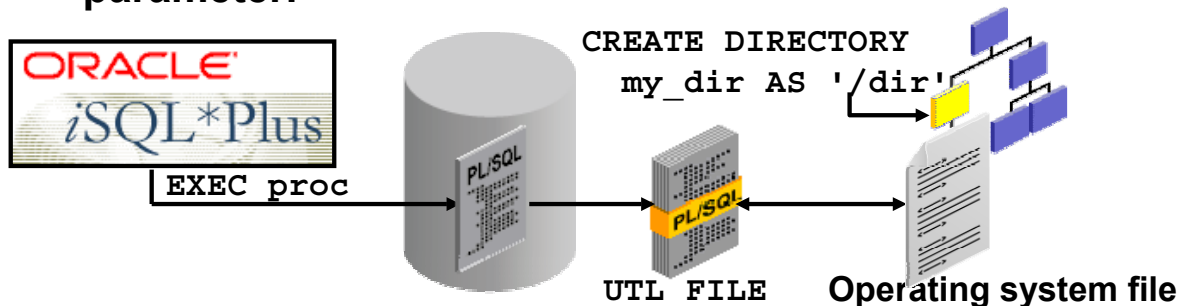
- You can output results to the window for debugging purposes.
- You can trace code execution path for a function or procedure.
- You can send messages between subprograms and triggers.

Note: There is no mechanism to flush output during the execution of a procedure.

Interacting with Operating System Files

The `UTL_FILE` package extends PL/SQL programs to read and write operating system text files. `UTL_FILE`:

- Provides a restricted version of operating system stream file I/O for text files
- Can access files in operating system directories defined by a `CREATE DIRECTORY` statement. You can also use the `utl_file_dir` database parameter.



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Interacting with Operating System Files

The Oracle-supplied `UTL_FILE` package is used to access text files in the operating system of the database server. The database provides read and write access to specific operating system directories by using:

- A `CREATE DIRECTORY` statement that associates an alias with an operating system directory. The database directory alias can be granted the `READ` and `WRITE` privileges to control the type of access to files in the operating system. For example:

```
CREATE DIRECTORY my_dir AS '/temp/my_files';  
GRANT READ, WRITE ON my_dir TO public.
```
- The paths specified in the `utl_file_dir` database initialization parameter

The preferred approach is to use the directory alias created by the `CREATE DIRECTORY` statement, which does not require the database to be restarted. The operating system directories specified by using either of these techniques should be accessible to and on the same machine as the database server processes. The path (directory) names may be case sensitive for some operating systems.

Note: The `DBMS_LOB` package can be used to read binary files on the operating system. `DBMS_LOB` is covered in the lesson titled “Manipulating Large Objects.”

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- ```

graph TD
 subgraph Reading_Flow [Reading from a file]
 R1[Open for reading] --> R2[Get lines from the text file]
 R2 --> R3{More to read?}
 R3 -- Yes --> R2
 R3 -- No --> R4[Close the text file]
 end
 subgraph Writing_Flow [Writing or appending to a file]
 W1[Open for write/append] --> W2[Put lines into the text file]
 W2 --> W3{More to write?}
 W3 -- Yes --> W2
 W3 -- No --> W4[Close the text file]
 end
 R4 --> W4

```
- Reading from a file:**
- Open for reading
  - Get lines from the text file  
`GET_LINE(f,buf,len)`
  - More to read?
    - Yes: Loop back to Get lines from the text file
    - No: Proceed to Close the text file
  - Close the text file  
`FCLOSE(f)`
- Writing or appending to a file:**
- Open for write/append
  - Put lines into the text file  
`PUT(f,buf)`  
`PUT_LINE(f,buf)`
  - More to write?
    - Yes: Loop back to Put lines into the text file
    - No: Proceed to Close the text file
  - Close the text file  
`FCLOSE(f)`

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Using the procedures and functions in the UTL\_FILE package, open files with the FOPEN function. You then either read from or write or append to the file until processing is done. After completing processing the file, close the file by using the FCLOSE procedure. The following are the subprograms:

- Oracle Database 10g: Develop PL/SQL Program Units 5-7**

## Exceptions in the UTL\_FILE Package

You may have to handle one of these exceptions when using UTL\_FILE subprograms:

- INVALID\_PATH
- INVALID\_MODE
- INVALID\_FILEHANDLE
- INVALID\_OPERATION
- READ\_ERROR
- WRITE\_ERROR
- INTERNAL\_ERROR

Other exceptions not in the UTL\_FILE package are:

- NO\_DATA\_FOUND and VALUE\_ERROR

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### Exceptions in the UTL\_FILE Package

The UTL\_FILE package declares seven exceptions that indicate an error condition in the operating system file processing. The UTL\_FILE exceptions are:

- INVALID\_PATH if the file location or file name was invalid
- INVALID\_MODE if the OPEN\_MODE parameter in FOPEN was invalid
- INVALID\_FILEHANDLE if the file handle was invalid
- INVALID\_OPERATION if the file could not be opened or operated on as requested
- READ\_ERROR if an operating system error occurred during the read operation
- WRITE\_ERROR if an operating system error occurred during the write operation
- INTERNAL\_ERROR if an unspecified error occurred in PL/SQL

**Note:** These exceptions must always be prefaced with the package name. UTL\_FILE procedures can also raise predefined PL/SQL exceptions such as NO\_DATA\_FOUND or VALUE\_ERROR.

The NO\_DATA\_FOUND exception is raised when reading past the end of a file by using UTL\_FILE.GET\_LINE or UTL\_FILE.GET\_LINES.

## FOPEN and IS\_OPEN Function Parameters

```
FUNCTION FOPEN (location IN VARCHAR2,
 filename IN VARCHAR2,
 open_mode IN VARCHAR2)
RETURN UTL_FILE.FILE_TYPE;
```

```
FUNCTION IS_OPEN (file IN FILE_TYPE)
RETURN BOOLEAN;
```

### Example:

```
CREATE PROCEDURE read_file(dir VARCHAR2, filename
 VARCHAR2) IS file UTL_FILE.FILE_TYPE;
...
BEGIN
 ...
 IF NOT UTL_FILE.IS_OPEN(file) THEN
 file := UTL_FILE.FOPEN (dir, filename, 'R');
 ...
 END IF;
END read_file;
```

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## FOPEN and IS\_OPEN Function Parameters

The parameters include the following:

- **location** parameter: Specifies the name of a directory alias defined by a CREATE DIRECTORY statement, or an operating system-specific path specified by using the utl\_file\_dir database parameter
- **filename** parameter: Specifies the name of the file, including the extension, without any path information
- **open\_mode** string: Specifies how the file is to be opened. Values are:
  - 'r' for reading text (use GET\_LINE)
  - 'w' for writing text (PUT, PUT\_LINE, NEW\_LINE, PUTF, FFLUSH)
  - 'a' for appending text (PUT, PUT\_LINE, NEW\_LINE, PUTF, FFLUSH)

The return value from FOPEN is a file handle whose type is UTL\_FILE.FILE\_TYPE. The handle must be used on subsequent calls to routines that operate on the opened file.

The IS\_OPEN function parameter is the file handle. The IS\_OPEN function tests a file handle to see whether it identifies an opened file. It returns a Boolean value of TRUE if the file has been opened; otherwise it returns a value of FALSE indicating that the file has not been opened. The slide example shows how to combine the use of the two subprograms.

**Note:** For the full syntax, refer to the *PL/SQL Packages and Types Reference*.



## Using UTL\_FILE: Example

```
CREATE OR REPLACE PROCEDURE sal_status(
 dir IN VARCHAR2, filename IN VARCHAR2) IS
 file UTL_FILE.FILE_TYPE;
CURSOR empc IS
 SELECT last_name, salary, department_id
 FROM employees ORDER BY department_id;
newdeptno employees.department_id%TYPE;
olddeptno employees.department_id%TYPE := 0;
BEGIN
 file:= UTL_FILE.FOPEN (dir, filename, 'w');
 UTL_FILE.PUT_LINE(file,
 'REPORT: GENERATED ON ' || SYSDATE);
 UTL_FILE.NEW_LINE (file); ...
```

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### Using UTL\_FILE: Example

In the example, the `sal_status` procedure creates a report of employees for each department, along with their salaries. The data is written to a text file by using the `UTL_FILE` package. In the code example, the variable `file` is declared as `UTL_FILE.FILE_TYPE`, a package type that is a record with a field called `ID` of the `BINARY_INTEGER` data type. For example:

```
TYPE file_type IS RECORD (id BINARY_INTEGER);
```

The field of `FILE_TYPE` record is private to the `UTL_FILE` package and should never be referenced or changed. The `sal_status` procedure accepts two parameters:

- The `dir` parameter for the name of the directory in which to write the text file
- The `filename` parameter to specify the name of the file

For example, to call the procedure, use the following:

```
EXECUTE sal_status('MY_DIR', 'salreport.txt')
```

**Note:** The directory location used (`MY_DIR`) must be in uppercase characters if it is a directory alias created by a `CREATE DIRECTORY` statement. When reading a file in a loop, the loop should exit when it detects the `NO_DATA_FOUND` exception. The `UTL_FILE` output is sent synchronously. `DBMS_OUTPUT` procedures do not produce output until the procedure is completed.



## Using UTL\_FILE: Example

```
FOR emp_rec IN empc LOOP
 IF emp_rec.department_id <> olddeptno THEN
 UTL_FILE.PUT_LINE (file,
 'DEPARTMENT: ' || emp_rec.department_id);
 UTL_FILE.NEW_LINE (file);
 END IF;
 UTL_FILE.PUT_LINE (file,
 ' EMPLOYEE: ' || emp_rec.last_name ||
 ' earns: ' || emp_rec.salary);
 olddeptno := emp_rec.department_id;
 UTL_FILE.NEW_LINE (file);
END LOOP;
UTL_FILE.PUT_LINE(file, '*** END OF REPORT ***');
UTL_FILE.FCLOSE (file);
EXCEPTION
 WHEN UTL_FILE.INVALID_FILEHANDLE THEN
 RAISE APPLICATION_ERROR(-20001, 'Invalid File.');
```

```
 WHEN UTL_FILE.WRITE_ERROR THEN
 RAISE APPLICATION_ERROR (-20002, 'Unable to
write to file');
END sal_status;
/
```

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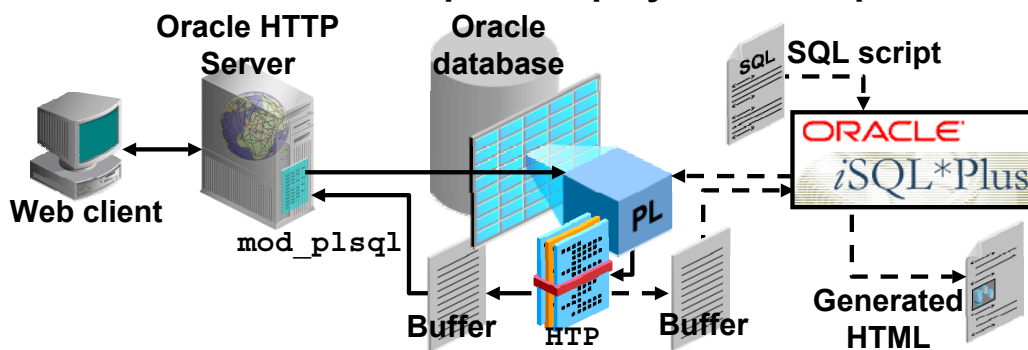
### Using UTL\_FILE: Example (continued)

The output for this report in the salreport.txt file is as follows:

```
SALARY REPORT: GENERATED ON 08-MAR-01
DEPARTMENT: 10
 EMPLOYEE: Whalen earns: 4400
DEPARTMENT: 20
 EMPLOYEE: Hartstein earns: 13000
 EMPLOYEE: Fay earns: 6000
DEPARTMENT: 30
 EMPLOYEE: Raphaely earns: 11000
 EMPLOYEE: Khoo earns: 3100
...
DEPARTMENT: 100
 EMPLOYEE: Greenberg earns: 12000
...
DEPARTMENT: 110
 EMPLOYEE: Higgins earns: 12000
 EMPLOYEE: Gietz earns: 8300
 EMPLOYEE: Grant earns: 7000
*** END OF REPORT ***
```

# Generating Web Pages with the HTP Package

- The HTP package procedures generate HTML tags.
- The HTP package is used to generate HTML documents dynamically and can be invoked from:
  - A browser using Oracle HTTP Server and PL/SQL Gateway (`mod_plsql`) services
  - An *iSQL\*Plus* script to display HTML output



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## Generating Web Pages with the HTP Package

The HTP package contains procedures that are used to generate HTML tags. The HTML tags that are generated typically enclose the data provided as parameters to the various procedures. The slide illustrates two ways in which the HTP package can be used:

- Most likely your procedures are invoked by the PL/SQL Gateway services, via the `mod_plsql` component supplied with Oracle HTTP Server, which is part of the Oracle Application Server product (represented by solid lines in the graphic).
- Alternatively (as represented by dotted lines in the graphic), your procedure can be called from *iSQL\*Plus* that can display the generated HTML output, which can be copied and pasted to a file. This technique is used in this course because Oracle Application Server software is not installed as a part of the course environment.

**Note:** The HTP procedures output information to a session buffer held in the database server. In the Oracle HTTP Server context, when the procedure completes, the `mod_plsql` component automatically receives the buffer contents, which are then returned to the browser as the HTTP response. In *SQL\*Plus*, you must manually execute:

- A `SET SERVEROUTPUT ON` command
- The procedure to generate the HTML into the buffer
- The `OWA_UTIL.SHOWPAGE` procedure to display the buffer contents

# Using the HTP Package Procedures

- **Generate one or more HTML tags. For example:**

```
http.bold('Hello'); -- Hello
http.print('Hi World'); -- Hi World
```

- **Are used to create a well-formed HTML document:**

```
BEGIN
 http.htmlOpen; -----> <HTML>
 http.headOpen; -----> <HEAD>
 http.title('Welcome'); --> <TITLE>Welcome</TITLE>
 http.headClose; -----> </HEAD>
 http.bodyOpen; -----> <BODY>
 http.print('My home page'); My home page
 http.bodyClose; -----> </BODY>
 http.htmlClose; -----> </HTML>
END;
```

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## Using the HTP Package Procedures

The HTP package is structured to provide a one-to-one mapping of a procedure to standard HTML tags. For example, to display bold text on a Web page, the text must be enclosed in the HTML tag pair `<B>` and `</B>`. The first code box in the slide shows how to generate the word `Hello` in HTML bold text by using the equivalent HTP package procedure—that is, `HTP.BOLD`. The `HTP.BOLD` procedure accepts a text parameter and ensures that it is enclosed in the appropriate HTML tags in the HTML output that is generated.

The `HTP.PRINT` procedure copies its text parameter to the buffer. The example in the slide shows how the parameter supplied to the `HTP.PRINT` procedure can contain HTML tags. This technique is recommended only if you need to use HTML tags that cannot be generated by using the set of procedures provided in the HTP package.

The second example in the slide provides a PL/SQL block that generates the basic form of an HTML document. The example serves to illustrate how each of the procedures generates the corresponding HTML line in the enclosed text box on the right.

The benefit of using the HTP package is that you create well-formed HTML documents, eliminating the need to manually type the HTML tags around each piece of data.

**Note:** For information about all the HTP package procedures, refer to the *PL/SQL Packages and Types Reference*.

# Creating an HTML File with *iSQL\*Plus*

To create an HTML file with *iSQL\*Plus*, perform the following steps:

1. Create a SQL script with the following commands:

```
SET SERVEROUTPUT ON
ACCEPT procname PROMPT "Procedure: "
EXECUTE &procname
EXECUTE owa_util.showpage
UNDEFINE proc
```

2. Load and execute the script in *iSQL\*Plus*, supplying values for substitution variables.
3. Select, copy, and paste the HTML text that is generated in the browser to an HTML file.
4. Open the HTML file in a browser.

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## Creating an HTML File with *iSQL\*Plus*

The slide example shows the steps for generating HTML by using any procedure and saving the output into an HTML file. You should perform the following steps:

1. Turn on server output with the `SET SERVEROUTPUT ON` command. Without this, you receive exception messages when running procedures that have calls to the `HTP` package.
2. Execute the procedure that contains calls to the `HTP` package.  
**Note:** This does *not* produce output, unless the procedure has calls to the `DBMS_OUTPUT` package.
3. Execute the `OWA_UTIL.SHOWPAGE` procedure to display the text. This call actually displays the HTML content that is generated from the buffer.

The `ACCEPT` command prompts for the name of the procedure to execute. The call to `OWA_UTIL.SHOWPAGE` displays the HTML tags in the browser window. You can then copy and paste the generated HTML tags from the browser window into an HTML file, typically with a `.htm` or `.html` extension.

**Note:** If you are using *SQL\*Plus*, then you can use the `SPOOL` command to direct the HTML output directly to an HTML file. The `SPOOL` command is not supported in *iSQL\*Plus*; therefore, the copy-and-paste technique is the only option.

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# Installing and Using UTL\_MAIL

- **As SYSDBA, using iSQL\*Plus:**
  - **Set the SMTP\_OUT\_SERVER (requires DBMS restart).**

```
ALTER SYSTEM SET SMTP_OUT_SERVER='smtp.server.com'
SCOPE=SPFILE
```

- **Install the UTL\_MAIL package.**

```
@?/rdbms/admin/utlmail.sql
@?/rdbms/admin/prvtmail.plb
```

- **As a developer, invoke a UTL\_MAIL procedure:**

```
BEGIN
 UTL_MAIL.SEND('otn@oracle.com','user@oracle.com',
 message => 'For latest downloads visit OTN',
 subject => 'OTN Newsletter');
END;
```

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## Installing and Using UTL\_MAIL

The slide shows how to configure the SMTP\_OUT\_SERVER parameter to the name of the SMTP host in your network, and how to install the UTL\_MAIL package that is not installed by default. Changing the SMTP\_OUT\_SERVER parameter requires restarting the database instance. These tasks are performed by a user with SYSDBA capabilities.

The last example in the slide shows the simplest way to send a text message by using the UTL\_MAIL.SEND procedure with at least a subject and a message. The first two required parameters are the following :

- The sender e-mail address (in this case, otn@oracle.com)
- The recipients e-mail address (for example, user@oracle.com). The value can be a comma-separated list of addresses.

The UTL\_MAIL.SEND procedure provides several other parameters, such as cc, bcc, and priority with default values, if not specified. In the example, the message parameter specifies the text for the e-mail, and the subject parameter contains the text for the subject line. To send an HTML message with HTML tags, add the mime\_type parameter (for example, mime\_type=>'text/html').

**Note:** For details about all the UTL\_MAIL procedure parameters, refer to the *PL/SQL Packages and Types Reference*.

# Sending E-Mail with a Binary Attachment

Use the UTL\_MAIL.SEND\_ATTACH\_RAW procedure:

```
CREATE OR REPLACE PROCEDURE send_mail_logo IS
BEGIN
 UTL_MAIL.SEND_ATTACH_RAW(
 sender => 'me@oracle.com',
 recipients => 'you@somewhere.net',
 message =>
 '<HTML><BODY>See attachment</BODY></HTML>',
 subject => 'Oracle Logo',
 mime_type => 'text/html'
 attachment => get_image('oracle.gif'),
 att_inline => true,
 att_mime_type => 'image/gif',
 att_filename => 'oralogo.gif');
END;
/
```

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## Sending E-Mail with a Binary Attachment

The slide shows a procedure calling the UTL\_MAIL.SEND\_ATTACH\_RAW procedure to send a textual or an HTML message with a binary attachment. In addition to the sender, recipients, message, subject, and mime\_type parameters that provide values for the main part of the e-mail message, the SEND\_ATTACH\_RAW procedure has the following highlighted parameters:

- The attachment parameter (required) accepts a RAW data type, with a maximum size of 32,767 binary characters.
- The att\_inline parameter (optional) is Boolean (default TRUE) to indicate that the attachment is viewable with the message body.
- The att\_mime\_type parameter (optional) specifies the format of the attachment. If not provided, it is set to application/octet.
- The att\_filename parameter (optional) assigns any file name to the attachment. It is NULL by default, in which case, the name is assigned a default name.

The get\_image function in the example uses a BFILE to read the image data. Using a BFILE requires creating a logical directory name in the database by using the CREATE DIRECTORY statement. The details about working with a BFILE are covered in the lesson titled “Manipulating Large Objects.” The code for get\_image is shown on the following page.



## Sending E-Mail with a Binary Attachment (continued)

The `get_image` function uses the `DBMS_LOB` package to read a binary file from the operating system:

```
CREATE OR REPLACE FUNCTION get_image(
 filename VARCHAR2, dir VARCHAR2 := 'TEMP')
RETURN RAW IS
 image RAW(32767);
 file BFILE := BFILENAME(dir, filename);
BEGIN
 DBMS_LOB.FILEOPEN(file, DBMS_LOB.FILE_READONLY);
 image := DBMS_LOB.SUBSTR(file);
 DBMS_LOB.CLOSE(file);
 RETURN image;
END;
/
```

To create the directory called `TEMP`, execute the following statement in *iSQL\*Plus*:

```
CREATE DIRECTORY temp AS 'e:\temp';
```

**Note:** You need the `CREATE ANY DIRECTORY` system privilege to execute this statement.



# Sending E-Mail with a Text Attachment

Use the `UTL_MAIL.SEND_ATTACH_VARCHAR2` procedure:

```
CREATE OR REPLACE PROCEDURE send_mail_file IS
BEGIN
 UTL_MAIL.SEND_ATTACH_VARCHAR2 (
 sender => 'me@oracle.com',
 recipients => 'you@somewhere.net',
 message =>
 '<HTML><BODY>See attachment</BODY></HTML>',
 subject => 'Oracle Notes',
 mime_type => 'text/html'
 attachment => get_file('notes.txt'),
 att_inline => false,
 att_mime_type => 'text/plain',
 att_filename => 'notes.txt');
END;
/
```

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## Sending E-Mail with a Text Attachment

The slide shows a procedure that calls the `UTL_MAIL.SEND_ATTACH_VARCHAR2` procedure to send a textual or an HTML message with a text attachment. In addition to the `sender`, `recipients`, `message`, `subject`, and `mime_type` parameters that provide values for the main part of the e-mail message, the `SEND_ATTACH_VARCHAR2` procedure has the following parameters highlighted:

- The `attachment` parameter (required) accepts a `VARCHAR2` data type with a maximum size of 32,767 binary characters.
- The `att_inline` parameter (optional) is a Boolean (default `TRUE`) to indicate that the attachment is viewable with the message body.
- The `att_mime_type` parameter (optional) specifies the format of the attachment. If not provided, it is set to `application/octet`.
- The `att_filename` parameter (optional) assigns any file name to the attachment. It is `NULL` by default, in which case, the name is assigned a default name.

The `get_file` function in the example uses a `BFILE` to read a text file from the operating system directories for the value of the `attachment` parameter, which could simply be populated from a `VARCHAR2` variable. The code for `get_file` is shown on the following page.

## Sending E-Mail with a Text Attachment (continued)

The `get_file` function uses the `DBMS_LOB` package to read a binary file from the operating system, and uses the `UTL_RAW` package to convert the RAW binary data into readable text data in the form of a `VARCHAR2` data type:

```
CREATE OR REPLACE FUNCTION get_file(
 filename VARCHAR2, dir VARCHAR2 := 'TEMP')
RETURN VARCHAR2 IS
 contents VARCHAR2(32767);
 file BFILE := BFILENAME(dir, filename);
BEGIN
 DBMS_LOB.FILEOPEN(file, DBMS_LOB.FILE_READONLY);
 contents := UTL_RAW.CAST_TO_VARCHAR2(
 DBMS_LOB.SUBSTR(file));
 DBMS_LOB.CLOSE(file);
 RETURN contents;
END;
/
```

**Note:** Alternatively, you could read the contents of the text file into a `VARCHAR2` variable by using the `UTL_FILE` package functionality.

The preceding example requires the `TEMP` directory to be created similar to the following statement in *iSQL\*Plus*:

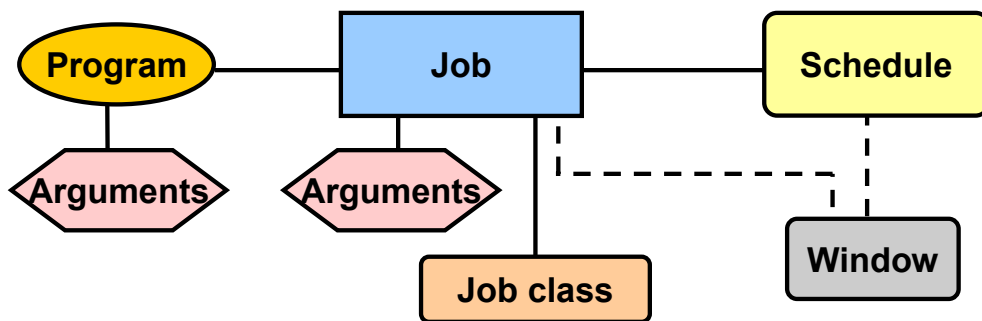
```
CREATE DIRECTORY temp AS 'e:\temp';
```

**Note:** The `CREATE ANY DIRECTORY` system privilege is required to execute this statement.

# DBMS\_SCHEDULER Package

The database Scheduler comprises several components to enable jobs to be run. Use the DBMS\_SCHEDULER package to create each job with:

- A unique job name
- A program (“what” should be executed)
- A schedule (“when” it should run)



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## DBMS\_SCHEDULER Package

Oracle Database 10g provides a collection of subprograms in the DBMS\_SCHEDULER package to simplify management and to provide a rich set of functionality for complex scheduling tasks. Collectively, these subprograms are called the Scheduler and can be called from any PL/SQL program. The Scheduler enables database administrators and application developers to control when and where various tasks take place. By ensuring that many routine database tasks occur without manual intervention, you can lower operating costs, implement more reliable routines, and minimize human error.

The diagram shows the following architectural components of the Scheduler:

- A **job** is the combination of a program and a schedule. Arguments required by the program can be provided with the program or the job. All job names have the format [schema.] name. When you create a job, you specify the job name, a program, a schedule, and (optionally) job characteristics that can be provided through a **job class**.
- A **program** determines what should be run. Every automated job involves a particular executable, whether it is a PL/SQL block, a stored procedure, a native binary executable, or a shell script. A program provides metadata about a particular executable and may require a list of arguments.
- A **schedule** specifies when and how many times a job is executed.

## DBMS\_SCHEDULER Package (continued)

- A **job class** defines a category of jobs that share common resource usage requirements and other characteristics. At any given time, each job can belong to only a single job class. A job class has the following attributes:
  - A database **service** name. The jobs in the job class will have an affinity to the particular service specified—that is, the jobs will run on the instances that cater to the specified service.
  - A **resource consumer group**, which classifies a set of user sessions that have common resource-processing requirements. At any given time, a user session or job class can belong to a single resource consumer group. The resource consumer group that the job class associates with determines the resources that are allocated to the job class.
- A **window** is represented by an interval of time with a well-defined beginning and end, and is used to activate different resource plans at different times.

The slide focuses on the job component as the primary entity. However, a program, a schedule, a window, and a job class are components that can be created as individual entities that can be associated with a job to be executed by the Scheduler. When a job is created, it may contain all the information needed in-line—that is, in the call that creates the job. Alternatively, creating a job may reference a program or schedule component that was previously defined. Examples of this are discussed in the next few pages.

For more information about the Scheduler, see the Online Course titled *Oracle Database 10g: Configure and Manage Jobs with the Scheduler*.

# Creating a Job

**A job can be created in several ways by using a combination of in-line parameters, named Programs, and named Schedules. You can create a job with the CREATE\_JOB procedure by:**

- **Using in-line information with the “what” and the schedule specified as parameters**
- **Using a named (saved) program and specifying the schedule in-line**
- **Specifying what should be done in-line and using a named Schedule**
- **Using named Program and Schedule components**

**Note: Creating a job requires the CREATE JOB system privilege.**

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## Creating a Job

The component that causes something to be executed at a specified time is called a **job**. Use the DBMS\_SCHEDULER.CREATE\_JOB procedure of the DBMS\_SCHEDULER package to create a job, which is in a disabled state by default. A job becomes active and scheduled when it is explicitly enabled. To create a job, you:

- Provide a name in the format [schema.] name
- Need the CREATE JOB privilege

**Note:** A user with the CREATE ANY JOB privilege can create a job in any schema except the SYS schema. Associating a job with a particular class requires the EXECUTE privilege for that class.

In simple terms, a job can be created by specifying all the job details—the program to be executed (what) and its schedule (when)—in the arguments of the CREATE\_JOB procedure. Alternatively, you can use predefined Program and Schedule components. If you have a named Program and Schedule, then these can be specified or combined with in-line arguments for maximum flexibility in the way a job is created.

A simple logical check is performed on the schedule information (that is, checking the date parameters when a job is created). The database checks whether the end date is after the start date. If the start date refers to a time in the past, then the start date is changed to the current date.

# Creating a Job with In-Line Parameters

**Specify the type of code, code, start time, and frequency of the job to be run in the arguments of the `CREATE_JOB` procedure.**

**Here is an example that schedules a PL/SQL block every hour:**

```
BEGIN
 DBMS_SCHEDULER.CREATE_JOB (
 job_name => 'JOB_NAME',
 job_type => 'PLSQL_BLOCK',
 job_action => 'BEGIN ...; END;',
 start_date => SYSTIMESTAMP,
 repeat_interval=>'FREQUENCY=HOURLY;INTERVAL=1',
 enabled => TRUE);
END;
/
```

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## Creating a Job with In-Line Parameters

You can create a job to run a PL/SQL block, stored procedure, or external program by using the `DBMS_SCHEDULER.CREATE_JOB` procedure. The `CREATE_JOB` procedure can be used directly without requiring you to create Program or Schedule components.

The example in the slide shows how you can specify all the job details in-line. The parameters of the `CREATE_JOB` procedure define “what” is to be executed, the schedule, and other job attributes. The following parameters define what is to be executed:

- The `job_type` parameter can be one of three values:
  - `PLSQL_BLOCK` for any PL/SQL block or SQL statement. This type of job cannot accept arguments.
  - `STORED_PROCEDURE` for any stored stand-alone or packaged procedure. The procedures can accept arguments that are supplied with the job.
  - `EXECUTABLE` for an executable command-line operating system application
- The schedule is specified by using the following parameters:
  - The `start_date` accepts a time stamp, and the `repeat_interval` is string-specified as a calendar or PL/SQL expression. An `end_date` can be specified.

**Note:** String expressions that are specified for `repeat_interval` are discussed later.

The example specifies that the job should run every hour.

# Creating a Job Using a Program

- **Use CREATE\_PROGRAM to create a program:**

```
BEGIN
 DBMS_SCHEDULER.CREATE_PROGRAM(
 program_name => 'PROG_NAME',
 program_type => 'PLSQL_BLOCK',
 program_action => 'BEGIN ...; END;');
END;
```

- **Use overloaded CREATE\_JOB procedure with its program\_name parameter:**

```
BEGIN
 DBMS_SCHEDULER.CREATE_JOB('JOB_NAME',
 program_name => 'PROG_NAME',
 start_date => SYSTIMESTAMP,
 repeat_interval => 'FREQ=DAILY',
 enabled => TRUE);
END;
```

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## Creating a Job Using a Program

The DBMS\_SCHEDULER.CREATE\_PROGRAM procedure defines a program that must be assigned a unique name. Creating the program separately for a job enables you to:

- Define the action once and then reuse this action within multiple jobs
- Change the schedule for a job without having to re-create the PL/SQL block
- Change the program executed without changing all the jobs

The program action string specifies a procedure, executable name, or PL/SQL block depending on the value of the program\_type parameter, which can be:

- PLSQL\_BLOCK to execute an anonymous block or SQL statement
- STORED\_PROCEDURE to execute a stored procedure, such as PL/SQL, Java, or C
- EXECUTABLE to execute operating system command-line programs

The example shown in the slide demonstrates calling an anonymous PL/SQL block. You can also call an external procedure within a program, as in the following example:

```
DBMS_SCHEDULER.CREATE_PROGRAM(program_name =>
 'GET_DATE',
 program_action => '/usr/local/bin/date',
 program_type => 'EXECUTABLE');
```

To create a job with a program, specify the program name in the program\_name argument in the call to the DBMS\_SCHEDULER.CREATE\_JOB procedure, as shown in the slide.

# Creating a Job for a Program with Arguments

- **Create a program:**

```
DBMS_SCHEDULER.CREATE_PROGRAM(
 program_name => 'PROG_NAME',
 program_type => 'STORED PROCEDURE',
 program_action => 'EMP_REPORT');
```

- **Define an argument:**

```
DBMS_SCHEDULER.DEFINE_PROGRAM_ARGUMENT(
 program_name => 'PROG_NAME',
 argument_name => 'DEPT_ID',
 argument_position => 1, argument_type => 'NUMBER',
 default_value => '50');
```

- **Create a job specifying the number of arguments:**

```
DBMS_SCHEDULER.CREATE_JOB('JOB_NAME', program_name
=> 'PROG_NAME', start_date => SYSTIMESTAMP,
repeat_interval => 'FREQ=DAILY',
number_of_arguments => 1, enabled => TRUE);
```

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## Creating a Job for a Program with Arguments

Programs, such as PL/SQL or external procedures, may require input arguments. Using the `DBMS_SCHEDULER.DEFINE_PROGRAM_ARGUMENT` procedure, you can define an argument for an existing program. The `DEFINE_PROGRAM_ARGUMENT` procedure parameters include the following:

- The `program_name` specifies an existing program that is to be altered.
- The `argument_name` specifies a unique argument name for the program.
- The `argument_position` specifies the position in which the argument is passed when the program is called.
- The `argument_type` specifies the data type of the argument value that is passed to the called program.
- The `default_value` specifies a default value that is supplied to the program if the job that schedules the program does not provide a value.

The slide shows how to create a job executing a program with one argument. The program argument default value is 50. To change the program argument value for a job, use:

```
DBMS_SCHEDULER.SET_JOB_ARGUMENT_VALUE(
 job_name => 'JOB_NAME',
 argument_name => 'DEPT_ID', argument_value => '80');
```



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# Setting the Repeat Interval for a Job

- **Using a calendaring expression:**

```
repeat_interval=> 'FREQ=HOURLY; INTERVAL=4 '
repeat_interval=> 'FREQ=DAILY '
repeat_interval=> 'FREQ=MINUTELY; INTERVAL=15 '
repeat_interval=> 'FREQ=YEARLY;
 BYMONTH=MAR, JUN, SEP, DEC;
 BYMONTHDAY=15 '
```

- **Using a PL/SQL expression:**

```
repeat_interval=> 'SYSDATE + 36/24 '
repeat_interval=> 'SYSDATE + 1 '
repeat_interval=> 'SYSDATE + 15/(24*60) '
```

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## Setting the Repeat Interval for a Job

When scheduling repeat intervals for a job, you can specify either a PL/SQL expression (if it is within a job argument) or a calendaring expression.

The examples in the slide include the following:

- `FREQ=HOURLY; INTERVAL=4` indicates a repeat interval of every four hours.
- `FREQ=DAILY` indicates a repeat interval of every day, at the same time as the start date of the schedule.
- `FREQ=MINUTELY; INTERVAL=15` indicates a repeat interval of every 15 minutes.
- `FREQ=YEARLY; BYMONTH=MAR, JUN, SEP, DEC; BYMONTHDAY=15` indicates a repeat interval of every year on March 15, June 15, September 15, and December 15.

With a calendaring expression, the next start time for a job is calculated using the repeat interval and the start date of the job.

**Note:** If no repeat interval is specified (that is, if a NULL value is provided in the argument), the job runs only once on the specified start date.

## Creating a Job Using a Named Program and Schedule

- Create a named program called `PROG_NAME` by using the `CREATE_PROGRAM` procedure.
- Create a named schedule called `SCHED_NAME` by using the `CREATE_SCHEDULE` procedure.
- Create a job referencing the named program and schedule:

```
BEGIN
 DBMS_SCHEDULER.CREATE_JOB('JOB_NAME',
 program_name => 'PROG_NAME',
 schedule_name => 'SCHED_NAME',
 enabled => TRUE);
END;
/
```

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### Creating a Job Using a Named Program and Schedule

The example in the slide shows the final form for using the `DBMS_SCHEDULER.CREATE_JOB` procedure. In this example, the named program (`PROG_NAME`) and schedule (`SCHED_NAME`) are specified in their respective parameters in the call to the `DBMS_SCHEDULER.CREATE_JOB` procedure.

With this example, you can see how easy it is to create jobs by using a predefined program and schedule.

Some jobs and schedules can be too complex to cover in this course. For example, you can create windows for recurring time plans and associate a resource plan with a window. A resource plan defines attributes about the resources required during the period defined by execution window.

For more information, refer to the Online Course titled *Oracle Database 10g: Configure and Manage Jobs with the Scheduler*.

# Managing Jobs

- **Run a job:**

```
DBMS_SCHEDULER.RUN_JOB('SCHEMA.JOB_NAME');
```

- **Stop a job:**

```
DBMS_SCHEDULER.STOP_JOB('SCHEMA.JOB_NAME');
```

- **Drop a job even if it is currently running:**

```
DBMS_SCHEDULER.DROP_JOB('JOB_NAME', TRUE);
```

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## Managing Jobs

After a job has been created, you can:

- Run the job by calling the `RUN_JOB` procedure specifying the name of the job. The job is immediately executed in your current session.
- Stop the job by using the `STOP_JOB` procedure. If the job is running currently, it is stopped immediately. The `STOP_JOB` procedure has two arguments:
  - **job\_name:** Is the name of the job to be stopped
  - **force:** Attempts to gracefully terminate a job. If this fails and `force` is set to `TRUE`, then the job slave is terminated. (Default value is `FALSE`.) To use `force`, you must have the `MANAGE SCHEDULER` system privilege.
- Drop the job with the `DROP_JOB` procedure. This procedure has two arguments:
  - **job\_name:** Is the name of the job to be dropped
  - **force:** Indicates whether the job should be stopped and dropped if it is currently running (Default value is `FALSE`.)

If the `DROP_JOB` procedure is called and the job specified is currently running, then the command fails unless the `force` option is set to `TRUE`. If the `force` option is set to `TRUE`, then any instance of the job that is running is stopped and the job is dropped.

**Note:** To run, stop, or drop a job that belongs to another user, you need `ALTER` privileges on that job or the `CREATE ANY JOB` system privilege.

# Data Dictionary Views

- [DBA | ALL | USER] \_SCHEDULER\_JOBS
- [DBA | ALL | USER] \_SCHEDULER\_RUNNING\_JOBS
- [DBA | ALL] \_SCHEDULER\_JOB\_CLASSES
- [DBA | ALL | USER] \_SCHEDULER\_JOB\_LOG
- [DBA | ALL | USER] \_SCHEDULER\_JOB\_RUN\_DETAILS
- [DBA | ALL | USER] \_SCHEDULER\_PROGRAMS

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## Data Dictionary Views

The DBA\_SCHEDULER\_JOB\_LOG view shows all completed job instances, both successful and failed.

To view the state of your jobs, use the following query:

```
SELECT job_name, program_name, job_type, state
FROM USER_SCHEDULER_JOBS;
```

To determine which instance a job is running on, use the following query:

```
SELECT owner, job_name, running_instance,
resource_consumer_group
FROM DBA_SCHEDULER_RUNNING_JOBS;
```

To determine information about how a job ran, use the following query:

```
SELECT job_name, instance_id, req_start_date,
actual_start_date, status
FROM ALL_SCHEDULER_JOB_RUN_DETAILS;
```

To determine the status of your jobs, use the following query:

```
SELECT job_name, status, error#, run_duration, cpu_used
FROM USER_SCHEDULER_JOB_RUN_DETAILS;
```

# Summary

In this lesson, you should have learned how to:

- Use various preinstalled packages that are provided by the Oracle server
- Use the following packages:
  - DBMS\_OUTPUT to buffer and display text
  - UTL\_FILE to write operating system text files
  - HTP to generate HTML documents
  - UTL\_MAIL to send messages with attachments
  - DBMS\_SCHEDULER to automate processing
- Create packages individually or by using the `catproc.sql` script

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## Summary

This lesson covers a small subset of packages provided with the Oracle database. You have extensively used DBMS\_OUTPUT for debugging purposes and displaying procedurally generated information on the screen in *iSQL\*Plus*.

In this lesson, you should have learned how to use the power features provided by the database to create text files in the operating system by using UTL\_FILE, generate HTML reports with the HTP package, send e-mail with or without binary or text attachments by using the UTL\_MAIL package, and schedule PL/SQL and external code for execution with the DBMS\_SCHEDULER package.

**Note:** For more information about all PL/SQL packages and types, refer to the *PL/SQL Packages and Types Reference*.

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- Using UTL\_FILE to generate a text report
- Using HTTP to generate a Web page report
- Using DBMS\_SCHEDULER to automate report processing

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In this practice, you use `UTL_FILE` to generate a text file report of employees in each department. You create a procedure to generate an HTML version of the employee report, and write a SQL script file to spool the results to a text file. You use the `DBMS_SCHEDULER` to run the first report that creates a text file every five minutes.

## Practice 5

1. Create a procedure called `EMPLOYEE_REPORT` that generates an employee report in a file in the operating system, using the `UTL_FILE` package. The report should generate a list of employees who have exceeded the average salary of their departments.
  - a. Your program should accept two parameters. The first parameter is the output directory. The second parameter is the name of the text file that is written.  
**Note:** Use the directory location value `UTL_FILE`. Add an exception-handling section to handle errors that may be encountered when using the `UTL_FILE` package.
  - b. Invoke the program, using the second parameter with a name such as `sal_rptxx.txt`, where `xx` represents your user number (for example, 01, 15, and so on). The following is a sample output from the report file:

```
Employees who earn more than average salary:
REPORT GENERATED ON 26-FEB-04
Hartstein 20 $13,000.00
Raphaely 30 $11,000.00
Marvis 40 $6,500.00
...
*** END OF REPORT ***
```

**Note:** The data displays the employee's last name, department ID, and salary. Ask your instructor to provide instructions on how to obtain the report file from the server using the Putty PSFTP utility.

2. Create a new procedure called `WEB_EMPLOYEE_REPORT` that generates the same data as the `EMPLOYEE_REPORT`.
  - a. First, execute `SET SERVEROUTPUT ON`, and then execute `http.print('hello')` followed by executing `OWA_UTIL.SHOWPAGE`. The exception messages generated can be ignored.
  - b. Write the `WEB_EMPLOYEE_REPORT` procedure by using the `HTP` package to generate an HTML report of employees with a salary greater than the average for their departments. If you know HTML, create an HTML table; otherwise, create simple lines of data.  
**Hint:** Copy the cursor definition and the `FOR` loop from the `EMPLOYEE_REPORT` procedure for the basic structure for your Web report.
  - c. Execute the procedure using *iSQL\*Plus* to generate the HTML data into a server buffer, and execute the `OWA_UTIL.SHOWPAGE` procedure to display contents of the buffer. Remember that `SERVEROUTPUT` should be `ON` before you execute the code.
  - d. Create an HTML file called `web_employee_report.htm` containing the output result text that you select and copy from the opening `<HTML>` tag to the closing `</HTML>` tag. Paste the copied text into the file and save it to disk. Double-click the file to display the results in your default browser.



## Practice 5 (continued)

3. Your boss wants to run the employee report frequently. You create a procedure that uses the DBMS\_SCHEDULER package to schedule the EMPLOYEE\_REPORT procedure for execution. You should use parameters to specify a frequency, and an optional argument to specify the number of minutes after which the scheduled job should be terminated.
  - a. Create a procedure called SCHEDULE\_REPORT that provides the following two parameters:
    - interval: To specify a string indicating the frequency of the scheduled job
    - minutes: To specify the total life in minutes (default of 10) for the scheduled job, after which it is terminated. The code divides the duration by the quantity ( $24 \times 60$ ) when it is added to the current date and time to specify the termination time.

When the procedure creates a job, with the name of EMPLOYEE\_REPORT by calling DBMS\_SCHEDULER.CREATE\_JOB, the job should be enabled and scheduled for the PL/SQL block to start immediately. You must schedule an anonymous block to invoke the EMPLOYEE\_REPORT procedure so that the file name can be updated with a new time, each time the report is executed. The EMPLOYEE\_REPORT is given the directory name supplied by your instructor for task 1, and the file name parameter is specified in the following format: sal\_rptxx\_hh24-mi-ss.txt, where xx is your assigned user number and hh24-mi-ss represents the hours, minutes, and seconds.

Use the following local PL/SQL variable to construct a PL/SQL block:

```
plsql_block VARCHAR2(200) :=
'BEGIN' ||
' EMPLOYEE_REPORT(''UTL_FILE'', '' ||
''sal_rptXX'' || to_char(sysdate, ''HH24-MI-SS'') || '''.txt''); ||
'END;';
```

This code is provided to help you because it is a nontrivial PL/SQL string to construct. In the PL/SQL block, **XX** is your student number.

- b. Test the SCHEDULE\_REPORT procedure by executing it with a parameter specifying a frequency of every two minutes and a termination time 10 minutes after it starts.

**Note:** You must connect to the database server by using PSFTP to check whether your files are created.
- c. During and after the process, you can query the job\_name and enabled columns from the USER\_SCHEDULER\_JOBS table to check whether the job still exists.

**Note:** This query should return no rows after 10 minutes have elapsed.



# 6

## Dynamic SQL and Metadata

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# Objectives

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

- **Describe the execution flow of SQL statements**
- **Build and execute SQL statements dynamically using Native Dynamic SQL (that is, with `EXECUTE IMMEDIATE` statements)**
- **Compare Native Dynamic SQL with the `DBMS_SQL` package approach**
- **Use the `DBMS_METADATA` package to obtain metadata from the data dictionary as XML or creation DDL that can be used to re-create the objects**

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## Lesson Aim

In this lesson, you learn to construct and execute SQL statements dynamically—that is, at run time using the Native Dynamic SQL statements in PL/SQL. You compare Native Dynamic SQL to the `DBMS_SQL` package, which provides similar capabilities.

You learn how to use the `DBMS_METADATA` package to retrieve metadata from the database dictionary as Extensible Markup Language (XML) or creation DDL and to submit the XML to re-create the object.

# Execution Flow of SQL

- **All SQL statements go through various stages:**
  - **Parse**
  - **Bind**
  - **Execute**
  - **Fetch**
- **Some stages may not be relevant for all statements—for example, the fetch phase is applicable to queries.**

**Note: For embedded SQL statements (`SELECT`, `DML`, `COMMIT`, and `ROLLBACK`), the parse and bind phases are done at compile time. For dynamic SQL statements, all phases are performed at run time.**

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## Steps to Process SQL Statements

All SQL statements have to go through various stages. However, some stages may not be relevant for all statements. The following are the key stages:

- **Parse:** Every SQL statement must be parsed. Parsing the statement includes checking the statement's syntax and validating the statement, ensuring that all references to objects are correct and that the relevant privileges to those objects exist.
- **Bind:** After parsing, the Oracle server may need values from or for any bind variable in the statement. The process of obtaining these values is called binding variables. This stage may be skipped if the statement does not contain bind variables.
- **Execute:** At this point, the Oracle server has all necessary information and resources, and the statement is executed. For nonquery statements, this is the last phase.
- **Fetch:** In the fetch stage, which is applicable to queries, the rows are selected and ordered (if requested by the query), and each successive fetch retrieves another row of the result, until the last row has been fetched.

# Dynamic SQL

**Use dynamic SQL to create a SQL statement whose structure may change during run time. Dynamic SQL:**

- **Is constructed and stored as a character string within the application**
- **Is a SQL statement with varying column data, or different conditions with or without placeholders (bind variables)**
- **Enables data-definition, data-control, or session-control statements to be written and executed from PL/SQL**
- **Is executed with Native Dynamic SQL statements or the DBMS\_SQL package**

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## Dynamic SQL

The embedded SQL statements available in PL/SQL are limited to SELECT, INSERT, UPDATE, DELETE, COMMIT, and ROLLBACK, all of which are parsed at compile time—that is, they have a fixed structure. You need to use dynamic SQL functionality if you require:

- The structure of a SQL statement to be altered at run time
- Access to data definition language (DDL) statements and other SQL functionality in PL/SQL

To perform these kinds of tasks in PL/SQL, you must construct SQL statements dynamically in character strings and execute them using either of the following:

- Native Dynamic SQL statements with EXECUTE IMMEDIATE
- The DBMS\_SQL package

The process of using SQL statements that are not embedded in your source program and are constructed in strings and executed at run time is known as “dynamic SQL.” The SQL statements are created dynamically at run time and can access and use PL/SQL variables. For example, you create a procedure that uses dynamic SQL to operate on a table whose name is not known until run time, or execute a DDL statement (such as CREATE TABLE), a data control statement (such as GRANT), or a session control statement (such as ALTER SESSION).

# Native Dynamic SQL

- Provides native support for dynamic SQL directly in the PL/SQL language
- Provides the ability to execute SQL statements whose structure is unknown until execution time
- Is supported by the following PL/SQL statements:
  - EXECUTE IMMEDIATE
  - OPEN-FOR
  - FETCH
  - CLOSE

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## Native Dynamic SQL

In Oracle 8 and earlier releases, the only way to implement dynamic SQL in a PL/SQL application was by using the DBMS\_SQL package. With Oracle 8i and later releases, the PL/SQL environment provides Native Dynamic SQL as an alternative.

Native Dynamic SQL provides the ability to dynamically execute SQL statements whose structure is constructed at execution time. The following statements have been added or extended in PL/SQL to support Native Dynamic SQL:

- **EXECUTE IMMEDIATE:** Prepares a statement, executes it, returns variables, and then deallocates resources
- **OPEN-FOR:** Prepares and executes a statement using a cursor variable
- **FETCH:** Retrieves the results of an opened statement by using the cursor variable
- **CLOSE:** Closes the cursor used by the cursor variable and deallocates resources

You can use bind variables in the dynamic parameters in the EXECUTE IMMEDIATE and OPEN statements. Native Dynamic SQL includes the following capabilities:

- Define a dynamic SQL statement.
- Bind instances of any SQL data types supported in PL/SQL.
- Handle IN, IN OUT, and OUT bind variables that are bound by position, not by name.

# Using the EXECUTE IMMEDIATE Statement

Use the EXECUTE IMMEDIATE statement for Native Dynamic SQL or PL/SQL anonymous blocks:

```
EXECUTE IMMEDIATE dynamic_string
 [INTO {define_variable
 [, define_variable] ... | record}]
 [USING [IN|OUT|IN OUT] bind_argument
 [, [IN|OUT|IN OUT] bind_argument] ...];
```

- INTO is used for single-row queries and specifies the variables or records into which column values are retrieved.
- USING is used to hold all bind arguments. The default parameter mode is IN, if not specified.

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## Using the EXECUTE IMMEDIATE Statement

The EXECUTE IMMEDIATE statement can be used to execute SQL statements or PL/SQL anonymous blocks. The syntactical elements include the following:

- *dynamic\_string* is a string expression that represents a dynamic SQL statement (without terminator) or a PL/SQL block (with terminator).
- *define\_variable* is a PL/SQL variable that stores the selected column value.
- *record* is a user-defined or %ROWTYPE record that stores a selected row.
- *bind\_argument* is an expression whose value is passed to the dynamic SQL statement or PL/SQL block.
- The INTO clause specifies the variables or record into which column values are retrieved. It is used only for single-row queries. For each value retrieved by the query, there must be a corresponding, type-compatible variable or field in the INTO clause.
- The USING clause holds all bind arguments. The default parameter mode is IN.

You can use numeric, character, and string literals as bind arguments, but you cannot use Boolean literals (TRUE, FALSE, and NULL).

**Note:** Use OPEN-FOR, FETCH, and CLOSE for a multirow query. The syntax shown in the slide is not complete because support exists for bulk-processing operations (which is a topic that is not covered in this course).



# Dynamic SQL with a DDL Statement

- **Create a table:**

```
CREATE PROCEDURE create_table(
 table_name VARCHAR2, col_specs VARCHAR2) IS
BEGIN
 EXECUTE IMMEDIATE 'CREATE TABLE ' || table_name ||
 ' (' || col_specs || ')';
END;
/
```

- **Call example:**

```
BEGIN
 create_table('EMPLOYEE_NAMES',
 'id NUMBER(4) PRIMARY KEY, name VARCHAR2(40)');
END;
/
```

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## Dynamic SQL with a DDL Statement

The code examples show the creation of a `create_table` procedure that accepts the table name and column definitions (specifications) as parameters.

The call shows the creation of a table called `EMPLOYEE_NAMES` with two columns:

- An ID column with a `NUMBER` data type used as a primary key
- A name column of up to 40 characters for the employee name

Any DDL statement can be executed by using the syntax shown in the slide, whether the statement is dynamically constructed or specified as a literal string. You can create and execute a statement that is stored in a PL/SQL string variable, as in the following example:

```
CREATE PROCEDURE add_col(table_name VARCHAR2,
 col_spec VARCHAR2) IS
 stmt VARCHAR2(100) := 'ALTER TABLE ' || table_name ||
 ' ADD ' || col_spec;
BEGIN
 EXECUTE IMMEDIATE stmt;
END;
/
```

To add a new column to a table, enter the following:

```
EXECUTE add_col('employee_names', 'salary number(8,2)')
```

# Dynamic SQL with DML Statements

- **Delete rows from any table:**

```
CREATE FUNCTION del_rows(table_name VARCHAR2)
RETURN NUMBER IS
BEGIN
 EXECUTE IMMEDIATE 'DELETE FROM ' || table_name;
 RETURN SQL%ROWCOUNT;
END;
```

```
BEGIN DBMS_OUTPUT.PUT_LINE(
 del_rows('EMPLOYEE_NAMES') || ' rows deleted. ');
END;
```

- **Insert a row into a table with two columns:**

```
CREATE PROCEDURE add_row(table_name VARCHAR2,
 id NUMBER, name VARCHAR2) IS
BEGIN
 EXECUTE IMMEDIATE 'INSERT INTO ' || table_name ||
 ' VALUES (:1, :2)' USING id, name;
END;
```

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## Dynamic SQL with DML Statements

The examples in the slide demonstrate the following:

- The `del_rows` function deletes rows from a specified table and returns the number of rows deleted by using the implicit SQL cursor `%ROWCOUNT` attribute. Executing the function is shown below the example for creating a function.
- The `add_row` procedure shows how to provide input values to a dynamic SQL statement with the `USING` clause. The bind variable names `:1` and `:2` are not important, but the order of the variable names (`id` and `name`) in the `USING` clause is associated to the bind variables by position, in the order of their respective appearance. Therefore, the PL/SQL variable `id` is assigned to the `:1` placeholder, and the `name` variable is assigned to the `:2` placeholder. Placeholder/bind variable names can be alphanumeric but must be preceded with a colon.

**Note:** The `EXECUTE IMMEDIATE` statement prepares (parses) and immediately executes the dynamic SQL statement. Dynamic SQL statements are always parsed.

Also, note that a `COMMIT` operation is not performed in either of the examples. Therefore, the operations can be undone with a `ROLLBACK` statement.

# Dynamic SQL with a Single-Row Query

## Example of a single-row query:

```
CREATE FUNCTION get_emp(emp_id NUMBER)
RETURN employees%ROWTYPE IS
 stmt VARCHAR2(200);
 emprec employees%ROWTYPE;
BEGIN
 stmt := 'SELECT * FROM employees ' ||
 'WHERE employee_id = :id';
 EXECUTE IMMEDIATE stmt INTO emprec USING emp_id;
 RETURN emprec;
END;
/
```

```
DECLARE
 emprec employees%ROWTYPE := get_emp(100);
BEGIN
 DBMS_OUTPUT.PUT_LINE('Emp: ' || emprec.last_name);
END;
/
```

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## Dynamic SQL with a Single-Row Query

The single-row query example demonstrates the `get_emp` function that retrieves an `EMPLOYEES` record into a variable specified in the `INTO` clause. It also shows how to provide input values for the `WHERE` clause.

The anonymous block is used to execute the `get_emp` function and return the result into a local `EMPLOYEES` record variable.

The example could be enhanced to provide alternative `WHERE` clauses depending on input parameter values, making it more suitable for dynamic SQL processing.

# Dynamic SQL with a Multirow Query

## Use OPEN-FOR, FETCH, and CLOSE processing:

```
CREATE PROCEDURE list_employees(deptid NUMBER) IS
 TYPE emp_refcsr IS REF CURSOR;
 emp_cv emp_refcsr;
 emprec employees%ROWTYPE;
 stmt varchar2(200) := 'SELECT * FROM employees';
BEGIN
 IF deptid IS NULL THEN OPEN emp_cv FOR stmt;
 ELSE
 stmt := stmt || ' WHERE department_id = :id';
 OPEN emp_cv FOR stmt USING deptid;
 END IF;
 LOOP
 FETCH emp_cv INTO emprec;
 EXIT WHEN emp_cv%NOTFOUND;
 DBMS_OUTPUT.PUT_LINE(emprec.department_id ||
 ' ' || emprec.last_name);
 END LOOP;
 CLOSE emp_cv;
END;
```

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## Dynamic SQL with a Multirow Query

The example in the slide shows how to execute a multirow query by performing the following programming steps:

- Declaring a REF CURSOR type
- Declaring a cursor variable based on the REF CURSOR type name that you declare
- Executing an OPEN-FOR statement that uses the cursor variable
- Using a FETCH statement referencing the cursor variable until all records are processed
- Executing the CLOSE statement by using the cursor variable

This process is the same as using static cursor definitions. However, the OPEN-FOR syntax accepts a string literal or variable specifying the SELECT statement, which can be dynamically constructed.

**Note:** The next page provides a brief introduction to the REF CURSOR type and cursor variables. An alternative to this is using the BULK COLLECT syntax supported by Native Dynamic SQL statements (a topic that is not covered in this course).

# Declaring Cursor Variables

- **Declare a cursor type as REF CURSOR:**

```
CREATE PROCEDURE process_data IS
 TYPE ref_ctype IS REF CURSOR; -- weak ref cursor
 TYPE emp_ref_ctype IS REF CURSOR -- strong
 RETURN employees%ROWTYPE;
:
```

- **Declare a cursor variable using the cursor type:**

```
:
dept_csrvar ref_ctype;
emp_csrvar emp_ref_ctype;
BEGIN
 OPEN emp_csrvar FOR SELECT * FROM employees;
 OPEN dept_csrvar FOR SELECT * from departments;
 -- Then use as normal cursors
END;
```

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## Declaring Cursor Variables

A cursor variable is a PL/SQL identifier whose type name has been declared as a REF CURSOR type. Creating a cursor variable involves two steps:

- Declaring a type name as a REF CURSOR type
- Declaring a PL/SQL variable by using the type name declared as a REF CURSOR type

The slide examples create two reference cursor types:

- The `ref_ctype` is a generic reference cursor, known as a weak reference cursor. A weak reference cursor can be associated with any query.
- The `emp_ref_ctype` is a strong reference cursor type that must be associated with a type-compatible query: the query must return data that is compatible with the type specified after the RETURN keyword (for example, an EMPLOYEES row type).

After a cursor variable is declared by using a reference cursor type name, the cursor variable that is associated with a query is opened by using the OPEN-FOR syntax shown in the slide. The standard FETCH, cursor attributes, and CLOSE operations used with explicit cursors are also applicable with cursor variables. To compare cursor variables with explicit cursors:

- A cursor variable can be associated with more than one query at run time
- An explicit cursor is associated with one query at compilation time

# Dynamically Executing a PL/SQL Block

## Execute a PL/SQL anonymous block dynamically:

```
CREATE FUNCTION annual_sal(emp_id NUMBER)
RETURN NUMBER IS
 plsql varchar2(200) :=
 'DECLARE ' ||
 ' emprec employees%ROWTYPE; ' ||
 'BEGIN ' ||
 ' emprec := get_emp(:empid); ' ||
 ' :res := emprec.salary * 12; ' ||
 'END;';
 result NUMBER;
BEGIN
 EXECUTE IMMEDIATE plsql
 USING IN emp_id, OUT result;
 RETURN result;
END;
/
```

```
EXECUTE DBMS_OUTPUT.PUT_LINE(annual_sal(100))
```

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## Dynamically Executing a PL/SQL Block

The `annual_sal` function dynamically constructs an anonymous PL/SQL block. The PL/SQL block contains bind variables for:

- The input of the employee ID using the `:empid` placeholder
- The output result computing the annual employees' salary using the placeholder called `:res`

**Note:** This example demonstrates how to use the OUT result syntax (in the USING clause of the EXECUTE IMMEDIATE statement) to obtain the result calculated by the PL/SQL block. The procedure output variables and function return values can be obtained in a similar way from a dynamically executed anonymous PL/SQL block.

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- ALTER PROCEDURE name COMPILE
- ALTER FUNCTION name COMPILE
- ALTER PACKAGE name COMPILE SPECIFICATION
- ALTER PACKAGE name COMPILE BODY

```
CREATE PROCEDURE compile_plsql(name VARCHAR2,
 plsql_type VARCHAR2, options VARCHAR2 := NULL) IS
 stmt varchar2(200) := 'ALTER ' || plsql_type ||
 ' ' || name || ' COMPILE';
BEGIN
 IF options IS NOT NULL THEN
 stmt := stmt || ' ' || options;
 END IF;
 EXECUTE IMMEDIATE stmt;
END;
/
```

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## Using Native Dynamic SQL to Compile PL/SQL Code

The `compile_plsql` procedure in the example can be used to compile different PL/SQL code using the `ALTER DDL` statement. Four basic forms of the `ALTER` statement are shown to compile:

- A procedure
- A function
- A package specification
- A package body

**Note:** If you leave out the keyword SPECIFICATION or BODY with the ALTER PACKAGE statement, then the specification and body are both compiled.

Here are examples of calling the procedure in the slide for each of the four cases, respectively:

```
EXEC compile_plsql ('list_employees', 'procedure')
EXEC compile_plsql ('get_emp', 'function')
EXEC compile_plsql ('mypack', 'package',
'specification')
EXEC compile_plsql ('mypack', 'package', 'body')
```

Here is an example of compiling with `debug` enabled for the `get_emp` function:

```
EXEC compile plsql ('get emp', 'function', 'debug')
```

# Using the DBMS\_SQL Package

**The DBMS\_SQL package is used to write dynamic SQL in stored procedures and to parse DDL statements. Some of the procedures and functions of the package include:**

- **OPEN\_CURSOR**
- **PARSE**
- **BIND\_VARIABLE**
- **EXECUTE**
- **FETCH\_ROWS**
- **CLOSE\_CURSOR**

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## Using the DBMS\_SQL Package

Using DBMS\_SQL, you can write stored procedures and anonymous PL/SQL blocks that use dynamic SQL, such as executing DDL statements in PL/SQL—for example, executing a DROP TABLE statement. The operations provided by this package are performed under the current user, not under the package owner SYS. The DBMS\_SQL package provides the following subprograms to execute dynamic SQL:

- OPEN\_CURSOR to open a new cursor and return a cursor ID number
- PARSE to parse the SQL statement—that is, it checks the statement syntax and associates it with the opened cursor. DDL statements are immediately executed when parsed.
- BIND\_VARIABLE to bind a given value to a bind variable identified by its name in the statement being parsed. This is not needed if the statement does not have bind variables.
- EXECUTE to execute the SQL statement and return the number of rows processed
- FETCH\_ROWS to retrieve the next row for a query (use in a loop for multiple rows)
- CLOSE\_CURSOR to close the specified cursor

**Note:** Using the DBMS\_SQL package to execute DDL statements can result in a deadlock. For example, the most likely reason is that the package is being used to drop a procedure that you are still using.



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```
CREATE table temp_emp as select * from employees;
BEGIN
 DBMS_OUTPUT.PUT_LINE('Rows Deleted: ' ||
delete_all_rows('temp_emp'));
END;
/
```

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## Using DBMS SQL with a Parameterized DML Statement

```
EXECUTE insert row('countries', 'ZA', 'South Africa', 4)
```

1. Execute `DBMS_SQL.DEFINE_COLUMN` for each column selected.
2. Execute `DBMS_SQL.BIND_VARIABLE` for each bind variable in the query.
3. For each row, perform the following steps:
  - a. Execute `DBMS_SQL.FETCH_ROWS` to retrieve a row and return the number of rows fetched. Stop additional processing when a zero value is returned.
  - b. Execute `DBMS_SQL.COLUMN_VALUE` to retrieve each selected column value into each PL/SQL variable for processing.

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# Comparison of Native Dynamic SQL and the DBMS\_SQL Package

## Native Dynamic SQL:

- **Is easier to use than DBMS\_SQL**
- **Requires less code than DBMS\_SQL**
- **Enhances performance because the PL/SQL interpreter provides native support for it**
- **Supports all types supported by static SQL in PL/SQL, including user-defined types**
- **Can fetch rows directly into PL/SQL records**

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## Comparison of Native Dynamic SQL and the DBMS\_SQL Package

Native Dynamic SQL provides the following advantages over the DBMS\_SQL package.

**Ease of use:** Because Native Dynamic SQL is integrated with SQL, you can use it in the same way that you currently use static SQL within PL/SQL code. The code is typically more compact and readable compared with the code written with the DBMS\_SQL package.

**Performance improvement:** Native Dynamic SQL performs significantly better than DBMS\_SQL, in most circumstances, due to native support provided by the PL/SQL interpreter. The DBMS\_SQL approach uses a procedural API and suffers from high procedure call and data copy overhead.

**Support for user-defined types:** Native Dynamic SQL supports all the types supported by static SQL in PL/SQL. Therefore, Native Dynamic SQL provides support for user-defined types such as user-defined objects, collections, and REFs. The DBMS\_SQL package does not support these user-defined types. However, it has limited support for arrays.

**Support for fetching into records:** With Native Dynamic SQL, the rows resulting from a query can be directly fetched into PL/SQL records. The DBMS\_SQL package does not support fetching into records structures.

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A 3D cylinder with a grid of colored squares on its side, representing a convolution kernel. The grid is 4 rows by 6 columns, with colors including green, blue, yellow, orange, and brown.

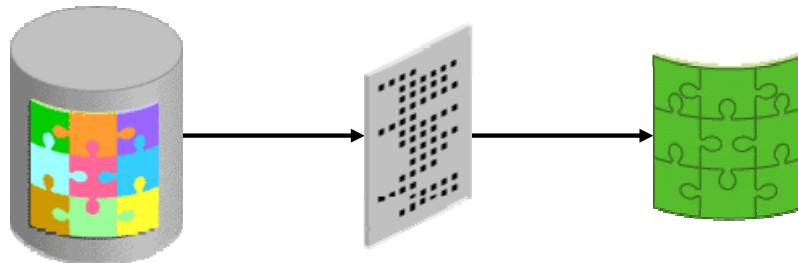
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**Note:** For more information about the DBMS\_DATAPUMP package, refer to the Online Course titled *Oracle Database 10g: Reduce Management - Tools and Utilities*.

# Metadata API

**Processing involves the following steps:**

- 1. Fetch an object's metadata as XML.**
- 2. Transform the XML in a variety of ways (including transforming it into SQL DDL).**
- 3. Submit the XML to re-create the object.**



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## Metadata API

Every entity in the database is modeled as an object that belongs to an object type. For example, the `EMPLOYEES` table is an object; its object type is `TABLE`. When you fetch an object's metadata, you must specify the object type.

Every object type is implemented by using three entities:

- A user-defined type (UDT) whose attributes comprise all the metadata for objects of the type. An object's XML representation is a translation of a type instance into XML, with the XML tag names derived from the type attribute names. (In the case of tables, several UDTs are needed to represent the different varieties of the object type.)
- An object view of the UDT that populates instances of the object type
- An Extensible Style Sheet Language (XSL) script that converts the XML representation of an object into SQL DDL

## Subprograms in DBMS\_METADATA

| Name                                    | Description                                                                                                                                                           |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| OPEN                                    | Specifies the type of object to be retrieved, the version of its metadata, and the object model. The return value is an opaque context handle for the set of objects. |
| SET_FILTER                              | Specifies restrictions on the objects to be retrieved such as the object name or schema                                                                               |
| SET_COUNT                               | Specifies the maximum number of objects to be retrieved in a single FETCH_xxx call                                                                                    |
| GET_QUERY                               | Returns the text of the queries that will be used by FETCH_xxx                                                                                                        |
| SET_PARSE_ITEM                          | Enables output parsing and specifies an object attribute to be parsed and returned                                                                                    |
| ADD_TRANSFORM                           | Specifies a transform that FETCH_xxx applies to the XML representation of the retrieved objects                                                                       |
| SET_TRANSFORM_PARAM,<br>SET_REMAP_PARAM | Specifies parameters to the XSLT stylesheet identified by transform_handle                                                                                            |
| FETCH_xxx                               | Returns metadata for objects meeting the criteria established by OPEN, SET_FILTER                                                                                     |
| CLOSE                                   | Invalidates the handle returned by OPEN and cleans up the associated state                                                                                            |

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## Subprograms in DBMS\_METADATA

The table provides an overview of the procedures and functions available in the DBMS\_METADATA package. To retrieve metadata, you can specify:

- The kind of object retrieved, either an object type (a table, index, procedure) or a heterogeneous collection of object types forming a logical unit (such as database export and schema export)
- Selection criteria (owner, name, and so on)
- “parse items” attributes of objects to be parsed and returned separately
- Transformations on the output, implemented by XSLT scripts

The package provides two types of retrieval interface for two types of usage:

- **For programmatic use:** OPEN, SET\_FILTER, SET\_COUNT, GET\_QUERY, SET\_PARSE\_ITEM, ADD\_TRANSFORM, SET\_TRANSFORM\_PARAM, SET\_REMAP\_PARAM (new in Oracle Database 10g), FETCH\_xxx, and CLOSE. These enable flexible selection criteria and the extraction of a stream of objects.
- **For use in SQL queries and for ad hoc browsing:** The GET\_xxx interfaces (GET\_XML and GET\_DDL) return metadata for a single named object. The GET\_DEPENDENT\_xxx and GET\_GRANTED\_xxx interfaces return metadata for one or more dependent or granted objects. None of these APIs support heterogeneous object types.

## FETCH\_xxx Subprograms

| Name           | Description                                                                                                                    |
|----------------|--------------------------------------------------------------------------------------------------------------------------------|
| FETCH_XML      | This function returns the XML metadata for an object as an XMLType.                                                            |
| FETCH_DDL      | This function returns the DDL (either to create or to drop the object) into a predefined nested table.                         |
| FETCH_CLOB     | This function returns the objects (transformed or not) as a CLOB.                                                              |
| FETCH_XML_CLOB | This procedure returns the XML metadata for the objects as a CLOB in an IN OUT NOCOPY parameter to avoid expensive LOB copies. |

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### FETCH\_xxx Subprograms

These functions and procedures return metadata for objects meeting the criteria established by the call to the OPEN function that returned the handle, and the subsequent calls to SET\_FILTER, SET\_COUNT, ADD\_TRANSFORM, and so on. Each call to FETCH\_xxx returns the number of objects specified by SET\_COUNT (or a smaller number, if fewer objects remain in the current cursor) until all objects have been returned.



## SET\_FILTER Procedure

- **Syntax:**

```
PROCEDURE set_filter
(handle IN NUMBER,
 name IN VARCHAR2,
 value IN VARCHAR2 | BOOLEAN | NUMBER,
 object_type_path VARCHAR2
);
```

- **Example:**

```
...
DBMS_METADATA.SET_FILTER (handle, 'NAME',
'HR');
...
```

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### SET\_FILTER Procedure

You use the SET\_FILTER procedure to identify restrictions on objects that are to be retrieved. For example, you can specify restrictions on an object or schema that is being retrieved. This procedure is overloaded with the parameters having the following meanings:

- `handle` is the handle returned from the OPEN function.
- `name` is the name of the filter. For each filter, the object type applies to its name, data type (text or Boolean), and meaning or effect (including its default value, if there is one).
- `value` is the value of the filter. It can be text, Boolean, or a numeric value.
- `object_type_path` is a path name designating the object types to which the filter applies. By default, the filter applies to the object type of the OPEN handle.

If you use an expression filter, then it is placed to the right of a SQL comparison, and the value is compared with it. The value must contain parentheses and quotation marks where appropriate. A filter value is combined with a particular object attribute to produce a WHERE condition in the query that fetches the objects.



# Filters

**There are over 70 filters, which are organized into object type categories such as:**

- **Named objects**
- **Tables**
- **Objects dependent on tables**
- **Index**
- **Dependent objects**
- **Granted objects**
- **Table data**
- **Index statistics**
- **Constraints**
- **All object types**
- **Database export**

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## Filters

There are over 70 filters that you can specify when using the `SET_FILTER` procedure. These filters are organized into object type categories. Some of the new object type categories in Oracle Database 10g are listed in the slide.

When using the `SET_FILTER` procedure, you specify the name of the filter and its respective value.

For example, you can use the `SCHEMA` filter with a value to identify the schema whose objects are selected. Then use a second call to the `SET_FILTER` procedure and use a filter named `INCLUDE_USER` that has a Boolean data type for its value. If it is set to `TRUE`, then objects containing privileged information about the user are retrieved.

```
DBMS_METADATA.SET_FILTER(handle, SCHEMA, 'HR');
DBMS_METADATA.SET_FILTER(handle, INCLUDE_USER, TRUE);
```

Each call to `SET_FILTER` causes a `WHERE` condition to be added to the underlying query that fetches the set of objects. The `WHERE` conditions are combined using an `AND` operator, so you can use multiple `SET_FILTER` calls to refine the set of objects to be returned.

# Examples of Setting Filters

**Set up the filter to fetch the HR schema objects excluding the object types of functions, procedures, and packages, as well as any views that contain PAYROLL in the start of the view name:**

```
DBMS_METADATA.SET_FILTER(handle, 'SCHEMA_EXPR',
 'IN (''PAYROLL'', ''HR'')');
DBMS_METADATA.SET_FILTER(handle, 'EXCLUDE_PATH_EXPR',
 '=''FUNCTION'');
DBMS_METADATA.SET_FILTER(handle, 'EXCLUDE_PATH_EXPR',
 '=''PROCEDURE'');
DBMS_METADATA.SET_FILTER(handle, 'EXCLUDE_PATH_EXPR',
 '=''PACKAGE'');
DBMS_METADATA.SET_FILTER(handle, 'EXCLUDE_NAME_EXPR',
 'LIKE ''PAYROLL%''', 'VIEW');
```

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## Examples of Setting Filters

The example shown in the slide calls the SET\_FILTER procedure several times to create a WHERE condition that identifies which object types are to be fetched. First, the objects in the PAYROLL and HR schemas are identified as object types to be fetched. Subsequently, the SET\_FILTER procedure identifies certain object types (functions, procedures, and packages) and view object names to be excluded.

# Programmatic Use: Example 1

```
CREATE PROCEDURE example_one IS
 h NUMBER; th1 NUMBER; th2 NUMBER;
 doc sys.ku$_ddl; ← ①
BEGIN
 h := DBMS_METADATA.OPEN('SCHEMA_EXPORT'); ← ②
 DBMS_METADATA.SET_FILTER (h, 'SCHEMA', 'HR'); ← ③
 th1 := DBMS_METADATA.ADD_TRANSFORM (h, ← ④
 'MODIFY', NULL, 'TABLE');
 DBMS_METADATA.SET_REMAP_PARAM(th1, ← ⑤
 'REMAP_TABLESPACE', 'SYSTEM', 'TBS1');
 th2 := DBMS_METADATA.ADD_TRANSFORM(h, 'DDL'); ← ⑥
 DBMS_METADATA.SET_TRANSFORM_PARAM(th2, ← ⑦
 'SQLTERMINATOR', TRUE);
 DBMS_METADATA.SET_TRANSFORM_PARAM(th2, ← ⑧
 'REF_CONSTRAINTS', FALSE, 'TABLE');
 LOOP
 doc := DBMS_METADATA.FETCH_DDL(h); ← ⑨
 EXIT WHEN doc IS NULL;
 END LOOP;
 DBMS_METADATA.CLOSE(h); ← ⑩
END;
```

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## Programmatic Use: Example 1

In this example, all objects are retrieved from the HR schema as creation DDL. The MODIFY transform is used to change the tablespaces for the tables.

1. The DBMS\_METADATA package has several predefined types that are owned by SYS. The sys.ku\$\_ddl type is defined in the DBMS\_METADATA package. It is a table type that holds the CLOB type of data.
2. You use the OPEN function to specify the type of object to be retrieved, the version of its metadata, and the object model. It returns a context handle for the set of objects.

In this example, 'SCHEMA\_EXPORT' is the object type, and it indicates all metadata objects in a schema. There are 85 predefined types of objects for the model that you can specify for this parameter. Both the version of metadata and the object model parameters are not identified in this example. The version of metadata parameter defaults to 'COMPATIBLE'. You can also specify 'LATEST' or a specific database version. Currently, the model parameter supports only the Oracle model in Oracle Database 10g. This is the default.

3. The SET\_FILTER procedure identifies restrictions on the objects to be retrieved.

## Programmatic Use: Example 1 (continued)

4. The `ADD_TRANSFORM` function specifies a transform that `FETCH_XXX` applies to the XML representation of the retrieved objects. You can have more than one transform. In the example, two transforms occur, one for each of the `th1` and `th2` program variables. The `ADD_TRANSFORM` function accepts four parameters and returns a number representing the opaque handle to the transform. The parameters are the handle returned from the `OPEN` statement, the name of the transform (`DDL`, `DROP`, or `MODIFY`), the encoding name (which is the name of the NLS [national language support] character set in which the style sheet pointed to by the name is encoded), and the object type. If the object type is omitted, the transform applies to all objects; otherwise, it applies only to the object type specified.  
The first transform shown in the program code is the handle returned from the `OPEN` function. The second transform shown in the code has two parameter values specified. The first parameter is the handle identified from the `OPEN` function. The second parameter value is `DDL`, which means the document is transformed to DDL that creates the object. The output of this transform is not an XML document. The third and fourth parameters are not specified. Both take the default values for the encoding and object type parameters.
5. The `SET_REMAP_PARAM` procedure identifies the parameters to the XSLT style sheet identified by the transform handle, which is the first parameter passed to the procedure. In the example, the second parameter value '`REMAP_TABLESPACE`' means that the objects have their tablespaces renamed from an old value to a new value. In the `ADD_TRANSFORM` function, the choices are `DDL`, `DROP`, or `MODIFY`. For each of these values, the `SET_REMAP_PARAM` identifies the name of the parameter.  
`REMAP_TABLESPACE` means the objects in the document will have their tablespaces renamed from an old value to a new value. The third and fourth parameters identify the old value and new value. In this example, the old tablespace name is `SYSTEM`, and the new tablespace name is `TBS1`.
6. `SET_TRANSFORM_PARAM` works similarly to `SET_REMAP_PARAM`. In the code shown, the first call to `SET_TRANSFORM_PARAM` identifies parameters for the `th2` variable. The `SQLTERMINATOR` and `TRUE` parameter values cause the SQL terminator (`;` or `/`) to be appended to each DDL statement.  
The second call to `SET_TRANSFORM_PARAM` identifies more characteristics for the `th2` variable. `REF_CONSTRAINTS`, `FALSE`, `TABLE` means that referential constraints on the tables are not copied to the document.
7. The `FETCH_DDL` function returns metadata for objects meeting the criteria established by the `OPEN`, `SET_FILTER`, `ADD_TRANSFORM`, `SET_REMAP_PARAM`, and `SET_TRANSFORM_PARAM` subroutines.
8. The `CLOSE` function invalidates the handle returned by the `OPEN` function and cleans up the associated state. Use this function to terminate the stream of objects established by the `OPEN` function.

## Programmatic Use: Example 2

```
CREATE FUNCTION get_table_md RETURN CLOB IS
 h NUMBER; -- returned by 'OPEN'
 th NUMBER; -- returned by 'ADD_TRANSFORM'
 doc CLOB;
BEGIN
 -- specify the OBJECT TYPE
 h := DBMS_METADATA.OPEN('TABLE');
 -- use FILTERS to specify the objects desired
 DBMS_METADATA.SET_FILTER(h, 'SCHEMA', 'HR');
 DBMS_METADATA.SET_FILTER(h, 'NAME', 'EMPLOYEES');
 -- request to be TRANSFORMED into creation DDL
 th := DBMS_METADATA.ADD_TRANSFORM(h, 'DDL');
 -- FETCH the object
 doc := DBMS_METADATA.FETCH_CLOB(h);
 -- release resources
 DBMS_METADATA.CLOSE(h);
 RETURN doc;
END;
/
```

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### Programmatic Use: Example 2

This example returns the metadata for the EMPLOYEES table. The result is:

```
set pagesize 0
set long 1000000
SELECT get_table_md FROM dual;

CREATE TABLE "HR"."EMPLOYEES"
("EMPLOYEE_ID" NUMBER(6,0),
 "FIRST_NAME" VARCHAR2(20),
 "LAST_NAME" VARCHAR2(25) CONSTRAINT
"EMP_LAST_NAME_NN"
 NOT NULL ENABLE,
 "e-mail" VARCHAR2(25) CONSTRAINT "EMP_e-mail_NN"
 NOT NULL ENABLE,
 "PHONE_NUMBER" VARCHAR2(20),
 "HIRE_DATE" DATE CONSTRAINT "EMP_HIRE_DATE_NN"
 NOT NULL ENABLE,
 "JOB_ID" VARCHAR2(10) CONSTRAINT "EMP_JOB_NN"
 NOT NULL ENABLE,
 "SALARY" NUMBER(8,2),
```

...

## Programmatic Use: Example 2 (continued)

```
"COMMISSION_PCT" NUMBER(2,2),
 "MANAGER_ID" NUMBER(6,0),
 "DEPARTMENT_ID" NUMBER(4,0),
 CONSTRAINT "EMP_SALARY_MIN" CHECK (salary > 0)
ENABLE,
 CONSTRAINT "EMP_e-mail_UK" UNIQUE ("e-mail")
USING INDEX PCTFREE 10 INITRANS 2 MAXTRANS 255
STORAGE(INITIAL 65536 NEXT 65536 MINEXTENTS 1
 MAXEXTENTS 2147483645
PCTINCREASE 0 FREELISTS 1 FREELIST GROUPS 1
 BUFFER_POOL DEFAULT)
TABLESPACE "EXAMPLE" ENABLE,
 CONSTRAINT "EMP_EMP_ID_PK" PRIMARY KEY
("EMPLOYEE_ID")
USING INDEX PCTFREE 10 INITRANS 2 MAXTRANS 255
STORAGE(INITIAL 65536 NEXT 65536 MINEXTENTS 1
 MAXEXTENTS 2147483645
PCTINCREASE 0 FREELISTS 1 FREELIST GROUPS 1
 BUFFER_POOL DEFAULT)
TABLESPACE "EXAMPLE" ENABLE,
 CONSTRAINT "EMP_DEPT_FK" FOREIGN KEY
("DEPARTMENT_ID")
REFERENCES "HR"."DEPARTMENTS"
("DEPARTMENT_ID") ENABLE,
 CONSTRAINT "EMP_JOB_FK" FOREIGN KEY ("JOB_ID")
REFERENCES "HR"."JOBS" ("JOB_ID") ENABLE,
 CONSTRAINT "EMP_MANAGER_FK" FOREIGN KEY
("MANAGER_ID")
REFERENCES "HR"."EMPLOYEES" ("EMPLOYEE_ID")
ENABLE
) PCTFREE 0 PCTUSED 40 INITRANS 1 MAXTRANS 255 C
OMPRESS LOGGING
STORAGE(INITIAL 65536 NEXT 65536 MINEXTENTS 1
 MAXEXTENTS 2147483645
PCTINCREASE 0 FREELISTS 1 FREELIST GROUPS 1
 BUFFER_POOL DEFAULT)
TABLESPACE "EXAMPLE"
You can accomplish the same effect with the browsing
interface:
SELECT dbms_metadata.get_ddl
 ('TABLE', 'EMPLOYEES', 'HR')
FROM dual;
```

# Browsing APIs

| Name              | Description                                                                  |
|-------------------|------------------------------------------------------------------------------|
| GET_XXX           | The GET_XML and GET_DDL functions return metadata for a single named object. |
| GET_DEPENDENT_XXX | This function returns metadata for a dependent object.                       |
| GET_GRANTED_XXX   | This function returns metadata for a granted object.                         |
| Where xxx is:     | DDL or XML                                                                   |

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## Browsing APIs

The browsing APIs are designed for use in SQL queries and ad hoc browsing. These functions allow you to fetch metadata for objects with a single call. They encapsulate calls to OPEN, SET\_FILTER, and so on. Which function you use depends on the characteristics of the object type and whether you want XML or DDL.

For some object types, you can use more than one function. You can use GET\_XXX to fetch an index by name, or GET\_DEPENDENT\_XXX to fetch the same index by specifying the table on which it is defined.

GET\_XXX returns a single object name.

For GET\_DEPENDENT\_XXX and GET\_GRANTED\_XXX, an arbitrary number of granted or dependent objects may match the input criteria. You can specify an object count when fetching these objects.

If you invoke these functions from *iSQL\*Plus*, then you should use the SET LONG and SET PAGESIZE commands to retrieve complete, uninterrupted output.

```
SET LONG 2000000
SET PAGESIZE 300
```

# Browsing APIs: Examples

## 1. Get the XML representation of HR.EMPLOYEES:

```
SELECT DBMS_METADATA.GET_XML
 ('TABLE', 'EMPLOYEES', 'HR')
FROM dual;
```

## 2. Fetch the DDL for all object grants on HR.EMPLOYEES:

```
SELECT DBMS_METADATA.GET_DEPENDENT_DDL
 ('OBJECT_GRANT', 'EMPLOYEES', 'HR')
FROM dual;
```

## 3. Fetch the DDL for all system grants granted to HR:

```
SELECT DBMS_METADATA.GET_GRANTED_DDL
 ('SYSTEM_GRANT', 'HR')
FROM dual;
```

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## Browsing APIs: Examples

### 1. Results for fetching the XML representation of HR.EMPLOYEES:

```
DBMS_METADATA.GET_XML('TABLE', 'EMPLOYEES', 'HR')

<?xml version="1.0"?>
<ROWSET>
 <ROW>
 <TABLE_T>
 <VERS_MAJOR>1</VERS_MAJOR>
```

### 2. Results for fetching the DDL for all object grants on HR.EMPLOYEES:

```
DBMS_METADATA.GET_DEPENDENT_DDL
('OBJECT_GRANT', 'EMPLOYEES', 'HR')

GRANT SELECT ON "HR"."EMPLOYEES" TO "OE"
GRANT REFERENCES ON "HR"."EMPLOY
```

### 3. Results for fetching the DDL for all system grants granted to HR:

```
DBMS_METADATA.GET_GRANTED_DDL('SYSTEM_GRANT', 'HR')

GRANT UNLIMITED TABLESPACE TO "HR"
```



# Browsing APIs: Examples

```
BEGIN
 DBMS_METADATA.SET_TRANSFORM_PARAM(
 DBMS_METADATA.SESSION_TRANSFORM,
 'STORAGE', false);
END;
/
SELECT DBMS_METADATA.GET_DDL('TABLE',u.table_name)
FROM user_all_tables u
WHERE u.nested = 'NO'
AND (u.iot_type IS NULL OR u.iot_type = 'IOT');

BEGIN
 DBMS_METADATA.SET_TRANSFORM_PARAM(
 DBMS_METADATA.SESSION_TRANSFORM, 'DEFAULT'):
END;
/
```

1

2

3

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## Browsing APIs: Examples (continued)

The example in the slide shows how to fetch creation DDL for all “complete” tables in the current schema, filtering out nested tables and overflow segments. The steps shown in the slide are as follows:

1. The SET\_TRANSFORM\_PARAM function specifies that the storage clauses are not to be returned in the SQL DDL. The SESSION\_TRANSFORM function is interpreted to mean “for the current session.”
2. Use the GET\_DDL function to retrieve DDL on all non-nested and non-IOT (index-organized table) tables.

```
CREATE TABLE "HR"."COUNTRIES"
("COUNTRY_ID" CHAR(2)
 CONSTRAINT "COUNTRY_ID_NN" NOT NULL ENABLE,
 "COUNTRY_NAME" VARCHAR2(40),
 "REGION_ID" NUMBER,
 CONSTRAINT "COUNTRY_C_ID_PK"
 PRIMARY KEY ("COUNTRY_ID") ENABLE,
 CONSTRAINT "COUNTR_REG_FK" FOREIGN KEY
...

```

3. Reset the session-level parameters to their defaults.

# Summary

**In this lesson, you should have learned how to:**

- **Explain the execution flow of SQL statements**
- **Create SQL statements dynamically and execute them using either Native Dynamic SQL statements or the DBMS\_SQL package**
- **Recognize the advantages of using Native Dynamic SQL compared to the DBMS\_SQL package**
- **Use DBMS\_METADATA subprograms to programmatically obtain metadata from the data dictionary**

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## Summary

In this lesson, you discovered how to dynamically create any SQL statement and execute it using the Native Dynamic SQL statements. Dynamically executing SQL and PL/SQL code extends the capabilities of PL/SQL beyond query and transactional operations. For earlier releases of the database, you could achieve similar results with the DBMS\_SQL package.

The lesson explored some differences and compared using Native Dynamic SQL to the DBMS\_SQL package. If you are using Oracle8i or later releases, you should use Native Dynamic SQL for new projects.

The lesson also discussed using the DBMS\_METADATA package to retrieve metadata from the database dictionary with results presented in XML or creational DDL format. The resulting XML data can be used for re-creating the object.

## Practice 6: Overview

**This practice covers the following topics:**

- **Creating a package that uses Native Dynamic SQL to create or drop a table and to populate, modify, and delete rows from a table**
- **Creating a package that compiles the PL/SQL code in your schema**
- **Using DBMS\_METADATA to display the statement to regenerate a PL/SQL subprogram**

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### Practice 6: Overview

In this practice, you write code to perform the following tasks:

- Create a package that uses Native Dynamic SQL to create or drop a table, and to populate, modify, and delete rows from the table.
- Create a package that compiles the PL/SQL code in your schema, either all the PL/SQL code or only code that has an INVALID status in the USER\_OBJECTS table.
- Use DBMS\_METADATA to regenerate PL/SQL code for any procedure that you have in your schema.

## Practice 6

1. Create a package called TABLE\_PKG that uses Native Dynamic SQL to create or drop a table, and to populate, modify, and delete rows from the table.
  - a. Create a package specification with the following procedures:
 

```
PROCEDURE make(table_name VARCHAR2, col_specs VARCHAR2)
PROCEDURE add_row(table_name VARCHAR2, col_values
VARCHAR2,
cols VARCHAR2 := NULL)
PROCEDURE upd_row(table_name VARCHAR2, set_values
VARCHAR2,
conditions VARCHAR2 := NULL)
PROCEDURE del_row(table_name VARCHAR2,
conditions VARCHAR2 := NULL);
PROCEDURE remove(table_name VARCHAR2)
```

Ensure that subprograms manage optional default parameters with NULL values.
  - b. Create the package body that accepts the parameters and dynamically constructs the appropriate SQL statements that are executed using Native Dynamic SQL, except for the remove procedure that should be written using the DBMS\_SQL package.
  - c. Execute the package MAKE procedure to create a table as follows:
 

```
make('my_contacts', 'id number(4), name varchar2(40)');
```
  - d. Describe the MY\_CONTACTS table structure.
  - e. Execute the ADD\_ROW package procedure to add the following rows:
 

```
add_row('my_contacts', '1, 'Geoff Gallus'', 'id, name');
add_row('my_contacts', '2, 'Nancy'', 'id, name');
add_row('my_contacts', '3, 'Sunitha Patel'', 'id, name');
add_row('my_contacts', '4, 'Valli Pataballa'', 'id, name');
```
  - f. Query the MY\_CONTACTS table contents.
  - g. Execute the DEL\_ROW package procedure to delete a contact with ID value 1.
  - h. Execute the UPD\_ROW procedure with the following row data:
 

```
upd_row('my_contacts', 'name='Nancy Greenberg'', 'id=2');
```
  - i. Select the data from the MY\_CONTACTS table again to view the changes.
  - j. Drop the table by using the remove procedure and describe the MY\_CONTACTS table.
2. Create a COMPILE\_PKG package that compiles the PL/SQL code in your schema.
  - a. In the specification, create a package procedure called MAKE that accepts the name of a PL/SQL program unit to be compiled.
  - b. In the body, the MAKE procedure should call a private function named GET\_TYPE to determine the PL/SQL object type from the data dictionary, and return the type name (use PACKAGE for a package with a body) if the object exists; otherwise, it should return a NULL. If the object exists, MAKE dynamically compiles it with the ALTER statement.
  - c. Use the COMPILE\_PKG.MAKE procedure to compile the EMPLOYEE\_REPORT procedure, the EMP\_PKG package, and a nonexistent object called EMP\_DATA.

## Practice 6 (continued)

3. Add a procedure to the `COMPILE_PKG` that uses the `DBMS_METADATA` to obtain a DDL statement that can regenerate a named PL/SQL subprogram, and writes the DDL statement to a file by using the `UTL_FILE` package.
  - a. In the package specification, create a procedure called `REGENERATE` that accepts the name of a PL/SQL component to be regenerated. Declare a public `VARCHAR2` variable called `dir` initialized with the directory alias value `'UTL_FILE'`. Compile the specification.
  - b. In the package body, implement the `REGENERATE` procedure so that it uses the `GET_TYPE` function to determine the PL/SQL object type from the supplied name. If the object exists, then obtain the DDL statement used to create the component using the `DBMS_METADATA.GET_DDL` procedure, which must be provided with the object name in uppercase text. Save the DDL statement in a file by using the `UTL_FILE.PUT` procedure. Write the file in the directory path stored in the public variable called `dir` (from the specification). Construct a file name (in lowercase characters) by concatenating the `USER` function, an underscore, and the object name with a `.sql` extension. For example: `ora1_myobject.sql`. Compile the body.
  - c. Execute the `COMPILE_PKG.REGENERATE` procedure by using the name of the `TABLE_PKG` created in the first task of this practice.
  - d. Use Putty FTP to get the generated file from the server to your local directory. Edit the file to insert a `/` terminator character at the end of a `CREATE` statement (if required). Cut and paste the results into the *iSQL\*Plus* buffer and execute the statement.



# 7

## Design Considerations for PL/SQL Code

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# Objectives

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

- **Use package specifications to create standard constants and exceptions**
- **Write and call local subprograms**
- **Set the AUTHID directive to control the run-time privileges of a subprogram**
- **Execute subprograms to perform autonomous transactions**
- **Use bulk binding and the RETURNING clause with DML**
- **Pass parameters by reference using a NOCOPY hint**
- **Use the PARALLEL ENABLE hint for optimization**

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## Lesson Aim

In this lesson, you learn to use package specifications to standardize names for constant values and exceptions. You learn how to create subprograms in the Declaration section of any PL/SQL block for using locally in the block. The AUTHID compiler directive is discussed to show how you can manage run-time privileges of the PL/SQL code, and create independent transactions by using the AUTONOMOUS TRANSACTION directive for subprograms.

This lesson also covers some performance considerations that can be applied to PL/SQL applications, such as bulk binding operations with a single SQL statement, the RETURNING clause, and the NOCOPY and PARALLEL ENABLE hints.



# Standardizing Constants and Exceptions

**Constants and exceptions are typically implemented using a bodiless package (that is, in a package specification).**

- **Standardizing helps to:**
  - **Develop programs that are consistent**
  - **Promote a higher degree of code reuse**
  - **Ease code maintenance**
  - **Implement company standards across entire applications**
- **Start with standardization of:**
  - **Exception names**
  - **Constant definitions**

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## Standardizing Constants and Exceptions

When several developers are writing their own exception handlers in an application, there could be inconsistencies in the handling of error situations. Unless certain standards are adhered to, the situation can become confusing because of the different approaches followed in handling the same error or because of the display of conflicting error messages that confuse users. To overcome these, you can:

- Implement company standards that use a consistent approach to error handling across the entire application
- Create predefined, generic exception handlers that produce consistency in the application
- Write and call programs that produce consistent error messages

All good programming environments promote naming and coding standards. In PL/SQL, a good place to start implementing naming and coding standards is with commonly used constants and exceptions that occur in the application domain.

The PL/SQL package specification construct is an excellent component to support standardization because all identifiers declared in the package specification are public. They are visible to the subprograms that are developed by the owner of the package and all code with EXECUTE rights to the package specification.

# Standardizing Exceptions

**Create a standardized error-handling package that includes all named and programmer-defined exceptions to be used in the application.**

```
CREATE OR REPLACE PACKAGE error_pkg IS
 fk_err EXCEPTION;
 seq_nbr_err EXCEPTION;
 PRAGMA EXCEPTION_INIT (fk_err, -2292);
 PRAGMA EXCEPTION_INIT (seq_nbr_err, -2277);
 ...
END error_pkg;
/
```

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## Standardizing Exceptions

In the example in the slide, the `error_pkg` package is a standardized exception package. It declares a set of programmer-defined exception identifiers. Because many of the Oracle database predefined exceptions do not have identifying names, the example package shown in the slide uses the `PRAGMA EXCEPTION_INIT` directive to associate selected exception names with an Oracle database error number. This enables you to refer to any of the exceptions in a standard way in your applications, as in the following example:

```
BEGIN
 DELETE FROM departments
 WHERE department_id = deptno;
 ...
EXCEPTION
 WHEN error_pkg.fk_err THEN
 ...
 WHEN OTHERS THEN
 ...
END;
/
```

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- **Display errors based on `SQLCODE` and `SQLERRM` values for exceptions**
- **Track run-time errors easily by using parameters in your code to identify:**
  - The procedure in which the error occurred
  - The location (line number) of the error
  - `RAISE_APPLICATION_ERROR` using stack trace capabilities, with the third argument set to `TRUE`

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Standardized exception handling can be implemented either as a stand-alone subprogram or a subprogram added to the package that defines the standard exceptions. Consider creating a package with:

- A common practice is to use parameters that identify the name of the procedure and the location in which the error has occurred. This enables you to keep track of run-time errors more easily. An alternative is to use the `RAISE_APPLICATION_ERROR` built-in procedure to keep a stack trace of exceptions that can be used to track the call sequence leading to the error. To do this, set the third optional argument to `TRUE`. For example:

This is meaningful when more than one exception is raised in this manner.

# Standardizing Constants

**For programs that use local variables whose values should not change:**

- **Convert the variables to constants to reduce maintenance and debugging**
- **Create one central package specification and place all constants in it**

```
CREATE OR REPLACE PACKAGE constant_pkg IS
 c_order_received CONSTANT VARCHAR(2) := 'OR';
 c_order_shipped CONSTANT VARCHAR(2) := 'OS';
 c_min_sal CONSTANT NUMBER(3) := 900;
 ...
END constant_pkg;
```

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## Standardizing Constants

By definition, a variable's value changes, whereas a constant's value cannot be changed. If you have programs that use local variables whose values should not and do not change, then convert the variables to constants. This can help with the maintenance and debugging of your code.

Consider creating a single shared package with all your constants in it. This makes maintenance and change of the constants much easier. This procedure or package can be loaded on system startup for better performance.

The example in the slide shows the `constant_pkg` package containing a few constants. Refer to any of the package constants in your application as required. Here is an example:

```
BEGIN
 UPDATE employees
 SET salary = salary + 200
 WHERE salary <= constant_pkg.c_min_sal;
 ...
END;
/
```

# Local Subprograms

- **A local subprogram is a PROCEDURE or FUNCTION defined in the declarative section.**

```
CREATE PROCEDURE employee_sal(id NUMBER) IS
 emp employees%ROWTYPE;
 FUNCTION tax(salary VARCHAR2) RETURN NUMBER IS
 BEGIN
 RETURN salary * 0.825;
 END tax;
BEGIN
 SELECT * INTO emp
 FROM EMPLOYEES WHERE employee_id = id;
 DBMS_OUTPUT.PUT_LINE('Tax: ' || tax(emp.salary));
END;
```

- **The local subprogram must be defined at the end of the declarative section.**

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## Local Subprograms

Local subprograms can drive top-down design. They reduce the size of a module by removing redundant code. This is one of the main reasons for creating a local subprogram. If a module needs the same routine several times, but only this module needs the routine, then define it as a local subprogram.

You can define a named PL/SQL block in the declarative section of any PL/SQL program, procedure, function, or anonymous block provided that it is declared at the end of the Declaration section. Local subprograms have the following characteristics:

- They are only accessible to the block in which they are defined.
- They are compiled as part of their enclosing blocks.

The benefits of local subprograms are:

- Reduction of repetitive code
- Improved code readability and ease of maintenance
- Less administration because there is one program to maintain instead of two

The concept is simple. The example shown in the slide illustrates this with a basic example of an income tax calculation of an employee's salary.

# Definer's Rights Versus Invoker's Rights

## Definer's rights:

- Used prior to Oracle8i
- Programs execute with the privileges of the creating user.
- User does not require privileges on underlying objects that the procedure accesses. User requires privilege only to execute a procedure.

## Invoker's rights:

- Introduced in Oracle8i
- Programs execute with the privileges of the calling user.
- User requires privileges on the underlying objects that the procedure accesses.

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## Definer's Rights Versus Invoker's Rights

### Definer's Rights Model

Prior to Oracle8i, all programs executed with the privileges of the user who created the subprogram. This is known as the definer's rights model, which:

- Allows a caller of the program the privilege to execute the procedure, but no privileges on the underlying objects that the procedure accesses
- Requires the owner to have all the necessary object privileges for the objects that the procedure references

For example, if user Scott creates a PL/SQL subprogram `get_employees` that is subsequently invoked by Sarah, then the `get_employees` procedure runs with the privileges of the definer Scott.

### Invoker's Rights Model

In the invoker's rights model, which was introduced in Oracle8i, programs are executed with the privileges of the calling user. A user of a procedure running with invoker's rights requires privileges on the underlying objects that the procedure references.

For example, if Scott's PL/SQL subprogram `get_employees` is invoked by Sarah, then the `get_employees` procedure runs with the privileges of the invoker Sarah.

# Specifying Invoker's Rights

## Set AUTHID to CURRENT\_USER:

```
CREATE OR REPLACE PROCEDURE add_dept(
 id NUMBER, name VARCHAR2) AUTHID CURRENT_USER IS
BEGIN
 INSERT INTO departments
 VALUES (id,name,NULL,NULL);
END;
```

When used with stand-alone functions, procedures, or packages:

- Names used in queries, DML, Native Dynamic SQL, and DBMS\_SQL package are resolved in the invoker's schema
- Calls to other packages, functions, and procedures are resolved in the definer's schema

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## Specifying Invoker's Rights

### Setting Invoker's Rights

The following is the syntax for setting invoker's rights for different PL/SQL subprogram constructs:

```
CREATE FUNCTION name RETURN type AUTHID CURRENT_USER
IS...
CREATE PROCEDURE name AUTHID CURRENT_USER IS...
CREATE PACKAGE name AUTHID CURRENT_USER IS...
CREATE TYPE name AUTHID CURRENT_USER IS OBJECT...
```

In these statements, set AUTHID to DEFINER, or do not use it for default behavior.

### Name Resolution

For a definer's rights procedure, all external references are resolved in the definer's schema. For an invoker's rights procedure, the resolution of external references depends on the kind of statement in which they appear:

- Names used in queries, data manipulation language (DML) statements, dynamic SQL, and DBMS\_SQL are resolved in the invoker's schema.
- All other statements, such as calls to packages, functions, and procedures, are resolved in the definer's schema.

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- The diagram illustrates two PL/SQL procedures, `proc1` and `proc2`, with numbered annotations 1 through 7 indicating specific lines of code.

**Procedure proc1:**

```
PROCEDURE proc1 IS
 emp_id NUMBER;
BEGIN
 emp_id := 1234;
 COMMIT;
 INSERT ...
 proc2;
 DELETE ...
 COMMIT;
END proc1;
```

**Procedure proc2:**

```
PROCEDURE proc2 IS
 PRAGMA
 AUTONOMOUS_TRANSACTION;
 dept_id NUMBER := 90;
 BEGIN
 UPDATE ...
 INSERT ...
 COMMIT; -- Required
 END proc2;
```

The annotations are as follows:

  - 1: Points to the `INSERT ...` line in `proc1`.
  - 2: Points to the `proc2;` line in `proc1`.
  - 3: Points to the `BEGIN` line in `proc2`.
  - 4: Points to the `UPDATE ...` line in `proc2`.
  - 5: Points to the `COMMIT; -- Required` line in `proc2`.
  - 6: Points to the `END proc2;` line in `proc2`.
  - 7: Points to the `COMMIT;` line in `proc1`.

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A transaction is a series of statements that does a logical unit of work that completes or fails as an integrated unit. Often, one transaction starts another that may need to operate outside the scope of the transaction that started it. That is, in an existing transaction, a required independent transaction may need to commit or roll back changes without affecting the outcome of the starting transaction. For example, in a stock purchase transaction, the customer's information must be committed regardless of whether the overall stock purchase completes. Or, while running that same transaction, you want to log messages to a table even if the overall transaction rolls back.

1. The main transaction begins.
2. A `proc2` procedure is called to start the autonomous transaction.
3. The main transaction is suspended.
4. The autonomous transactional operation begins.
5. The autonomous transaction ends with a commit or roll back operation.
6. The main transaction is resumed.
7. The main transaction ends.



# Features of Autonomous Transactions

## Autonomous transactions:

- **Are independent of the main transaction**
- **Suspend the calling transaction until it is completed**
- **Are not nested transactions**
- **Do not roll back if the main transaction rolls back**
- **Enable the changes to become visible to other transactions upon a commit**
- **Are demarcated (started and ended) by individual subprograms and not by nested or anonymous PL/SQL blocks**

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## Features of Autonomous Transactions

Autonomous transactions exhibit the following features:

- Although called within a transaction, autonomous transactions are independent of that transaction. That is, they are not nested transactions.
- If the main transaction rolls back, autonomous transactions do not.
- Changes made by an autonomous transaction become visible to other transactions when the autonomous transaction commits.
- With their stack-like functionality, only the “top” transaction is accessible at any given time. After completion, the autonomous transaction is popped, and the calling transaction is resumed.
- There are no limits other than resource limits on how many autonomous transactions can be recursively called.
- Autonomous transactions must be explicitly committed or rolled back; otherwise, an error is returned when attempting to return from the autonomous block.
- You cannot use PRAGMA to mark all subprograms in a package as autonomous. Only individual routines can be marked autonomous.
- You cannot mark a nested or anonymous PL/SQL block as autonomous.

# Using Autonomous Transactions

## Example:

```
PROCEDURE bank_trans(cardnbr NUMBER, loc NUMBER) IS
BEGIN
 log_usage (cardnbr, loc);
 INSERT INTO txn VALUES (9001, 1000,...);
END bank_trans;
```

```
PROCEDURE log_usage (card_id NUMBER, loc NUMBER)
IS
 PRAGMA AUTONOMOUS_TRANSACTION;
BEGIN
 INSERT INTO usage
 VALUES (card_id, loc);
 COMMIT;
END log_usage;
```

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## Using Autonomous Transactions

To define autonomous transactions, you use `PRAGMA AUTONOMOUS_TRANSACTION`. `PRAGMA` instructs the PL/SQL compiler to mark a routine as autonomous (independent). In this context, the term “routine” includes top-level (not nested) anonymous PL/SQL blocks; local, stand-alone, and packaged functions and procedures; methods of a SQL object type; and database triggers. You can code `PRAGMA` anywhere in the declarative section of a routine. However, for readability, it is best placed at the top of the Declaration section.

In the example in the slide, you track where the bankcard is used, regardless of whether the transaction is successful. The following are the benefits of autonomous transactions:

- After starting, an autonomous transaction is fully independent. It shares no locks, resources, or commit dependencies with the main transaction, so you can log events, increment retry counters, and so on even if the main transaction rolls back.
- More important, autonomous transactions help you build modular, reusable software components. For example, stored procedures can start and finish autonomous transactions on their own. A calling application need not know about a procedure’s autonomous operations, and the procedure need not know about the application’s transaction context. That makes autonomous transactions less error-prone than regular transactions and easier to use.

# RETURNING Clause

## The RETURNING clause:

- Improves performance by returning column values with INSERT, UPDATE, and DELETE statements
- Eliminates the need for a SELECT statement

```
CREATE PROCEDURE update_salary(emp_id NUMBER) IS
 name employees.last_name%TYPE;
 new_sal employees.salary%TYPE;
BEGIN
 UPDATE employees
 SET salary = salary * 1.1
 WHERE employee_id = emp_id
 RETURNING last_name, salary INTO name, new_sal;
END update_salary;
/
```

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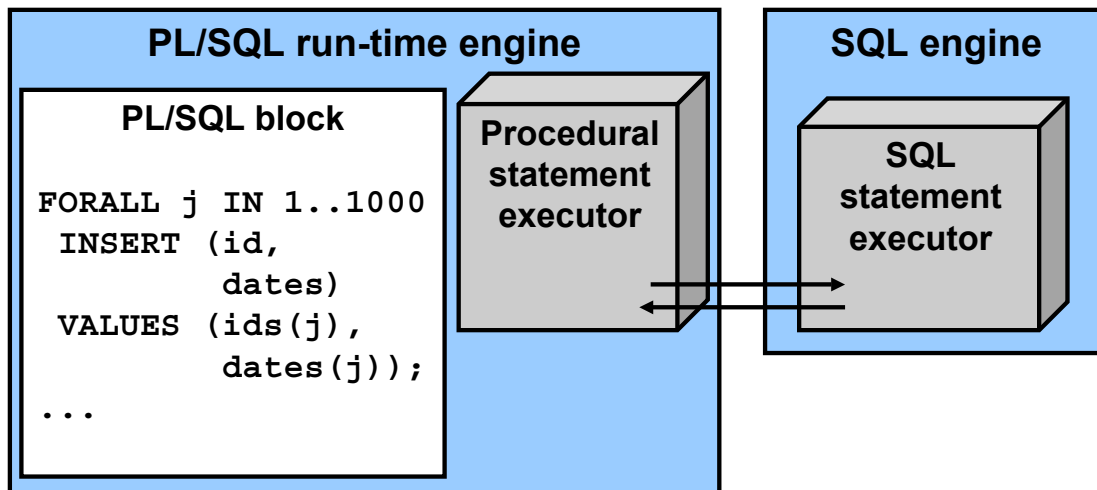
## RETURNING Clause

Often, applications need information about the row affected by a SQL operation—for example, to generate a report or to take a subsequent action. The INSERT, UPDATE, and DELETE statements can include a RETURNING clause, which returns column values from the affected row into PL/SQL variables or host variables. This eliminates the need to SELECT the row after an INSERT or UPDATE, or before a DELETE. As a result, fewer network round trips, less server CPU time, fewer cursors, and less server memory are required.

The example in the slide shows how to update the salary of an employee and, at the same time, retrieve the employee's last name and new salary into a local PL/SQL variable.

# Bulk Binding

**Binds whole arrays of values in a single operation, rather than using a loop to perform a `FETCH`, `INSERT`, `UPDATE`, and `DELETE` operation multiple times**



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## Bulk Binding

The Oracle server uses two engines to run PL/SQL blocks and subprograms:

- The PL/SQL run-time engine, which runs procedural statements but passes the SQL statements to the SQL engine
- The SQL engine, which parses and executes the SQL statement and, in some cases, returns data to the PL/SQL engine

During execution, every SQL statement causes a context switch between the two engines, which results in a performance penalty for excessive amounts of SQL processing. This is typical of applications that have a SQL statement in a loop that uses indexed collection elements values. Collections include nested tables, varying arrays, index-by tables, and host arrays.

Performance can be substantially improved by minimizing the number of context switches through the use of bulk binding. Bulk binding causes an entire collection to be bound in one call, a context switch, to the SQL engine. That is, a bulk bind process passes the entire collection of values back and forth between the two engines in a single context switch, compared with incurring a context switch for each collection element in an iteration of a loop. The more rows affected by a SQL statement, the greater is the performance gain with bulk binding.

# Using Bulk Binding

## Keywords to support bulk binding:

- The **FORALL** keyword instructs the PL/SQL engine to bulk bind input collections before sending them to the SQL engine.

```
FORALL index IN lower_bound .. upper_bound
[SAVE EXCEPTIONS]
sql_statement;
```

- The **BULK COLLECT** keyword instructs the SQL engine to bulk bind output collections before returning them to the PL/SQL engine.

```
... BULK COLLECT INTO
collection_name[,collection_name] ...
```

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## Using Bulk Binding

Use bulk binds to improve the performance of:

- DML statements that reference collection elements
- SELECT statements that reference collection elements
- Cursor FOR loops that reference collections and the RETURNING INTO clause

### Keywords to Support Bulk Binding

The **FORALL** keyword instructs the PL/SQL engine to bulk bind input collections before sending them to the SQL engine. Although the **FORALL** statement contains an iteration scheme, it is not a FOR loop.

The **BULK COLLECT** keyword instructs the SQL engine to bulk bind output collections, before returning them to the PL/SQL engine. This allows you to bind locations into which SQL can return the retrieved values in bulk. Thus, you can use these keywords in the **SELECT INTO**, **FETCH INTO**, and **RETURNING INTO** clauses.

The **SAVE EXCEPTIONS** keyword is optional. However, if some of the DML operations succeed and some fail, you will want to track or report on those that fail. Using the **SAVE EXCEPTIONS** keyword causes failed operations to be stored in a cursor attribute called **%BULK\_EXCEPTIONS**, which is a collection of records indicating the bulk DML iteration number and corresponding error code.

# Bulk Binding FORALL: Example

```
CREATE PROCEDURE raise_salary(percent NUMBER) IS
 TYPE numlist IS TABLE OF NUMBER
 INDEX BY BINARY_INTEGER;
 id numlist;
BEGIN
 id(1) := 100; id(2) := 102;
 id(3) := 104; id(4) := 110;
 -- bulk-bind the PL/SQL table
 FORALL i IN id.FIRST .. id.LAST
 UPDATE employees
 SET salary = (1 + percent/100) * salary
 WHERE manager_id = id(i);
END;
/
```

```
EXECUTE raise_salary(10)
```

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## Bulk Binding FORALL: Example

In the example in the slide, the PL/SQL block increases the salary for employees whose manager's ID is 100, 102, 104, or 110. It uses the FORALL keyword to bulk bind the collection. Without bulk binding, the PL/SQL block would have sent a SQL statement to the SQL engine for each employee that is updated. If there are many employees to update, then the large number of context switches between the PL/SQL engine and the SQL engine can affect performance. However, the FORALL keyword bulk binds the collection to improve performance.

**Note:** A looping construct is no longer required when using this feature.

To manage exceptions and have the bulk bind complete despite errors, add the SAVE EXCEPTIONS keyword to your FORALL statement after the bounds, before the DML statement. Use the new cursor attribute %BULK\_EXCEPTIONS, which stores a collection of records with two fields:

- %BULK\_EXCEPTIONS(i).ERROR\_INDEX holds the “iteration” of the statement during which the exception was raised.
- %BULK\_EXCEPTIONS(i).ERROR\_CODE holds the corresponding error code.

Values stored in %BULK\_EXCEPTIONS refer to the most recently executed FORALL statement. Its subscripts range from 1 to %BULK\_EXCEPTIONS.COUNT.

## Bulk Binding FORALL: Example (continued)

### An Additional Cursor Attribute for DML Operations

Another cursor attribute added to support bulk operations is %BULK\_ROWCOUNT. The %BULK\_ROWCOUNT attribute is a composite structure designed for use with the FORALL statement. This attribute acts like an index-by table. Its *i*th element stores the number of rows processed by the *i*th execution of an UPDATE or DELETE statement. If the *i*th execution affects no rows, then %BULK\_ROWCOUNT(*i*) returns zero.

Here is an example:

```
CREATE TABLE num_table (n NUMBER);
DECLARE
 TYPE NumList IS TABLE OF NUMBER
 INDEX BY BINARY_INTEGER;
 nums NumList;
BEGIN
 nums(1) := 1;
 nums(2) := 3;
 nums(3) := 5;
 nums(4) := 7;
 nums(5) := 11;
 FORALL i IN nums.FIRST .. nums.LAST
 INSERT INTO num_table (n) VALUES (nums(i));
 FOR i IN nums.FIRST .. nums.LAST
 LOOP
 dbms_output.put_line('Inserted ' ||
 SQL%BULK_ROWCOUNT(i) || ' row(s) '
 || ' on iteration ' || i);
 END LOOP;
END;
/
DROP TABLE num_table;
```

The following results are produced by this example:

```
Inserted 1 row(s) on iteration 1
Inserted 1 row(s) on iteration 2
Inserted 1 row(s) on iteration 3
Inserted 1 row(s) on iteration 4
Inserted 1 row(s) on iteration 5
```

PL/SQL procedure successfully completed.

# Using BULK COLLECT INTO with Queries

The **SELECT** statement has been enhanced to support the **BULK COLLECT INTO** syntax.

**Example:**

```
CREATE PROCEDURE get_departments(loc NUMBER) IS
 TYPE dept_tabtype IS
 TABLE OF departments%ROWTYPE;
 depts dept_tabtype;
BEGIN
 SELECT * BULK COLLECT INTO depts
 FROM departments
 WHERE location_id = loc;
 FOR I IN 1 .. depts.COUNT LOOP
 DBMS_OUTPUT.PUT_LINE(depts(i).department_id
 || ' ' || depts(i).department_name);
 END LOOP;
END;
```

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## Using BULK COLLECT INTO with Queries

In Oracle Database 10g, when using a **SELECT** statement in PL/SQL, you can use the bulk collection syntax shown in the example in the slide. Thus, you can quickly obtain a set of rows without using a cursor mechanism.

The example reads all the department rows for a specified region into a PL/SQL table, whose contents are displayed with the **FOR** loop that follows the **SELECT** statement.



# Using BULK COLLECT INTO with Cursors

The **FETCH** statement has been enhanced to support the **BULK COLLECT INTO** syntax.

**Example:**

```
CREATE PROCEDURE get_departments(loc NUMBER) IS
 CURSOR dept_csr IS SELECT * FROM departments
 WHERE location_id = loc;
 TYPE dept_tabtype IS TABLE OF dept_csr%ROWTYPE;
 depts dept_tabtype;
BEGIN
 OPEN dept_csr;
 FETCH dept_csr BULK COLLECT INTO depts;
 CLOSE dept_csr;
 FOR I IN 1 .. depts.COUNT LOOP
 DBMS_OUTPUT.PUT_LINE(depts(i).department_id
 || ' ' || depts(i).department_name);
 END LOOP;
END;
```

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## Using BULK COLLECT INTO with Cursors

In Oracle Database 10g, when using cursors in PL/SQL, you can use a form of the **FETCH** statement that supports the bulk collection syntax shown in the example in the slide.

This example shows how **BULK COLLECT INTO** can be used with cursors.

You can also add a **LIMIT** clause to control the number of rows fetched in each operation.

The code example in the slide could be modified as follows:

```
CREATE PROCEDURE get_departments(loc NUMBER,
 nrows NUMBER) IS
 CURSOR dept_csr IS SELECT * FROM departments
 WHERE location_id = loc;
 TYPE dept_tabtype IS TABLE OF dept_csr%ROWTYPE;
 depts dept_tabtype;
BEGIN
 OPEN dept_csr;
 FETCH dept_csr BULK COLLECT INTO depts LIMIT nrows;
 CLOSE dept_csr;
 DBMS_OUTPUT.PUT_LINE(depts.COUNT || ' rows read');
END;
```

# Using BULK COLLECT INTO with a RETURNING Clause

## Example:

```
CREATE PROCEDURE raise_salary(rate NUMBER) IS
 TYPE emplist IS TABLE OF NUMBER;
 TYPE numlist IS TABLE OF employees.salary%TYPE
 INDEX BY BINARY_INTEGER;
 emp_ids emplist := emplist(100,101,102,104);
 new_sals numlist;
BEGIN
 FORALL i IN emp_ids.FIRST .. emp_ids.LAST
 UPDATE employees
 SET commission_pct = rate * salary
 WHERE employee_id = emp_ids(i)
 RETURNING salary BULK COLLECT INTO new_sals;
 FOR i IN 1 .. new_sals.COUNT LOOP ...
END;
```

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## Using BULK COLLECT INTO with a RETURNING Clause

Bulk binds can be used to improve the performance of FOR loops that reference collections and return DML. If you have, or plan to have, PL/SQL code that does this, then you can use the FORALL keyword along with the RETURNING and BULK COLLECT INTO keywords to improve performance.

In the example shown in the slide, the salary information is retrieved from the EMPLOYEES table and collected into the new\_sals array. The new\_sals collection is returned in bulk to the PL/SQL engine.

The example in the slide shows an incomplete FOR loop that is used to iterate through the new salary data received from the UPDATE operation and then process the results.

# Using the NOCOPY Hint

## The NOCOPY hint:

- **Is a request to the PL/SQL compiler to pass OUT and IN OUT parameters by reference rather than by value**
- **Enhances performance by reducing overhead when passing parameters**

```
DECLARE
 TYPE emptabtype IS TABLE OF employees%ROWTYPE;
 emp_tab emptabtype;
 PROCEDURE populate(tab IN OUT NOCOPY emptabtype)
 IS BEGIN ... END;
BEGIN
 populate(emp_tab);
END;
/
```

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## Using the NOCOPY Hint

Note that PL/SQL subprograms support three parameter-passing modes: IN, OUT, and IN OUT. By default:

- The IN parameter is passed by reference. A pointer to the IN actual parameter is passed to the corresponding formal parameter. So both parameters reference the same memory location, which holds the value of the actual parameter.
- The OUT and IN OUT parameters are passed by value. The value of the OUT or IN OUT actual parameter is copied into the corresponding formal parameter. Then, if the subprogram exits normally, the values assigned to the OUT and IN OUT formal parameters are copied into the corresponding actual parameters.

Copying parameters that represent large data structures (such as collections, records, and instances of object types) with OUT and IN OUT parameters slows down execution and uses up memory. To prevent this overhead, you can specify the NOCOPY hint, which enables the PL/SQL compiler to pass OUT and IN OUT parameters by reference.

The slide shows an example of declaring an IN OUT parameter with the NOCOPY hint.

## Effects of the NOCOPY Hint

- **If the subprogram exits with an exception that is not handled:**
  - You cannot rely on the values of the actual parameters passed to a NOCOPY parameter
  - Any incomplete modifications are not “rolled back”
- **The remote procedure call (RPC) protocol enables you to pass parameters only by value.**

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### Effects of the NOCOPY Hint

As a trade-off for better performance, the NOCOPY hint enables you to trade well-defined exception semantics for better performance. Its use affects exception handling in the following ways:

- Because NOCOPY is a hint, not a directive, the compiler can pass NOCOPY parameters to a subprogram by value or by reference. So, if the subprogram exits with an unhandled exception, you cannot rely on the values of the NOCOPY actual parameters.
- By default, if a subprogram exits with an unhandled exception, the values assigned to its OUT and IN OUT formal parameters are not copied to the corresponding actual parameters, and changes appear to roll back. However, when you specify NOCOPY, assignments to the formal parameters immediately affect the actual parameters as well. So, if the subprogram exits with an unhandled exception, the (possibly unfinished) changes are not “rolled back.”
- Currently, the RPC protocol enables you to pass parameters only by value. So exception semantics can change without notification when you partition applications. For example, if you move a local procedure with NOCOPY parameters to a remote site, those parameters are no longer passed by reference.

# NOCOPY Hint Can Be Ignored

The **NOCOPY** hint has no effect if:

- **The actual parameter:**
  - Is an element of an index-by table
  - Is constrained (for example, by scale or NOT NULL)
  - And formal parameter are records, where one or both records were declared by using %ROWTYPE or %TYPE, and constraints on corresponding fields in the records differ
  - Requires an implicit data type conversion
- **The subprogram is involved in an external or remote procedure call**

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## NOCOPY Hint Can Be Ignored

In the following cases, the PL/SQL compiler ignores the **NOCOPY** hint and uses the by-value parameter-passing method (with no error generated):

- The actual parameter is an element of an index-by table. This restriction does not apply to entire index-by tables.
- The actual parameter is constrained (by scale or NOT NULL). This restriction does not extend to constrained elements or attributes. Also, it does not apply to size-constrained character strings.
- The actual and formal parameters are records; one or both records were declared by using %ROWTYPE or %TYPE, and constraints on corresponding fields in the records differ.
- The actual and formal parameters are records; the actual parameter was declared (implicitly) as the index of a cursor FOR loop, and constraints on corresponding fields in the records differ.
- Passing the actual parameter requires an implicit data type conversion.
- The subprogram is involved in an external or remote procedure call.

# PARALLEL\_ENABLE Hint

## The PARALLEL\_ENABLE hint:

- Can be used in functions as an optimization hint

```
CREATE OR REPLACE FUNCTION f2 (p1 NUMBER)
 RETURN NUMBER PARALLEL_ENABLE IS
BEGIN
 RETURN p1 * 2;
END f2;
```

- Indicates that a function can be used in a parallelized query or parallelized DML statement

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## PARALLEL\_ENABLE Hint

The PARALLEL\_ENABLE keyword can be used in the syntax for declaring a function. It is an optimization hint that indicates that the function can be used in a parallelized query or parallelized DML statement. Oracle's parallel execution feature divides the work of executing a SQL statement across multiple processes. Functions called from a SQL statement that is run in parallel can have a separate copy run in each of these processes, with each copy called for only the subset of rows that are handled by that process.

For DML statements, prior to Oracle8i, the parallelization optimization looked to see whether a function was noted as having all four of RNDS, WNDS, RNPS, and WNPS specified in a PRAGMA RESTRICT\_REFERENCES declaration; those functions that were marked as neither reading nor writing to either the database or package variables could run in parallel. Again, those functions defined with a CREATE FUNCTION statement had their code implicitly examined to determine whether they were actually pure enough; parallelized execution might occur even though a PRAGMA cannot be specified on these functions.

The PARALLEL\_ENABLE keyword is placed after the return value type in the declaration of the function, as shown in the example in the slide.

**Note:** The function should not use session state, such as package variables, because those variables may not be shared among the parallel execution servers.

# Summary

**In this lesson, you should have learned how to:**

- **Create standardized constants and exceptions using packages**
- **Develop and invoke local subprograms**
- **Control the run-time privileges of a subprogram by setting the AUTHID directive**
- **Execute autonomous transactions**
- **Use the RETURNING clause with DML statements, and bulk binding collections with the FORALL and BULK COLLECT INTO clauses**
- **Pass parameters by reference using a NOCOPY hint**
- **Enable optimization with PARALLEL ENABLE hints**

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## Summary

The lesson provides insights into managing your PL/SQL code by defining constants and exceptions in a package specification. This enables a high degree of reuse and standardization of code.

Local subprograms can be used to simplify and modularize a block of code where the subprogram functionality is repeatedly used in the local block.

The run-time security privileges of a subprogram can be altered by using definer's or invoker's rights.

Autonomous transactions can be executed without affecting an existing main transaction.

You should understand how to obtain performance gains by using the NOCOPY hint, bulk binding and the RETURNING clauses in SQL statements, and the PARALLEL\_ENABLE hint for optimization of functions.

## Practice 7: Overview

**This practice covers the following topics:**

- **Creating a package that uses bulk fetch operations**
- **Creating a local subprogram to perform an autonomous transaction to audit a business operation**
- **Testing AUTHID functionality**

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### Practice 7: Overview

In this practice, you create a package that performs a bulk fetch of employees in a specified department. The data is stored in a PL/SQL table in the package. You also provide a procedure to display the contents of the table.

You add an `add_employee` procedure to the package that inserts new employees. The procedure uses a local autonomous subprogram to write a log record each time the `add_employee` procedure is called, whether it successfully adds a record or not.

Finally, you make the package use `AUTHID` of `CURRENT_USER` and test the behavior with any other student. You test the code first with definer's rights and then with invoker's rights.



## Practice 7

1. Update EMP\_PKG with a new procedure to query employees in a specified department.
  - a. In the specification, declare a get\_employees procedure, with its parameter called dept\_id based on the employees.department\_id column type. Define an index-by PL/SQL type as a TABLE OF EMPLOYEES%ROWTYPE.
  - b. In the body of the package, define a private variable called emp\_table based on the type defined in the specification to hold employee records. Implement the get\_employees procedure to bulk fetch the data into the table.
  - c. Create a new procedure in the specification and body, called show\_employees, that does not take arguments and displays the contents of the private PL/SQL table variable (if any data exists).  
**Hint:** Use the print\_employee procedure.
  - d. Invoke the emp\_pkg.get\_employees procedure for department 30, and then invoke emp\_pkg.show\_employees. Repeat this for department 60.
2. Your manager wants to keep a log whenever the add\_employee procedure in the package is invoked to insert a new employee into the EMPLOYEES table.
  - a. First, load and execute the E:\labs\PLPU\labs\lab\_07\_02\_a.sql script to create a log table called LOG\_NEWEMP, and a sequence called log\_newemp\_seq.
  - b. In the package body, modify the add\_employee procedure, which performs the actual INSERT operation, to have a local procedure called audit\_newemp. The audit\_newemp procedure must use an autonomous transaction to insert a log record into the LOG\_NEWEMP table. Store the USER, the current time, and the new employee name in the log table row. Use log\_newemp\_seq to set the entry\_id column.  
**Note:** Remember to perform a COMMIT operation in a procedure with an autonomous transaction.
  - c. Modify the add\_employee procedure to invoke audit\_emp before it performs the insert operation.
  - d. Invoke the add\_employee procedure for these new employees: Max Smart in department 20 and Clark Kent in department 10. What happens?
  - e. Query the two EMPLOYEES records added, and the records in LOG\_NEWEMP table. How many log records are present?
  - f. Execute a ROLLBACK statement to undo the insert operations that have not been committed. Use the same queries from Exercise 2e: the first to check whether the employee rows for Smart and Kent have been removed, and the second to check the log records in the LOG\_NEWEMP table. How many log records are present? Why?

## Practice 7 (continued)

**If you have time, complete the following exercise:**

3. Modify the EMP\_PKG package to use AUTHID of CURRENT\_USER and test the behavior with any other student.

**Note:** Verify whether the LOG\_NEWEMP table exists from Exercise 2 in this practice.

- a. Grant the EXECUTE privilege on your EMP\_PKG package to another student.
- b. Ask the other student to invoke your add\_employee procedure to insert employee Jaco Pastorius in department 10. Remember to prefix the package name with the owner of the package. The call should operate with definer's rights.
- c. Now, execute a query of the employees in department 10. In which user's employee table did the new record get inserted?
- d. Modify your package EMP\_PKG specification to use an AUTHID CURRENT\_USER. Compile the body of EMP\_PKG.
- e. Ask the same student to execute the add\_employee procedure again, to add employee Joe Zawinal in department 10.
- f. Query your employees in department 10. In which table was the new employee added?
- g. Write a query to display the records added in the LOG\_NEWEMP tables. Ask the other student to query his or her own copy of the table.

# 8

## Managing Dependencies

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# Objectives

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

- **Track procedural dependencies**
- **Predict the effect of changing a database object on stored procedures and functions**
- **Manage procedural dependencies**

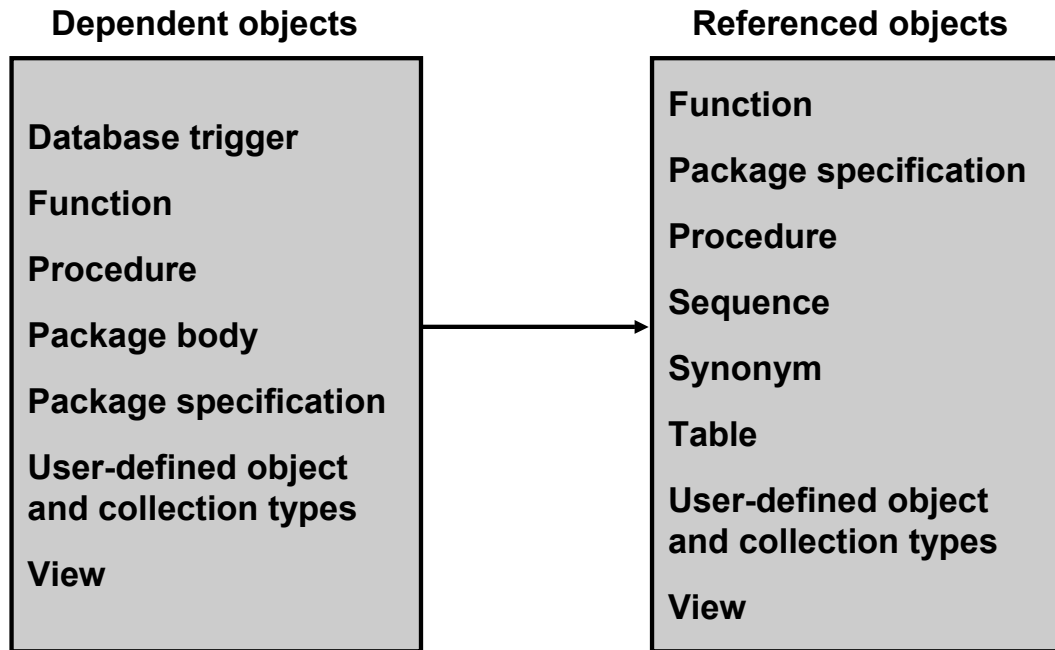
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## Lesson Aim

This lesson introduces you to object dependencies and implicit and explicit recompilation of invalid objects.

# Understanding Dependencies



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## Dependent and Referenced Objects

Some objects reference other objects as part of their definitions. For example, a stored procedure could contain a `SELECT` statement that selects columns from a table. For this reason, the stored procedure is called a dependent object, whereas the table is called a referenced object.

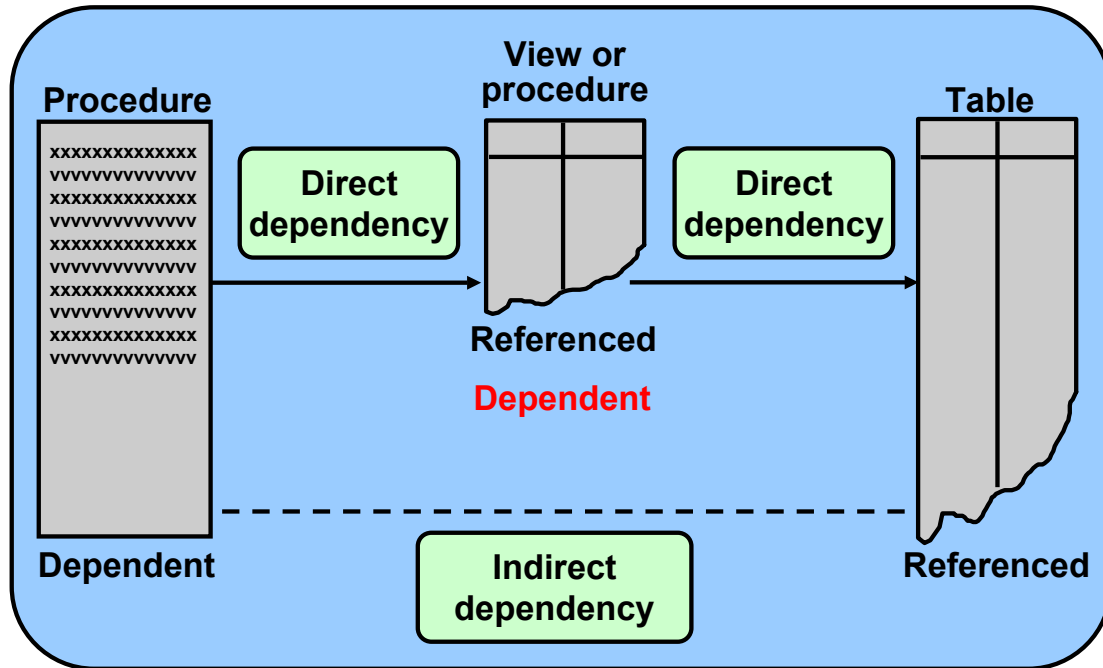
### Dependency Issues

If you alter the definition of a referenced object, dependent objects may or may not continue to work properly. For example, if the table definition is changed, the procedure may or may not continue to work without error.

The Oracle server automatically records dependencies among objects. To manage dependencies, all schema objects have a status (valid or invalid) that is recorded in the data dictionary, and you can view the status in the `USER_OBJECTS` data dictionary view.

Status	Significance
<b>VALID</b>	The schema object has been compiled and can be immediately used when referenced.
<b>INVALID</b>	The schema object must be compiled before it can be used.

# Dependencies



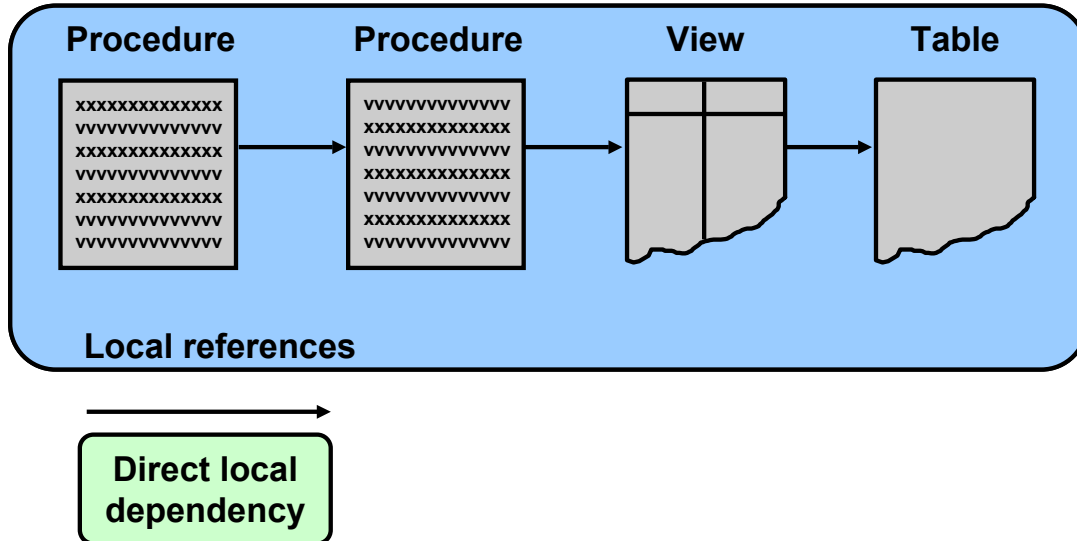
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## Dependent and Referenced Objects (continued)

A procedure or function can directly or indirectly (through an intermediate view, procedure, function, or packaged procedure or function) reference the following objects:

- Tables
- Views
- Sequences
- Procedures
- Functions
- Packaged procedures or functions

# Local Dependencies



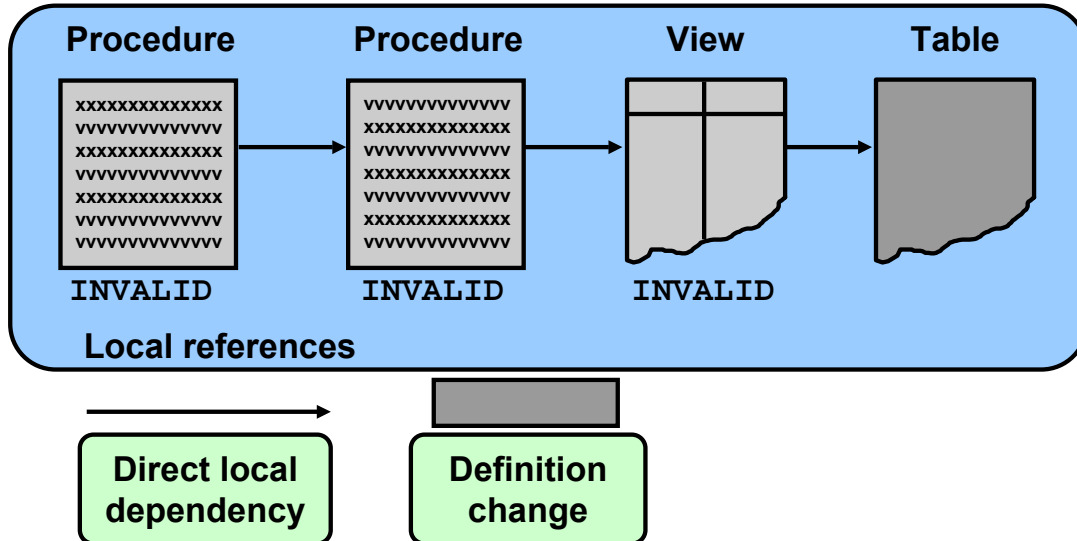
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## Managing Local Dependencies

In the case of local dependencies, the objects are on the same node in the same database. The Oracle server automatically manages all local dependencies, using the database's internal "depends-on" table. When a referenced object is modified, the dependent objects are invalidated. The next time an invalidated object is called, the Oracle server automatically recompiles it.

# Local Dependencies



**The Oracle server implicitly recompiles any INVALID object when the object is next called.**

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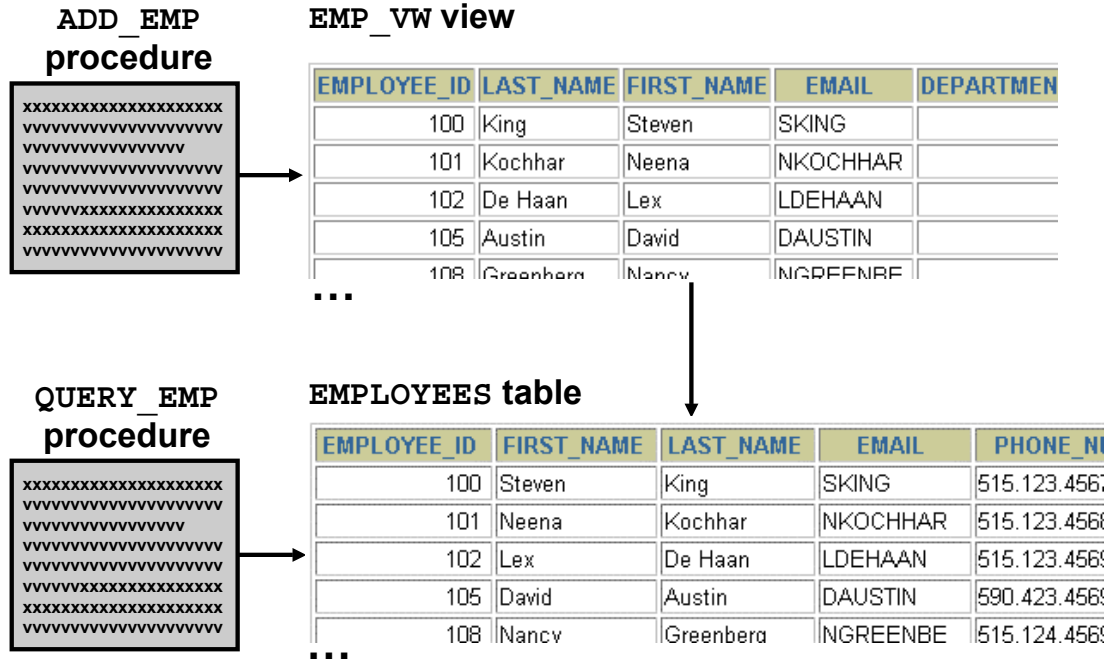
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## Managing Local Dependencies (continued)

Assume that the structure of the table on which a view is based is modified. When you describe the view by using the `iSQL*Plus DESCRIBE` command, you get an error message that states that the object is invalid to describe. This is because the command is not a SQL command; at this stage, the view is invalid because the structure of its base table is changed. If you query the view now, then the view is recompiled automatically and you can see the result if it is successfully recompiled.



# A Scenario of Local Dependencies



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## Example

The QUERY\_EMP procedure directly references the EMPLOYEES table. The ADD\_EMP procedure updates the EMPLOYEES table indirectly by using the EMP\_VW view.

In each of the following cases, is the ADD\_EMP procedure invalidated and does it successfully recompile?

1. The internal logic of the QUERY\_EMP procedure is modified.
2. A new column is added to the EMPLOYEES table.
3. The EMP\_VW view is dropped.

## Displaying Direct Dependencies by Using USER\_DEPENDENCIES

```
SELECT name, type, referenced_name, referenced_type
FROM user_dependencies
WHERE referenced_name IN ('EMPLOYEES','EMP_VW');
```

NAME	TYPE	REFERENCED_NAME	REFERENCED_T
EMP_DETAILS_VIEW	VIEW	EMPLOYEES	TABLE
...			
EMP_VW	VIEW	EMPLOYEES	TABLE
...			
QUERY_EMP	PROCEDURE	EMPLOYEES	TABLE
ADD_EMP	PROCEDURE	EMP_VW	VIEW

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### Displaying Direct Dependencies by Using USER\_DEPENDENCIES

Determine which database objects to recompile manually by displaying direct dependencies from the USER\_DEPENDENCIES data dictionary view.

Examine the ALL\_DEPENDENCIES and DBA\_DEPENDENCIES views, each of which contains the additional column OWNER, which references the owner of the object.

Column	Column Description
NAME	The name of the dependent object
TYPE	The type of the dependent object (PROCEDURE, FUNCTION, PACKAGE, PACKAGE BODY, TRIGGER, or VIEW)
REFERENCED_OWNER	The schema of the referenced object
REFERENCED_NAME	The name of the referenced object
REFERENCED_TYPE	The type of the referenced object
REFERENCED_LINK_NAME	The database link used to access the referenced object

# Displaying Direct and Indirect Dependencies

1. Run the `utldtree.sql` script that creates the objects that enable you to display the direct and indirect dependencies.
2. Execute the `DEPTREE_FILL` procedure.

```
EXECUTE deptree_fill('TABLE','SCOTT','EMPLOYEES')
```

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## Displaying Direct and Indirect Dependencies by Using Views Provided by Oracle

Display direct and indirect dependencies from additional user views called `DEPTREE` and `IDETREE`; these views are provided by Oracle.

### Example

1. Make sure that the `utldtree.sql` script has been executed. This script is located in the `$ORACLE_HOME/rdbms/admin` folder. (This script is supplied in the `lab` folder of your class files.)
2. Populate the `DEPTREE_TEMPTAB` table with information for a particular referenced object by invoking the `DEPTREE_FILL` procedure. There are three parameters for this procedure:

<i>object_type</i>	Type of the referenced object
<i>object_owner</i>	Schema of the referenced object
<i>object_name</i>	Name of the referenced object

# Displaying Dependencies

## The DEPTREE view:

```
SELECT nested_level, type, name
FROM deptree
ORDER BY seq#;
```

NESTED_LEVEL	TYPE	NAME
0	TABLE	EMPLOYEES
1	VIEW	EMP_DETAILS_VIEW
...		
1	TRIGGER	CHECK_SALARY
1	VIEW	EMP_VW
2	PROCEDURE	ADD_EMP
1	PACKAGE	MGR_CONSTRAINTS_PKG
2	TRIGGER	CHECK PRES_TITLE
...		

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## Displaying Dependencies

### Example

Display a tabular representation of all dependent objects by querying the DEPTREE view.

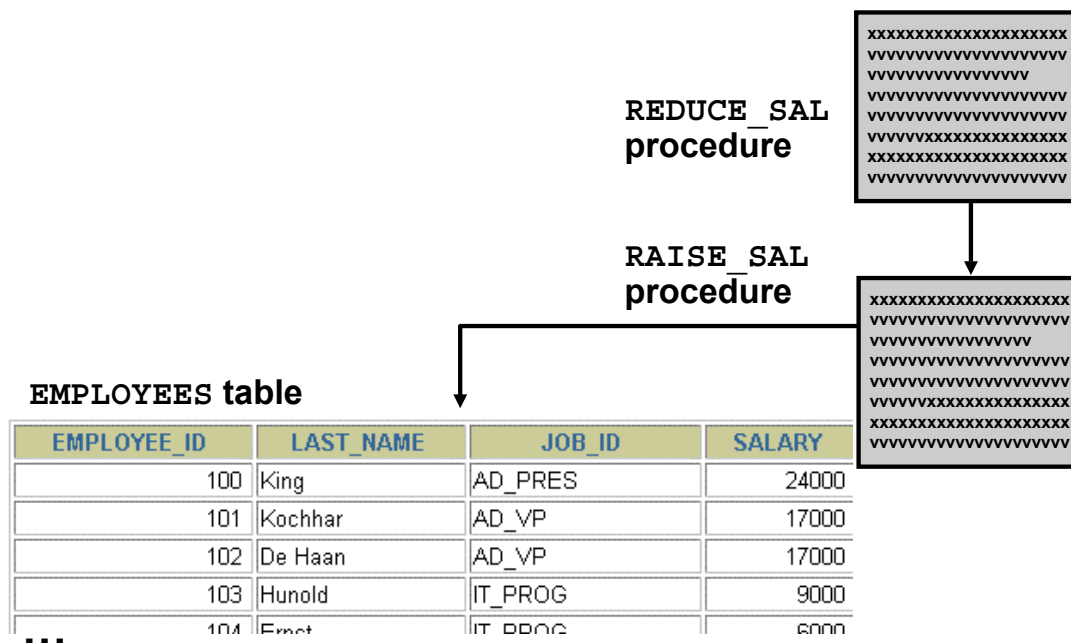
Display an indented representation of the same information by querying the IDEPTREE view, which consists of a single column named DEPENDENCIES.

For example,

```
SELECT *
FROM ideptree;
```

provides a single column of indented output of the dependencies in a hierarchical structure.

## Another Scenario of Local Dependencies



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## Another Scenario of Local Dependencies

### Example 1

Predict the effect that a change in the definition of a procedure has on the recompilation of a dependent procedure.

Suppose that the **RAISE\_SAL** procedure updates the **EMPLOYEES** table directly, and that the **REDUCE\_SAL** procedure updates the **EMPLOYEES** table indirectly by way of **RAISE\_SAL**.

In each of the following cases, does the **REDUCE\_SAL** procedure successfully recompile?

1. The internal logic of the **RAISE\_SAL** procedure is modified.
2. One of the formal parameters to the **RAISE\_SAL** procedure is eliminated.

# A Scenario of Local Naming Dependencies

## QUERY\_EMP procedure

```
xxxxxxxxxxxxxxxxxxxxx
vvvvvvvvvvvvvvvvvvvv
vvvvvvvvvvvvvvvvvvvv
vvvvvvvvvvvvvvvvvvvv
vvvvvvvvvvvvvvvvvvvv
vvvvvvvvvvvvvvvvvvvv
xxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxx
vvvvvvvvvvvvvvvvvvvv
```



## EMPLOYEES public synonym

EMPLOYEE_ID	LAST_NAME	JOB_ID	SALARY
100	King	AD_PRES	24000
101	Kochhar	AD_VP	17000
102	De Haan	AD_VP	17000
103	Hunold	IT_PROG	9000
...	...	...	...
104	Ernst	IT_PROG	6000

## EMPLOYEES table

EMPLOYEE_ID	LAST_NAME	JOB_ID	SALARY
100	King	AD_PRES	24000
101	Kochhar	AD_VP	17000
102	De Haan	AD_VP	17000
103	Hunold	IT_PROG	9000
...	...	...	...
104	Ernst	IT_PROG	6000

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## A Scenario of Local Naming Dependencies

### Example 2

Be aware of the subtle case in which the creation of a table, view, or synonym may unexpectedly invalidate a dependent object because it interferes with the Oracle server hierarchy for resolving name references.

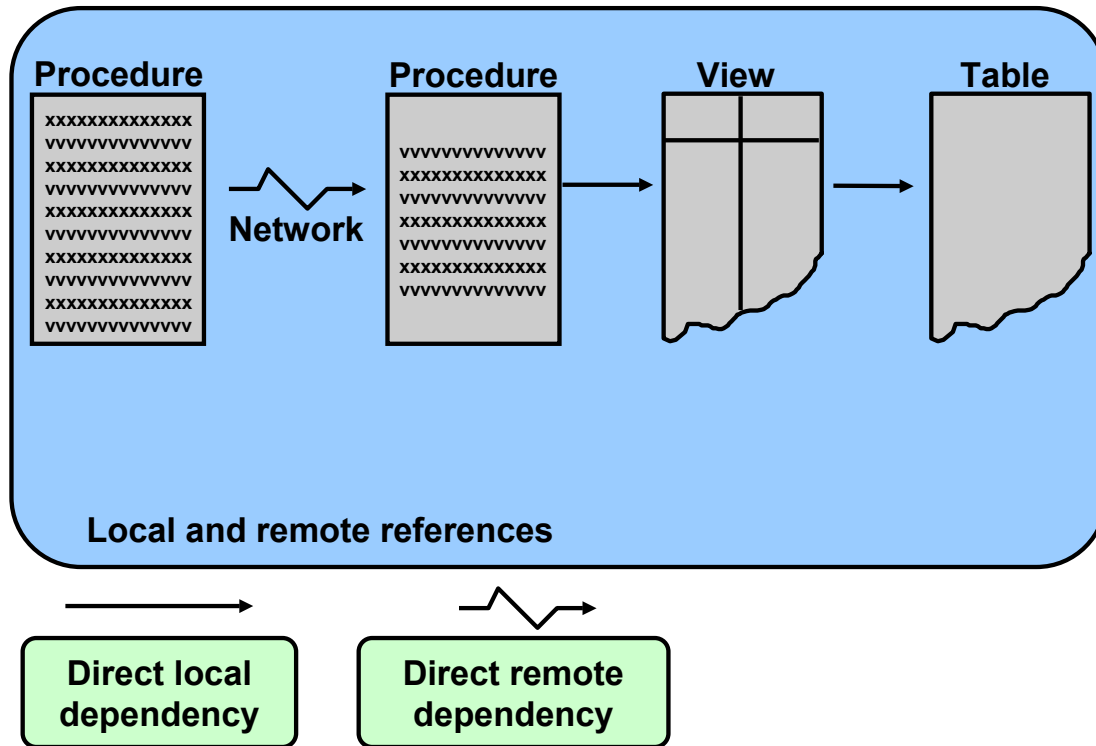
Predict the effect that the name of a new object has upon a dependent procedure.

Suppose that your QUERY\_EMP procedure originally referenced a public synonym called EMPLOYEES. However, you have just created a new table called EMPLOYEES within your own schema. Does this change invalidate the procedure? Which of the two EMPLOYEES objects does QUERY\_EMP reference when the procedure recompiles?

Now suppose that you drop your private EMPLOYEES table. Does this invalidate the procedure? What happens when the procedure recompiles?

You can track security dependencies in the USER\_TAB\_PRIVS data dictionary view.

# Understanding Remote Dependencies

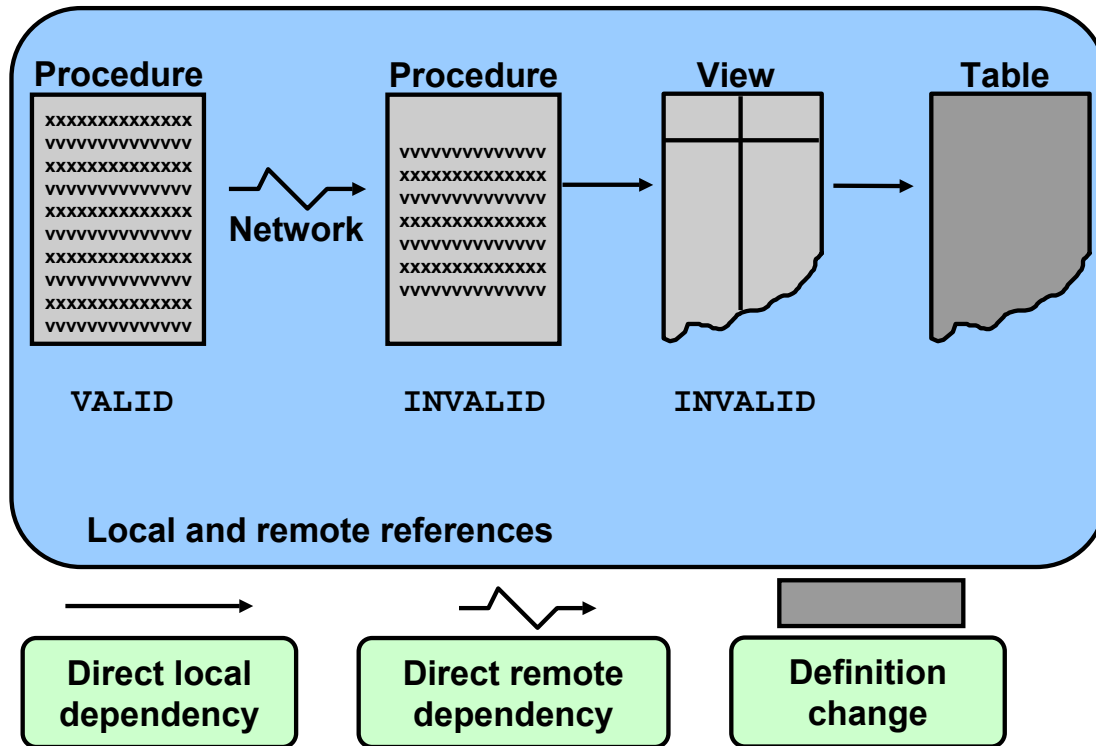


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## Understanding Remote Dependencies

In the case of remote dependencies, the objects are on separate nodes. The Oracle server does not manage dependencies among remote schema objects other than local-procedure-to-remote-procedure dependencies (including functions, packages, and triggers). The local stored procedure and all its dependent objects are invalidated but do not automatically recompile when called for the first time.

# Understanding Remote Dependencies



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## Understanding Remote Dependencies (continued)

### Recompilation of Dependent Objects: Local and Remote

- Verify successful explicit recompilation of the dependent remote procedures and implicit recompilation of the dependent local procedures by checking the status of these procedures within the `USER_OBJECTS` view.
- If an automatic implicit recompilation of the dependent local procedures fails, the status remains invalid and the Oracle server issues a run-time error. Therefore, to avoid disrupting production, it is strongly recommended that you recompile local dependent objects manually, rather than relying on an automatic mechanism.



# Concepts of Remote Dependencies

**Remote dependencies are governed by the mode that is chosen by the user:**

- **TIMESTAMP checking**
- **SIGNATURE checking**

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## Concepts of Remote Dependencies

### **TIMESTAMP Checking**

Each PL/SQL program unit carries a time stamp that is set when it is created or recompiled. Whenever you alter a PL/SQL program unit or a relevant schema object, all its dependent program units are marked as invalid and must be recompiled before they can execute. The actual time stamp comparison occurs when a statement in the body of a local procedure calls a remote procedure.

### **SIGNATURE Checking**

For each PL/SQL program unit, both the time stamp and the signature are recorded. The signature of a PL/SQL construct contains information about the following:

- The name of the construct (procedure, function, or package)
- The base types of the parameters of the construct
- The modes of the parameters (IN, OUT, or IN OUT)
- The number of the parameters

The recorded time stamp in the calling program unit is compared with the current time stamp in the called remote program unit. If the time stamps match, the call proceeds. If they do not match, the remote procedure call (RPC) layer performs a simple comparison of the signature to determine whether the call is safe or not. If the signature has not been changed in an incompatible manner, execution continues; otherwise, an error is returned.

# REMOTE\_DEPENDENCIES\_MODE Parameter

## Setting REMOTE\_DEPENDENCIES\_MODE:

- **As an `init.ora` parameter**  
`REMOTE_DEPENDENCIES_MODE = value`
- **At the system level**  
`ALTER SYSTEM SET`  
`REMOTE_DEPENDENCIES_MODE = value`
- **At the session level**  
`ALTER SESSION SET`  
`REMOTE_DEPENDENCIES_MODE = value`

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## REMOTE\_DEPENDENCIES\_MODE Parameter

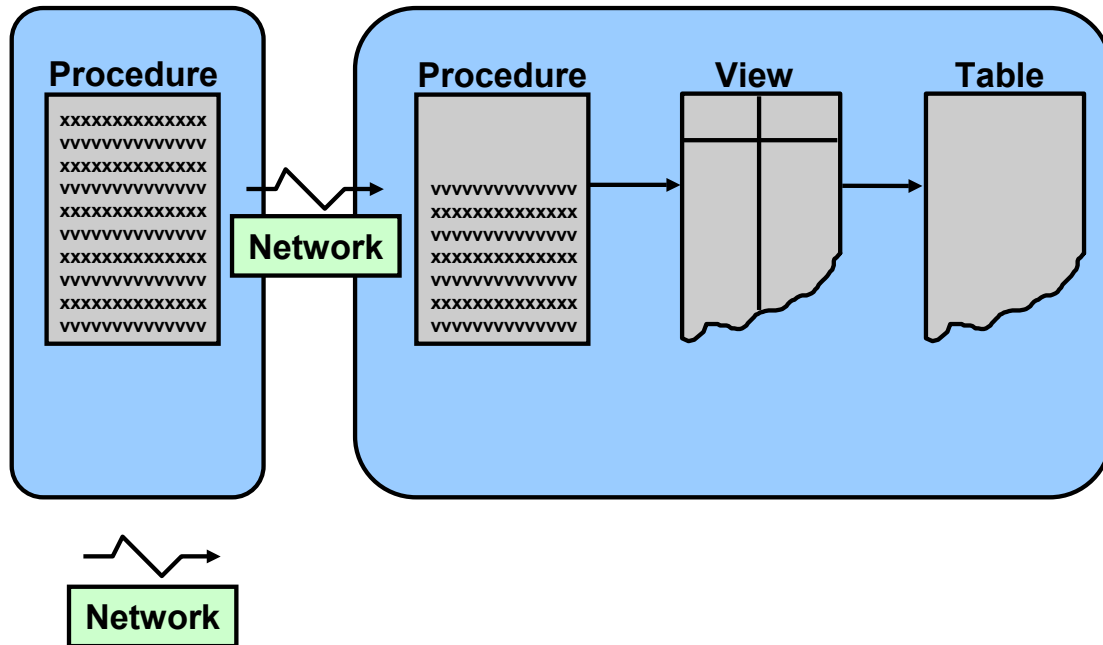
### Setting the REMOTE\_DEPENDENCIES\_MODE

*value*      `TIMESTAMP`  
             `SIGNATURE`

Specify the value of the REMOTE\_DEPENDENCIES\_MODE parameter using one of the three methods described in the slide.

**Note:** The calling site determines the dependency model.

## Remote Dependencies and Time Stamp Mode



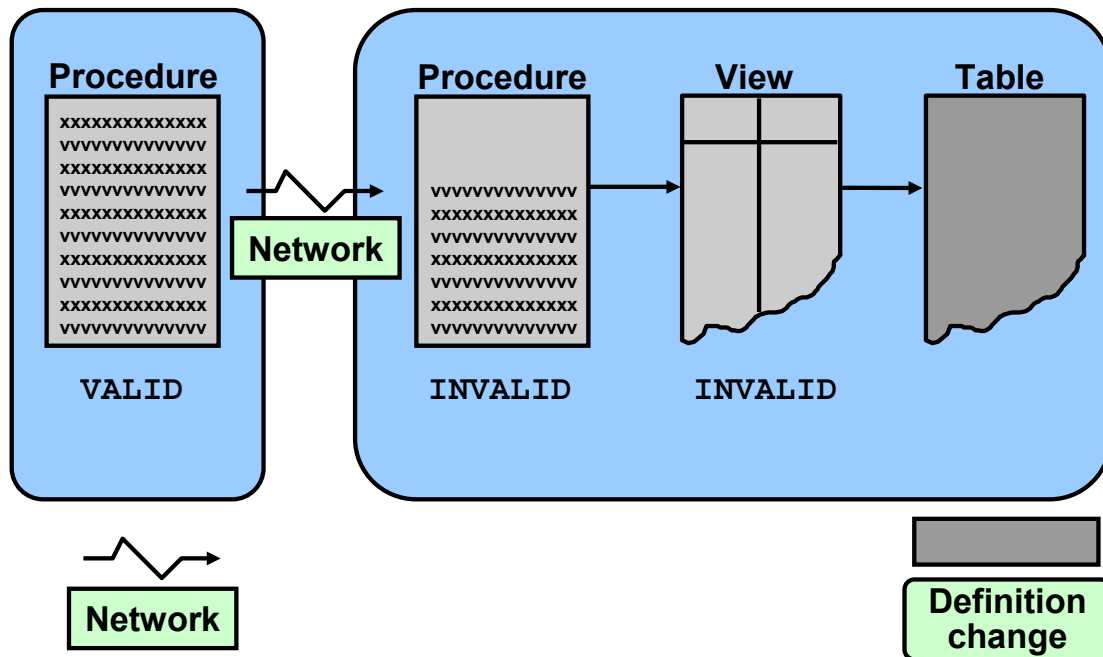
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### Remote Dependencies and Time Stamp Mode

If time stamps are used to handle dependencies among PL/SQL program units, then whenever you alter a program unit or a relevant schema object, all its dependent units are marked as invalid and must be recompiled before they can be run.

# Remote Dependencies and Time Stamp Mode



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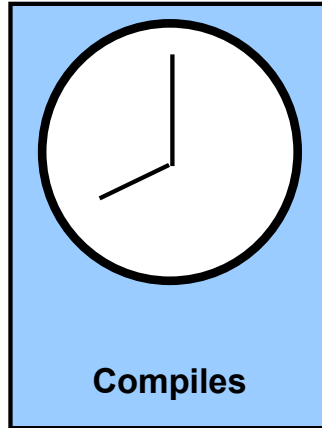
## Remote Dependencies and Time Stamp Mode (continued)

In the example in the slide, the definition of the table changes. Therefore, all its dependent units are marked as invalid and must be recompiled before they can be run.

- When remote objects change, it is strongly recommended that you recompile local dependent objects manually in order to avoid disrupting production.
- The remote dependency mechanism is different from the automatic local dependency mechanism already discussed. The first time a recompiled remote subprogram is invoked by a local subprogram, you get an execution error and the local subprogram is invalidated; the second time it is invoked, implicit automatic recompilation takes place.

# Remote Procedure B Compiles at 8:00 a.m.

Remote procedure B



Valid

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## Local Procedures Referencing Remote Procedures

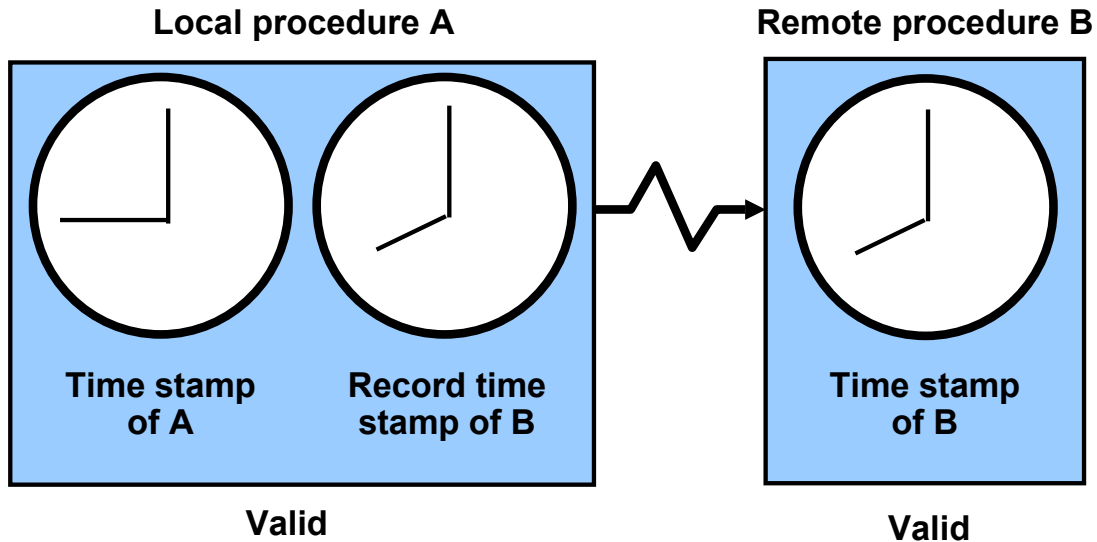
A local procedure that references a remote procedure is invalidated by the Oracle server if the remote procedure is recompiled after the local procedure is compiled.

### Automatic Remote Dependency Mechanism

When a procedure compiles, the Oracle server records the time stamp of that compilation within the P code of the procedure.

In the slide, when the remote procedure B is successfully compiled at 8:00 a.m., this time is recorded as its time stamp.

## Local Procedure A Compiles at 9:00 a.m.



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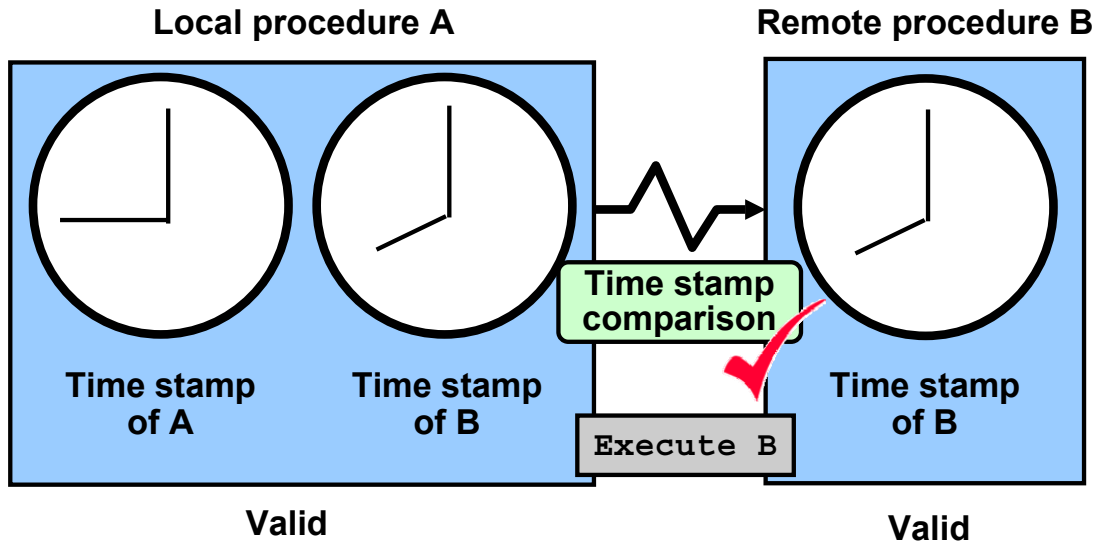
### Local Procedures Referencing Remote Procedures (continued)

#### Automatic Remote Dependency Mechanism (continued)

When a local procedure referencing a remote procedure compiles, the Oracle server also records the time stamp of the remote procedure in the P code of the local procedure.

In the slide, local procedure A (which is dependent on remote procedure B) is compiled at 9:00 a.m. The time stamps of both procedure A and remote procedure B are recorded in the P code of procedure A.

# Execute Procedure A



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## Automatic Remote Dependency

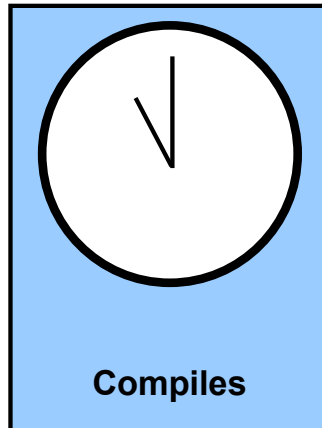
When the local procedure is invoked at run time, the Oracle server compares the two time stamps of the referenced remote procedure.

If the time stamps are equal (indicating that the remote procedure has not recompiled), then the Oracle server executes the local procedure.

In the example in the slide, the time stamp recorded with the P code of remote procedure B is the same as that recorded with local procedure A. Therefore, local procedure A is valid.

## Remote Procedure B Recompiled at 11:00 a.m.

Remote procedure B



Valid

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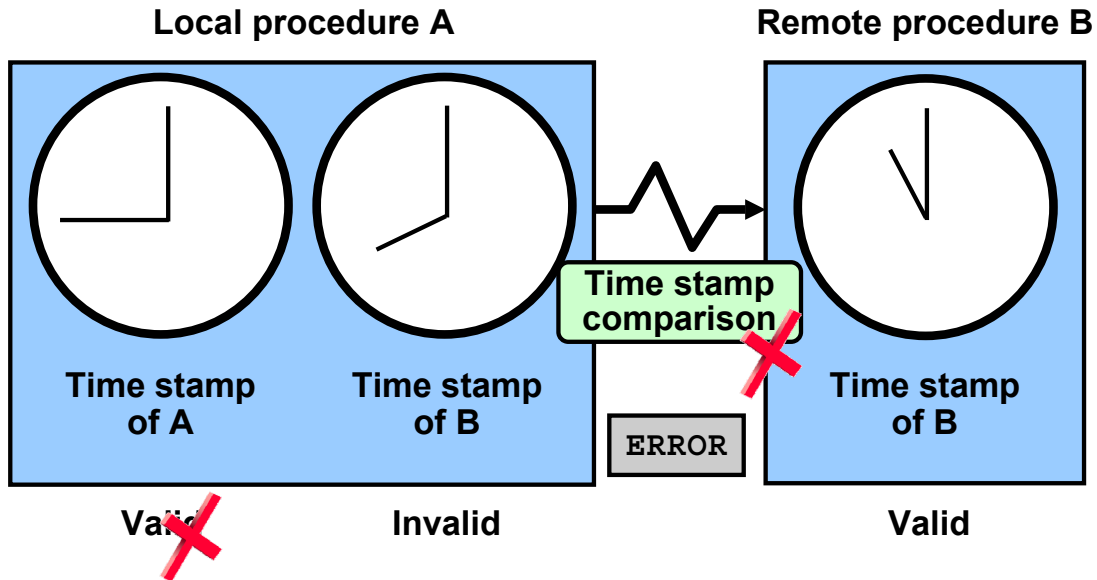
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### Local Procedures Referencing Remote Procedures

Assume that remote procedure B is successfully recompiled at 11:00 a.m. The new time stamp is recorded along with its P code.



# Execute Procedure A



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## Automatic Remote Dependency

If the time stamps are not equal (indicating that the remote procedure has recompiled), then the Oracle server invalidates the local procedure and returns a run-time error. If the local procedure (which is now tagged as invalid) is invoked a second time, then the Oracle server recompiles it before executing, in accordance with the automatic local dependency mechanism.

**Note:** If a local procedure returns a run-time error the first time it is invoked (indicating that the remote procedure's time stamp has changed), then you should develop a strategy to reinvoke the local procedure.

In the example in the slide, the remote procedure is recompiled at 11:00 a.m. and this time is recorded as its time stamp in the P code. The P code of local procedure A still has 8:00 a.m. as the time stamp for remote procedure B. Because the time stamp recorded with the P code of local procedure A is different from that recorded with the remote procedure B, the local procedure is marked invalid. When the local procedure is invoked for the second time, it can be successfully compiled and marked valid.

A disadvantage of time stamp mode is that it is unnecessarily restrictive. Recompilation of dependent objects across the network is often performed when not strictly necessary, leading to performance degradation.

# Signature Mode

- **The signature of a procedure is:**
  - The name of the procedure
  - The data types of the parameters
  - The modes of the parameters
- **The signature of the remote procedure is saved in the local procedure.**
- **When executing a dependent procedure, the signature of the referenced remote procedure is compared.**

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## Signatures

To alleviate some of the problems with the time stamp–only dependency model, you can use the signature model. This allows the remote procedure to be recompiled without affecting the local procedures. This is important if the database is distributed.

The signature of a subprogram contains the following information:

- The name of the subprogram
- The data types of the parameters
- The modes of the parameters
- The number of parameters
- The data type of the return value for a function

If a remote program is changed and recompiled but the signature does not change, then the local procedure can execute the remote procedure. With the time stamp method, an error would have been raised because the time stamps would not have matched.

# Recompiling a PL/SQL Program Unit

## Recompilation:

- Is handled automatically through implicit run-time recompilation
- Is handled through explicit recompilation with the **ALTER statement**

```
ALTER PROCEDURE [SCHEMA.]procedure_name COMPILE;
```

```
ALTER FUNCTION [SCHEMA.]function_name COMPILE;
```

```
ALTER PACKAGE [SCHEMA.]package_name
COMPILE [PACKAGE | SPECIFICATION | BODY];
```

```
ALTER TRIGGER trigger_name [COMPILE[DEBUG]];
```

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## Recompiling PL/SQL Objects

If the recompilation is successful, the object becomes valid. If not, the Oracle server returns an error and the object remains invalid. When you recompile a PL/SQL object, the Oracle server first recompiles any invalid object on which it depends.

**Procedure:** Any local objects that depend on a procedure (such as procedures that call the recompiled procedure or package bodies that define the procedures that call the recompiled procedure) are also invalidated.

**Packages:** The `COMPILE PACKAGE` option recompiles both the package specification and the body, regardless of whether it is invalid. The `COMPILE SPECIFICATION` option recompiles the package specification. Recompiling a package specification invalidates any local objects that depend on the specification, such as subprograms that use the package. Note that the body of a package also depends on its specification. The `COMPILE BODY` option recompiles only the package body.

**Triggers:** Explicit recompilation eliminates the need for implicit run-time recompilation and prevents associated run-time compilation errors and performance overhead.

The `DEBUG` option instructs the PL/SQL compiler to generate and store the code for use by the PL/SQL debugger.

# Unsuccessful Recompilation

**Recompiling dependent procedures and functions is unsuccessful when:**

- **The referenced object is dropped or renamed**
- **The data type of the referenced column is changed**
- **The referenced column is dropped**
- **A referenced view is replaced by a view with different columns**
- **The parameter list of a referenced procedure is modified**

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## Unsuccessful Recompilation

Sometimes a recompilation of dependent procedures is unsuccessful (for example, when a referenced table is dropped or renamed).

The success of any recompilation is based on the exact dependency. If a referenced view is re-created, any object that is dependent on the view needs to be recompiled. The success of the recompilation depends on the columns that the view now contains, as well as the columns that the dependent objects require for their execution. If the required columns are not part of the new view, then the object remains invalid.

# Successful Recompilation

**Recompiling dependent procedures and functions is successful if:**

- **The referenced table has new columns**
- **The data type of referenced columns has not changed**
- **A private table is dropped, but a public table that has the same name and structure exists**
- **The PL/SQL body of a referenced procedure has been modified and recompiled successfully**

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## Successful Recompilation

The recompilation of dependent objects is successful if:

- New columns are added to a referenced table
- All INSERT statements include a column list
- No new column is defined as NOT NULL

When a private table is referenced by a dependent procedure and the private table is dropped, the status of the dependent procedure becomes invalid. When the procedure is recompiled (either explicitly or implicitly) and a public table exists, the procedure can recompile successfully but is now dependent on the public table. The recompilation is successful only if the public table contains the columns that the procedure requires; otherwise, the status of the procedure remains invalid.

# Recompilation of Procedures

**Minimize dependency failures by:**

- **Declaring records with the %ROWTYPE attribute**
- **Declaring variables with the %TYPE attribute**
- **Querying with the SELECT \* notation**
- **Including a column list with INSERT statements**

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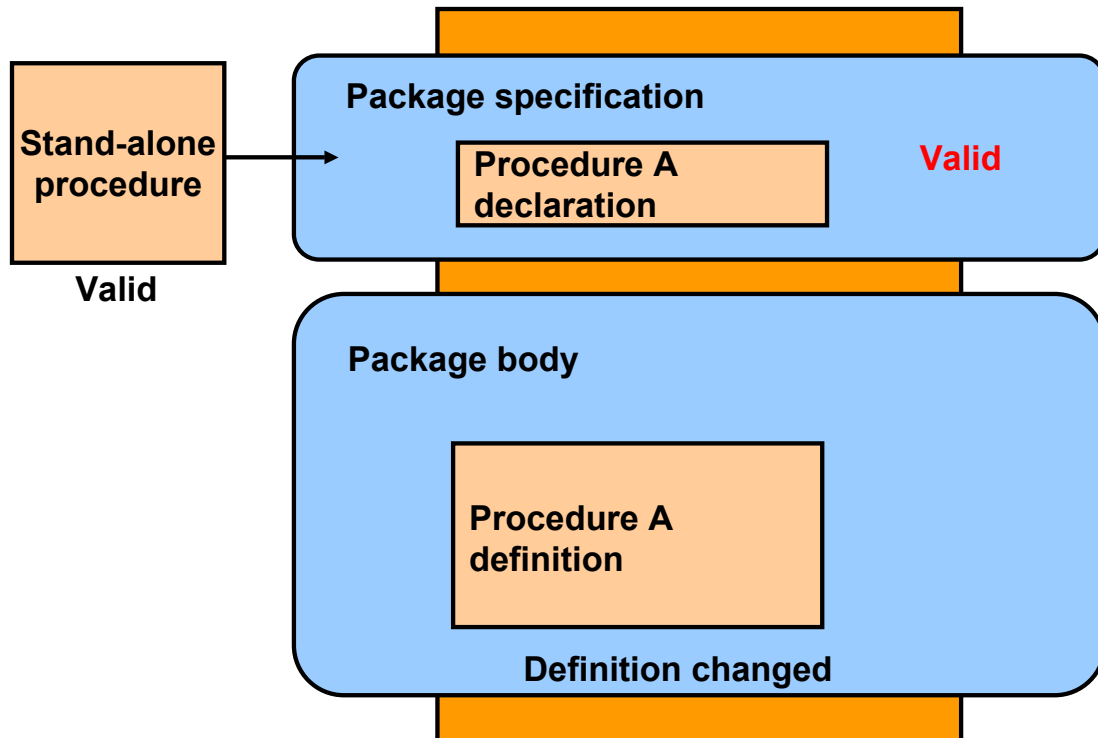
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## Recompilation of Procedures

You can minimize recompilation failure by following the guidelines that are shown in the slide.

# Packages and Dependencies



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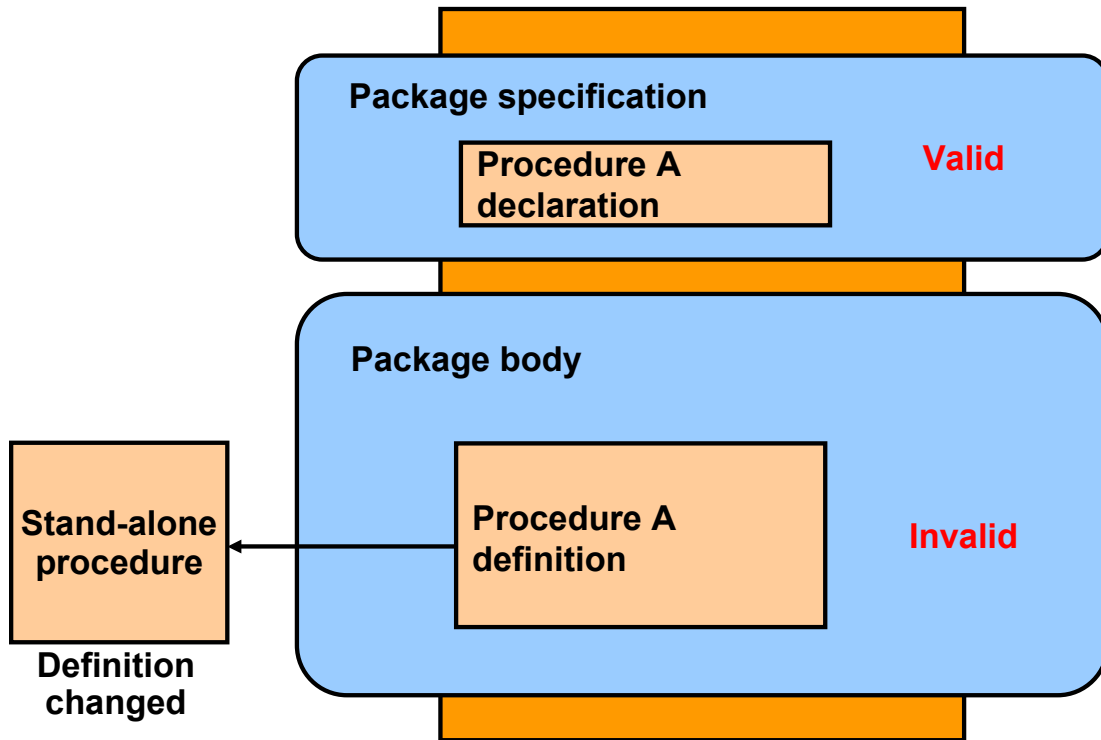
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## Managing Dependencies

You can simplify dependency management with packages when referencing a package procedure or function from a stand-alone procedure or function.

- If the package body changes and the package specification does not change, then the stand-alone procedure that references a package construct remains valid.
- If the package specification changes, then the outside procedure referencing a package construct is invalidated, as is the package body.

# Packages and Dependencies



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## Managing Dependencies (continued)

If a stand-alone procedure that is referenced within the package changes, then the entire package body is invalidated, but the package specification remains valid. Therefore, it is recommended that you bring the procedure into the package.



# Summary

In this lesson, you should have learned how to:

- **Keep track of dependent procedures**
- **Recompile procedures manually as soon as possible after the definition of a database object changes**

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## Summary

Avoid disrupting production by keeping track of dependent procedures and recompiling them manually as soon as possible after the definition of a database object changes.

Situation	Automatic Recompilation
Procedure depends on a local object.	Yes, at first reexecution
Procedure depends on a remote procedure.	Yes, but at second reexecution. Use manual recompilation for first reexecution, or reinvoke it a second time.
Procedure depends on a remote object other than a procedure.	No

## Practice 8: Overview

**This practice covers the following topics:**

- **Using DEPTREE\_FILL and IDEPTREE to view dependencies**
- **Recompiling procedures, functions, and packages**

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### Practice 8: Overview

In this practice, you use the DEPTREE\_FILL procedure and the IDEPTREE view to investigate dependencies in your schema. In addition, you recompile invalid procedures, functions, packages, and views.

## Practice 8

1. Answer the following questions:

- a. Can a table or a synonym be invalidated?
- b. Consider the following dependency example:

The stand-alone procedure `MY_PROC` depends on the `MY_PROC_PACK` package procedure. The `MY_PROC_PACK` procedure's definition is changed by recompiling the package body. The `MY_PROC_PACK` procedure's declaration is not altered in the package specification.

In this scenario, is the stand-alone procedure `MY_PROC` invalidated?

2. Create a tree structure showing all dependencies involving your `add_employee` procedure and your `valid_deptid` function.

**Note:** `add_employee` and `valid_deptid` were created in the lesson titled "Creating Stored Functions." You can run the solution scripts for Practice 2 if you need to create the procedure and function.

- a. Load and execute the `utldtree.sql` script, which is located in the `E:\lab\PLPU\labs` folder.
- b. Execute the `deptree_fill` procedure for the `add_employee` procedure.
- c. Query the `IDEPTREE` view to see your results.
- d. Execute the `deptree_fill` procedure for the `valid_deptid` function.
- e. Query the `IDEPTREE` view to see your results.

**If you have time, complete the following exercise:**

3. Dynamically validate invalid objects.
  - a. Make a copy of your `EMPLOYEES` table, called `EMPS`.
  - b. Alter your `EMPLOYEES` table and add the column `TOTSAL` with data type `NUMBER(9,2)`.
  - c. Create and save a query to display the name, type, and status of all invalid objects.
  - d. In the `compile_pkg` (created in Practice 6 in the lesson titled "Dynamic SQL and Metadata"), add a procedure called `recompile` that recompiles all invalid procedures, functions, and packages in your schema. Use Native Dynamic SQL to alter the invalid object type and compile it.
  - e. Execute the `compile_pkg.recompile` procedure.
  - f. Run the script file that you created in step 3c to check the status column value. Do you still have objects with an `INVALID` status?



# 9

## Manipulating Large Objects

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# Objectives

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

- **Compare and contrast LONG and LOB (large object) data types**
- **Create and maintain LOB data types**
- **Differentiate between internal and external LOBs**
- **Use the DBMS\_LOB PL/SQL package**
- **Describe the use of temporary LOBs**

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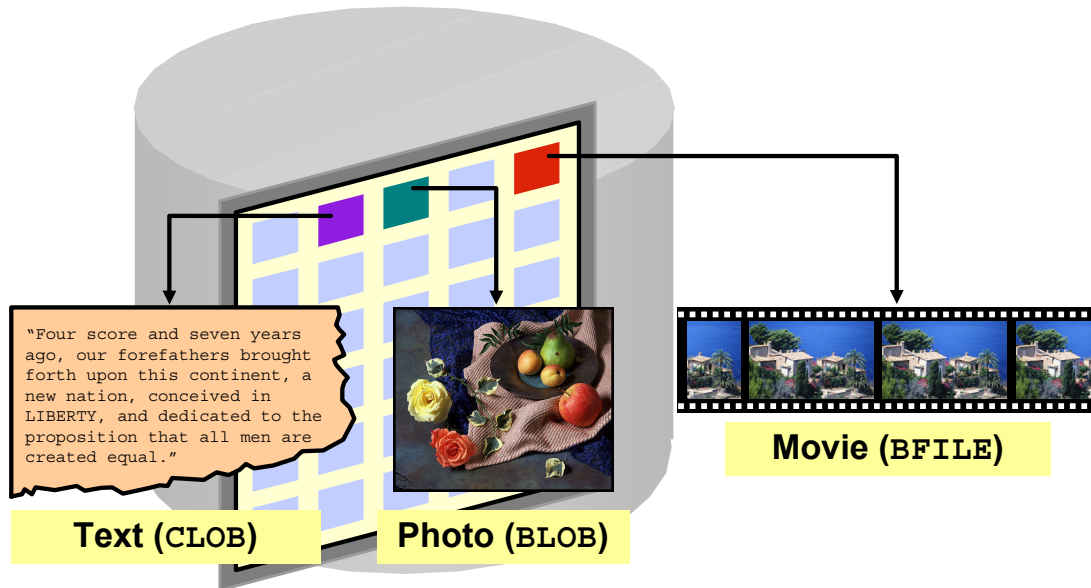
## Lesson Aim

Databases have long been used to store large objects. However, the mechanisms built into databases have never been as useful as the large object (LOB) data types that have been provided since Oracle8. This lesson describes the characteristics of the new data types, comparing and contrasting them with earlier data types. Examples, syntax, and issues regarding the LOB types are also presented.

**Note:** A LOB is a data type and should not be confused with an object type.

# What Is a LOB?

**LOBs are used to store large unstructured data such as text, graphic images, films, and sound waveforms.**



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## LOB: Overview

A LOB is a data type that is used to store large, unstructured data such as text, graphic images, video clippings, and so on. Structured data, such as a customer record, may be a few hundred bytes, but even small amounts of multimedia data can be thousands of times larger. Also, multimedia data may reside in operating system (OS) files, which may need to be accessed from a database.

There are four large object data types:

- BLOB represents a binary large object, such as a video clip.
- CLOB represents a character large object.
- NCLOB represents a multibyte character large object.
- BFILE represents a binary file stored in an OS binary file outside the database. The BFILE column or attribute stores a file locator that points to the external file.

LOBs are characterized in two ways, according to their interpretations by the Oracle server (binary or character) and their storage aspects. LOBs can be stored internally (inside the database) or in host files. There are two categories of LOBs:

- **Internal LOBs (CLOB, NCLOB, BLOB):** Stored in the database
- **External files (BFILE):** Stored outside the database

## LOB: Overview (continued)

Oracle Database 10g performs implicit conversion between CLOB and VARCHAR2 data types. The other implicit conversions between LOBs are not possible. For example, if the user creates a table T with a CLOB column and a table S with a BLOB column, the data is not directly transferable between these two columns.

BFILES can be accessed only in read-only mode from an Oracle server.



# Contrasting LONG and LOB Data Types

LONG and LONG RAW	LOB
Single LONG column per table	Multiple LOB columns per table
Up to 2 GB	Up to 4 GB
SELECT returns data	SELECT returns locator
Data stored in-line	Data stored in-line or out-of-line
Sequential access to data	Random access to data

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## LONG and LOB Data Types

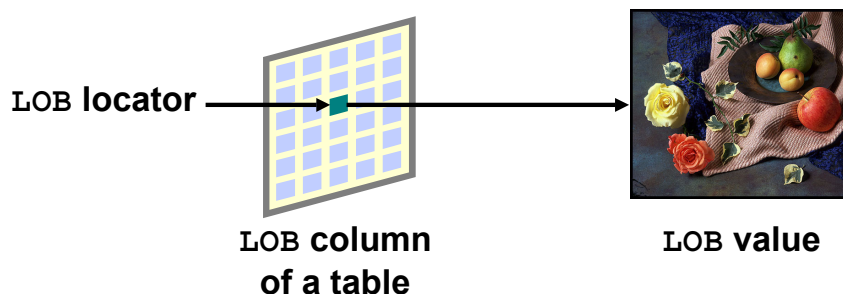
LONG and LONG RAW data types were previously used for unstructured data such as binary images, documents, or geographical information. These data types are superseded by the LOB data types. Oracle Database 10g provides a LONG-to-LOB application programming interface (API) to migrate from LONG columns to LOB columns. The following bulleted list compares the LOB functionality with the older types, where LONGs refer to LONG and LONG RAW, and LOBs refer to all LOB data types:

- A table can have multiple LOB columns and object type attributes. A table can have only one LONG column.
- The maximum size of LONGs is 2 GB; LOBs can be up to 4 GB.
- LOBs return the locator; LONGs return the data.
- LOBs store a locator in the table and the data in a different segment, unless the data is less than 4,000 bytes; LONGs store all data in the same data block. In addition, LOBs allow data to be stored in a separate segment and tablespace, or in a host file.
- LOBs can be object type attributes; LONGs cannot be object type attributes.
- LOBs support random piecewise access to the data through a file-like interface; LONGs are restricted to sequential piecewise access.

The TO\_LOB function can be used to convert LONG and LONG RAW values in a column to LOB values. You use this in the SELECT list of a subquery in an INSERT statement.

# Anatomy of a LOB

**The LOB column stores a locator to the LOB's value.**



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## Components of a LOB

There are two distinct parts to a LOB:

- **LOB value:** The data that constitutes the real object being stored
- **LOB locator:** A pointer to the location of the LOB value stored in the database

Regardless of where the value of LOB is stored, a locator is stored in the row. You can think of a LOB locator as a pointer to the actual location of the LOB value.

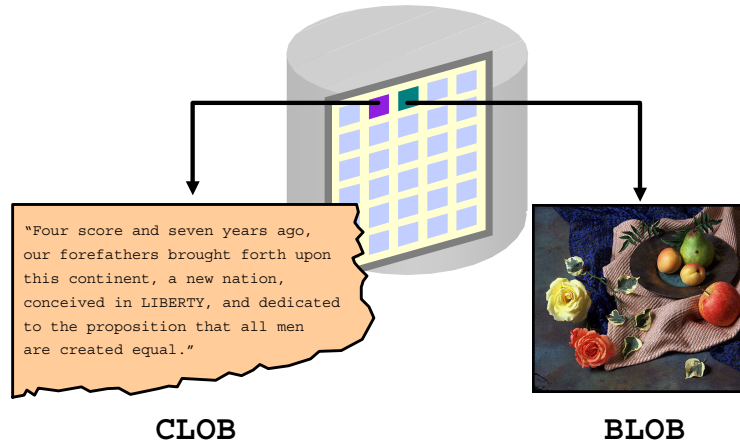
A LOB column does not contain the data; it contains the locator of the LOB value.

When a user creates an internal LOB, the value is stored in the LOB segment and a locator to the out-of-line LOB value is placed in the LOB column of the corresponding row in the table. External LOBs store the data outside the database, so only a locator to the LOB value is stored in the table.

To access and manipulate LOBs without SQL data manipulation language (DML), you must create a LOB locator. The programmatic interfaces operate on the LOB values, using these locators in a manner similar to OS file handles.

# Internal LOBs

**The LOB value is stored in the database.**



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## Features of Internal LOBs

The internal LOB is stored in the Oracle server. A BLOB, NCLOB, or CLOB can be one of the following:

- An attribute of a user-defined type
- A column in a table
- A bind or host variable
- A PL/SQL variable, parameter, or result

Internal LOBs can take advantage of Oracle features such as:

- Concurrency mechanisms
- Redo logging and recovery mechanisms
- Transactions with COMMIT or ROLLBACK

The BLOB data type is interpreted by the Oracle server as a bitstream, similar to the LONG RAW data type.

The CLOB data type is interpreted as a single-byte character stream.

The NCLOB data type is interpreted as a multiple-byte character stream, based on the byte length of the database national character set.

# Managing Internal LOBs

- **To interact fully with LOB, file-like interfaces are provided in:**
  - **PL/SQL package DBMS\_LOB**
  - **Oracle Call Interface (OCI)**
  - **Oracle Objects for object linking and embedding (OLE)**
  - **Pro\*C/C++ and Pro\*COBOL precompilers**
  - **Java Database Connectivity (JDBC)**
- **The Oracle server provides some support for LOB management through SQL.**

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## How to Manage LOBs

To manage an internal LOB, perform the following steps:

1. Create and populate the table containing the LOB data type.
2. Declare and initialize the LOB locator in the program.
3. Use SELECT FOR UPDATE to lock the row containing the LOB into the LOB locator.
4. Manipulate the LOB with DBMS\_LOB package procedures, OCI calls, Oracle Objects for OLE, Oracle precompilers, or JDBC using the LOB locator as a reference to the LOB value.

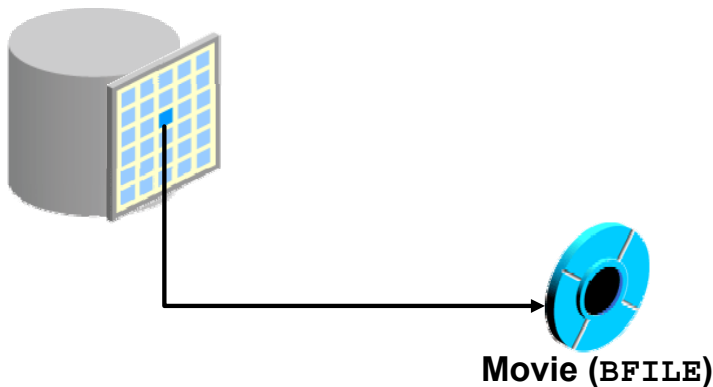
You can also manage LOBs through SQL.

5. Use the COMMIT command to make any changes permanent.

# What Are BFILES?

The **BFILE** data type supports an external or file-based large object as:

- **Attributes in an object type**
- **Column values in a table**



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## What Are BFILES?

BFILES are external large objects (LOBs) stored in OS files that are external to database tables. The BFILE data type stores a locator to the physical file. A BFILE can be in GIF, JPEG, MPEG, MPEG2, text, or other formats. The external LOBs may be located on hard disks, CD-ROMs, photo CDs, or other media, but a single LOB cannot extend from one medium or device to another. The BFILE data type is available so that database users can access the external file system. Oracle Database 10g provides:

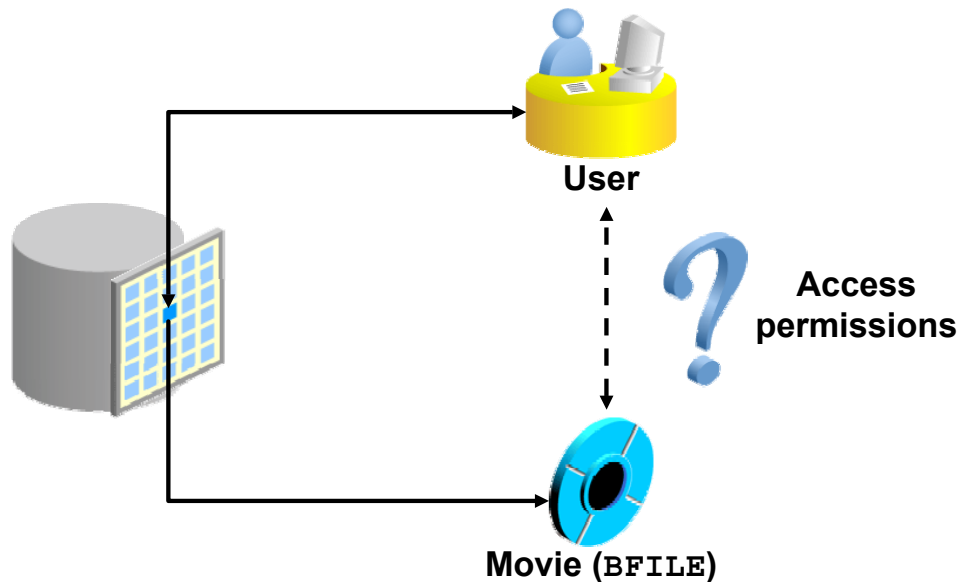
- Definition of BFILE objects
- Association of BFILE objects to corresponding external files
- Security for BFILES

The remaining operations that are required for using BFILES are possible through the DBMS\_LOB package and OCI. BFILES are read-only; they do not participate in transactions. Support for integrity and durability must be provided by the operating system. The file must be created and placed in the appropriate directory, giving the Oracle process privileges to read the file. When the LOB is deleted, the Oracle server does not delete the file.

Administration of the files and the OS directory structures can be managed by the database administrator (DBA), system administrator, or user. The maximum size of an external large object depends on the operating system but cannot exceed 4 GB.

**Note:** BFILES are available with the Oracle8 database and later releases.

# Securing BFILES



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## Securing BFILES

Unauthenticated access to files on a server presents a security risk. Oracle Database 10g can act as a security mechanism to shield the operating system from unsecured access while removing the need to manage additional user accounts on an enterprise computer system.

### File Location and Access Privileges

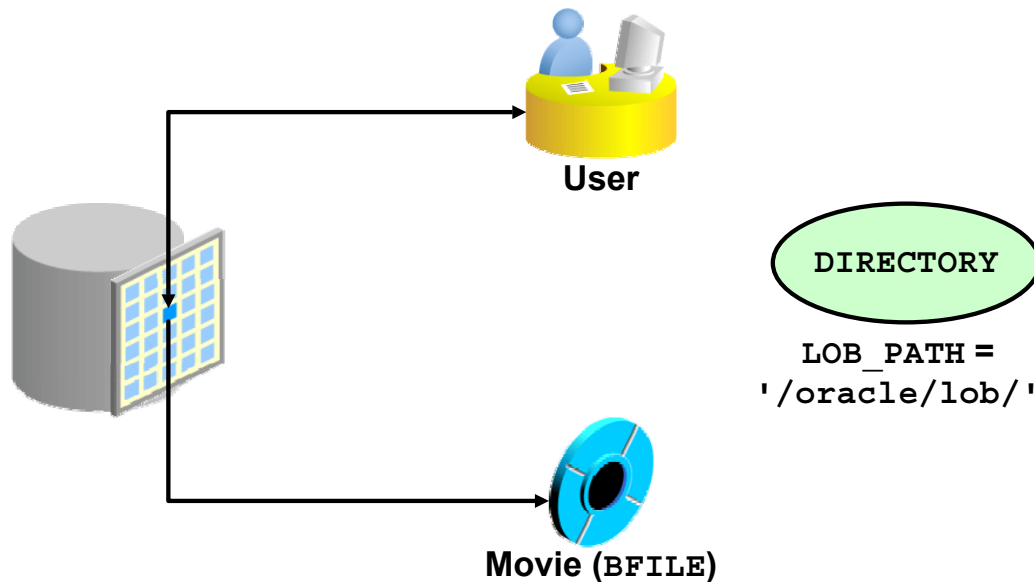
The file must reside on the machine where the database exists. A timeout to read a nonexistent BFILE is based on the OS value.

You can read a BFILE in the same way as you read an internal LOB. However, there could be restrictions related to the file itself, such as:

- Access permissions
- File system space limits
- Non-Oracle manipulations of files
- OS maximum file size

Oracle Database 10g does not provide transactional support on BFILES. Any support for integrity and durability must be provided by the underlying file system and the OS. Oracle backup and recovery methods support only the LOB locators, not the physical BFILES.

# A New Database Object: DIRECTORY



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## A New Database Object: DIRECTORY

A DIRECTORY is a nonschema database object that enables the administration of access and usage of BFILES in Oracle Database 10g.

A DIRECTORY specifies an alias for a directory on the file system of the server under which a BFILE is located. By granting suitable privileges for these items to users, you can provide secure access to files in the corresponding directories on a user-by-user basis (certain directories can be made read-only, inaccessible, and so on).

Furthermore, these directory aliases can be used while referring to files (open, close, read, and so on) in PL/SQL and OCI. This provides application abstraction from hard-coded path names and gives flexibility in portably managing file locations.

The DIRECTORY object is owned by SYS and created by the DBA (or a user with the CREATE ANY DIRECTORY privilege). The directory objects have object privileges, unlike any other nonschema object. Privileges to the DIRECTORY object can be granted and revoked. Logical path names are not supported.

The permissions for the actual directory depend on the operating system. They may differ from those defined for the DIRECTORY object and could change after the creation of the DIRECTORY object.

# Guidelines for Creating DIRECTORY Objects

- **Do not create DIRECTORY objects on paths with database files.**
- **Limit the number of people who are given the following system privileges:**
  - CREATE ANY DIRECTORY
  - DROP ANY DIRECTORY
- **All DIRECTORY objects are owned by SYS.**
- **Create directory paths and properly set permissions before using the DIRECTORY object so that the Oracle server can read the file.**

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## Guidelines for Creating DIRECTORY Objects

To associate an OS file with a BFILE, you should first create a DIRECTORY object that is an alias for the full path name to the OS file.

Create DIRECTORY objects by using the following guidelines:

- Directories should point to paths that do not contain database files because tampering with these files could corrupt the database. Currently, only the READ privilege can be given for a DIRECTORY object.
- The CREATE ANY DIRECTORY and DROP ANY DIRECTORY system privileges should be used carefully and not granted to users indiscriminately.
- DIRECTORY objects are not schema objects; all are owned by SYS.
- Create the directory paths with appropriate permissions on the OS before creating the DIRECTORY object. Oracle does not create the OS path.

If you migrate the database to a different OS, then you may need to change the path value of the DIRECTORY object.

The DIRECTORY object information that you create by using the CREATE DIRECTORY command is stored in the DBA\_DIRECTORIES and ALL\_DIRECTORIES data dictionary views.



# Managing BFILES

**The DBA or the system administrator:**

1. **Creates an OS directory and supplies files**
2. **Creates a DIRECTORY object in the database**
3. **Grants the READ privilege on the DIRECTORY object to appropriate database users**

**The developer or the user:**

4. **Creates an Oracle table with a column defined as a BFILE data type**
5. **Inserts rows into the table using the BFILENAME function to populate the BFILE column**
6. **Writes a PL/SQL subprogram that declares and initializes a LOB locator, and reads BFILE**

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## How to Manage BFILES

Managing BFILES requires cooperation between the database administrator and the system administrator and then between the developer and the user of the files.

The database or system administrator should perform the following privileged tasks:

1. Create the operating system (OS) directory (as an Oracle user), and set permissions so that the Oracle server can read the contents of the OS directory. Load files into the OS directory.
2. Create a database DIRECTORY object that references the OS directory.
3. Grant the READ privilege on the database DIRECTORY object to database users requiring access to it.

The designer, application developer, or user should perform the following tasks:

4. Create a database table containing a column defined as the BFILE data type.
5. Insert rows into the table using the BFILENAME function to populate the BFILE column associating the field to an OS file in the named DIRECTORY.
6. Write PL/SQL subprograms that:
  - a. Declare and initialize the BFILE LOB locator
  - b. Select the row and column containing the BFILE into the LOB locator
  - c. Read the BFILE with a DBMS\_LOB function, using the locator file reference

# Preparing to Use BFILES

1. Create an OS directory to store the physical data files:

```
mkdir /temp/data_files
```

2. Create a DIRECTORY object by using the CREATE DIRECTORY command:

```
CREATE DIRECTORY data_files
AS '/temp/data_files';
```

3. Grant the READ privilege on the DIRECTORY object to appropriate users:

```
GRANT READ ON DIRECTORY data_files
TO SCOTT, MANAGER_ROLE, PUBLIC;
```

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## Preparing to Use BFILES

To use a BFILE within an Oracle table, you must have a table with a column of the BFILE type. For the Oracle server to access an external file, the server needs to know the physical location of the file in the OS directory structure.

The database DIRECTORY object provides the means to specify the location of the BFILES. Use the CREATE DIRECTORY command to specify the pointer to the location where your BFILES are stored. You need the CREATE ANY DIRECTORY privilege.

**Syntax definition:** CREATE DIRECTORY *dir\_name* AS *os\_path*;

In this syntax, *dir\_name* is the name of the directory database object, and *os\_path* is the location of the BFILES.

The slide examples show the commands to set up:

- The physical directory (for example /temp/data\_files) in the OS
- A named DIRECTORY object, called data\_files, that points to the physical directory in the OS
- The READ access right on the directory to be granted to users in the database, providing the privilege to read the BFILES from the directory

**Note:** The value of the SESSION\_MAX\_OPEN\_FILES database initialization parameter, which is set to 10 by default, limits the number of BFILES that can be opened in a session.

# Populating BFILE Columns with SQL

- Use the BFILENAME function to initialize a BFILE column. The function syntax is:

```
FUNCTION BFILENAME(directory_alias IN VARCHAR2,
 filename IN VARCHAR2)
RETURN BFILE;
```

- Example:

- Add a BFILE column to a table:

```
ALTER TABLE employees ADD video BFILE;
```

- Update the column using the BFILENAME function:

```
UPDATE employees
SET video = BFILENAME('DATA_FILES', 'King.avi')
WHERE employee_id = 100;
```

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## Populating BFILE Columns with SQL

The BFILENAME function is a built-in function that you use to initialize a BFILE column, using the following two parameters:

- *directory\_alias* for the name of the DIRECTORY database object that references the OS directory containing the files
- *filename* for the name of the BFILE to be read

The BFILENAME function creates a pointer (or LOB locator) to the external file stored in a physical directory, which is assigned a directory alias name that is used in the first parameter of the function. Populate the BFILE column using the BFILENAME function in either of the following:

- The VALUES clause of an INSERT statement
- The SET clause of an UPDATE statement

An UPDATE operation can be used to change the pointer reference target of the BFILE. A BFILE column can also be initialized to a NULL value and updated later with the BFILENAME function, as shown in the slide.

After the BFILE columns have been associated with a file, subsequent read operations on the BFILE can be performed by using the PL/SQL DBMS\_LOB package and OCI. However, these files are read-only when accessed through BFILES. Therefore, they cannot be updated or deleted through BFILES.

# Populating a BFILE Column with PL/SQL

```
CREATE PROCEDURE set_video(
 dir_alias VARCHAR2, dept_id NUMBER) IS
 filename VARCHAR2(40);
 file_ptr BFILE;
 CURSOR emp_csr IS
 SELECT first_name FROM employees
 WHERE department_id = dept_id FOR UPDATE;
BEGIN
 FOR rec IN emp_csr LOOP
 filename := rec.first_name || '.gif';
 file_ptr := BFILENAME(dir_alias, filename);
 DBMS_LOB.FILEOPEN(file_ptr);
 UPDATE employees SET video = file_ptr
 WHERE CURRENT OF emp_csr;
 DBMS_OUTPUT.PUT_LINE('FILE: ' || filename ||
 ' SIZE: ' || DBMS_LOB.GETLENGTH(file_ptr));
 DBMS_LOB.FILECLOSE(file_ptr);
 END LOOP;
END set_video;
```

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## Populating a BFILE Column with PL/SQL

The example shows a PL/SQL procedure called `set_video`, which accepts the name of the directory alias referencing the OS file system as a parameter, and a department ID. The procedure performs the following tasks:

- Uses a cursor FOR loop to obtain each employee record
- Sets the filename by appending `.gif` to the employee's `first_name`
- Creates an in-memory LOB locator for the BFILE in the `file_ptr` variable
- Calls the `DBMS_LOB.FILEOPEN` procedure to verify whether the file exists, and to determine the size of the file using the `DBMS_LOB.GETLENGTH` function
- Executes an `UPDATE` statement to write the BFILE locator value to the `video` BFILE column
- Displays the file size returned from the `DBMS_LOB.GETLENGTH` function
- Closes the file using the `DBMS_LOB.FILECLOSE` procedure

Suppose that you execute the following call:

```
EXECUTE set_video('DATA_FILE', 60)
```

Sample results are:

```
FILE: Alexander.gif SIZE: 5213
FILE: Bruce.gif SIZE: 26059
:
```

## Using DBMS\_LOB Routines with BFILES

The `DBMS_LOB.FILEEXISTS` function can check whether the file exists in the OS. The function:

- Returns 0 if the file does not exist
- Returns 1 if the file does exist

```
CREATE FUNCTION get_filesize(file_ptr IN OUT BFILE)
RETURN NUMBER IS
 file_exists BOOLEAN;
 length NUMBER := -1;
BEGIN
 file_exists := DBMS_LOB.FILEEXISTS(file_ptr)=1;
 IF file_exists THEN
 DBMS_LOB.FILEOPEN(file_ptr);
 length := DBMS_LOB.GETLENGTH(file_ptr);
 DBMS_LOB.FILECLOSE(file_ptr);
 END IF;
 RETURN length;
END;
/
```

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## Using DBMS\_LOB Routines with BFILES

The `set_video` procedure on the previous page will terminate with an exception if a file does not exist. To prevent the loop from prematurely terminating, you could create a function, such as `get_filesize`, to determine whether a given BFILE locator references a file that actually exists on the server's file system. The `DBMS_LOB.FILEEXISTS` function expects the BFILE locator as a parameter and returns an INTEGER with:

- A value 0 if the physical file does not exist
- A value 1 if the physical file exists

If the BFILE parameter is invalid, one of the three exceptions may be raised:

- `NOEXIST_DIRECTORY` if the directory does not exist
- `NOPRIV_DIRECTORY` if database processes do not have privileges for the directory
- `INVALID_DIRECTORY` if the directory was invalidated after the file was opened

In the `get_filesize` function, the output of the `DBMS_LOB.FILEEXISTS` function is compared with value 1 and the result of the condition sets the BOOLEAN variable `file_exists`. The `DBMS_LOB.FILEOPEN` call is performed only if the file does exist, preventing unwanted exceptions from occurring. The `get_filesize` function returns a value of -1 if a file does not exist; otherwise, it returns the size of the file in bytes. The caller can take appropriate action with this information.

# Migrating from LONG to LOB

**Oracle Database 10g enables the migration of LONG columns to LOB columns.**

- **Data migration consists of the procedure to move existing tables containing LONG columns to use LOBS:**

```
ALTER TABLE [<schema>.] <table_name>
 MODIFY (<long_col_name> {CLOB | BLOB | NCLOB})
```

- **Application migration consists of changing existing LONG applications for using LOBS.**

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## Migrating from LONG to LOB

Oracle Database 10g supports LONG-to-LOB migration using an API. In data migration, existing tables that contain LONG columns need to be moved to use LOB columns. This can be done by using the ALTER TABLE command. In Oracle8i, an operator named TO\_LOB had to be used to copy a LONG to a LOB. In Oracle Database 10g, this operation can be performed using the syntax shown in the slide. You can use the syntax shown to:

- Modify a LONG column to a CLOB or an NCLOB column
- Modify a LONG RAW column to a BLOB column

The constraints of the LONG column (NULL and NOT NULL are the only allowed constraints) are maintained for the new LOB columns. The default value specified for the LONG column is also copied to the new LOB column. For example, suppose you have the following table:

```
CREATE TABLE long_tab (id NUMBER, long_col LONG);
```

To change the long\_col column in the long\_tab table to the CLOB data type, use:

```
ALTER TABLE long_tab MODIFY (long_col CLOB);
```

For information about the limitations on LONG-to-LOB migration, refer to the *Oracle Database Application Developer's Guide - Large Objects*. In application migration, the existing LONG applications change for using LOBs. You can use SQL and PL/SQL to access LONGs and LOBs. The LONG-to-LOB migration API is provided for both OCI and PL/SQL.

# Migrating from LONG to LOB

- **Implicit conversion: From LONG (LONG RAW) or a VARCHAR2 (RAW) variable to a CLOB (BLOB) variable, and vice versa**
- **Explicit conversion:**
  - **TO\_CLOB () converts LONG, VARCHAR2, and CHAR to CLOB.**
  - **TO\_BLOB () converts LONG RAW and RAW to BLOB.**
- **Function and procedure parameter passing:**
  - **CLOBs and BLOBs are passed as actual parameters**
  - **VARCHAR2, LONG, RAW, and LONG RAW are formal parameters, and vice versa.**
- **LOB data is acceptable in most of the SQL and PL/SQL operators and built-in functions.**

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## Migrating from LONG to LOB (continued)

With the new LONG-to-LOB API introduced in Oracle Database 10g, data from CLOB and BLOB columns can be referenced by regular SQL and PL/SQL statements.

**Implicit assignment and parameter passing:** The LONG-to-LOB migration API supports assigning a CLOB (BLOB) variable to a LONG (LONG RAW) or a VARCHAR2(RAW) variable, and vice versa.

**Explicit conversion functions:** In PL/SQL, the following two new explicit conversion functions have been added in Oracle Database 10g to convert other data types to CLOB and BLOB as part of the LONG-to-LOB migration:

- **TO\_CLOB () converts LONG, VARCHAR2, and CHAR to CLOB**
- **TO\_BLOB () converts LONG RAW and RAW to BLOB**

**Note:** TO\_CHAR () is enabled to convert a CLOB to a CHAR type.

**Function and procedure parameter passing:** This enables the use of CLOBs and BLOBs as actual parameters where VARCHAR2, LONG, RAW, and LONG RAW are formal parameters, and vice versa. In SQL and PL/SQL built-in functions and operators, a CLOB can be passed to SQL and PL/SQL VARCHAR2 built-in functions, behaving exactly like a VARCHAR2. Or, the VARCHAR2 variable can be passed into DBMS\_LOB APIs acting like a LOB locator.



## DBMS\_LOB Package

- **Working with LOBs often requires the use of the Oracle-supplied DBMS\_LOB package.**
- **DBMS\_LOB provides routines to access and manipulate internal and external LOBs.**
- **Oracle Database 10g enables retrieving LOB data directly using SQL without a special LOB API.**
- **In PL/SQL, you can define a VARCHAR2 for a CLOB and a RAW for a BLOB.**

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### DBMS\_LOB Package

In releases prior to Oracle9i, you must use the DBMS\_LOB package for retrieving data from LOBs. To create the DBMS\_LOB package, the `dbmslob.sql` and `prvtlob.plb` scripts must be executed as SYS. The `catproc.sql` script executes the scripts. Then users can be granted appropriate privileges to use the package.

The package does not support any concurrency control mechanism for BFILE operations. The user is responsible for locking the row containing the destination internal LOB before calling any subprograms that involve writing to the LOB value. These DBMS\_LOB routines do not implicitly lock the row containing the LOB.

The two constants, `LOBMAXSIZE` and `FILE_READONLY`, defined in the package specification are also used in the procedures and functions of DBMS\_LOB—for example, use them to achieve the maximum level of purity to be used in SQL expressions.

The DBMS\_LOB functions and procedures can be broadly classified into two types: mutators and observers.

- The mutators can modify LOB values: `APPEND`, `COPY`, `ERASE`, `TRIM`, `WRITE`, `FILECLOSE`, `FILECLOSEALL`, and `FILEOPEN`.
- The observers can read LOB values: `COMPARE`, `FILEGETNAME`, `INSTR`, `GETLENGTH`, `READ`, `SUBSTR`, `FILEEXISTS`, and `FILEISOPEN`.



# DBMS\_LOB Package

- **Modify LOB values:**  
APPEND, COPY, ERASE, TRIM, WRITE,  
LOADFROMFILE
- **Read or examine LOB values:**  
GETLENGTH, INSTR, READ, SUBSTR
- **Specific to BFILES:**  
FILECLOSE, FILECLOSEALL, FILEEXISTS,  
FILEGETNAME, FILEISOPEN, FILEOPEN

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## DBMS\_LOB Package (continued)

APPEND	Appends the contents of the source LOB to the destination LOB
COPY	Copies all or part of the source LOB to the destination LOB
ERASE	Erases all or part of a LOB
LOADFROMFILE	Loads BFILE data into an internal LOB
TRIM	Trims the LOB value to a specified shorter length
WRITE	Writes data to the LOB from a specified offset
GETLENGTH	Gets the length of the LOB value
INSTR	Returns the matching position of the <i>n</i> th occurrence of the pattern in the LOB
READ	Reads data from the LOB starting at the specified offset
SUBSTR	Returns part of the LOB value starting at the specified offset
FILECLOSE	Closes the file
FILECLOSEALL	Closes all previously opened files
FILEEXISTS	Checks whether the file exists on the server
FILEGETNAME	Gets the directory alias and file name
FILEISOPEN	Checks whether the file was opened using the input BFILE locators
FILEOPEN	Opens a file

## DBMS\_LOB Package

- **NULL parameters get NULL returns.**
- **Offsets:**
  - **BLOB, BFILE: Measured in bytes**
  - **CLOB, NCLOB: Measured in characters**
- **There are no negative values for parameters.**

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### Using the DBMS\_LOB Routines

All functions in the DBMS\_LOB package return NULL if any input parameters are NULL. All mutator procedures in the DBMS\_LOB package raise an exception if the destination LOB/BFILE is input as NULL.

Only positive, absolute offsets are allowed. They represent the number of bytes or characters from the beginning of LOB data from which to start the operation. Negative offsets and ranges observed in SQL string functions and operators are not allowed. Corresponding exceptions are raised upon violation. The default value for an offset is 1, which indicates the first byte or character in the LOB value.

Similarly, only natural number values are allowed for the amount (BUFSIZ) parameter. Negative values are not allowed.

## DBMS\_LOB.READ and DBMS\_LOB.WRITE

```
PROCEDURE READ (
 lobsrc IN BFILE|BLOB|CLOB ,
 amount IN OUT BINARY_INTEGER,
 offset IN INTEGER,
 buffer OUT RAW|VARCHAR2)
```

```
PROCEDURE WRITE (
 lobdst IN OUT BLOB|CLOB,
 amount IN OUT BINARY_INTEGER,
 offset IN INTEGER := 1,
 buffer IN RAW|VARCHAR2) -- RAW for BLOB
```

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### DBMS\_LOB.READ

Call the READ procedure to read and return piecewise a specified AMOUNT of data from a given LOB, starting from OFFSET. An exception is raised when no more data remains to be read from the source LOB. The value returned in AMOUNT is less than the one specified if the end of the LOB is reached before the specified number of bytes or characters can be read. In the case of CLOBs, the character set of data in BUFFER is the same as that in the LOB.

PL/SQL allows a maximum length of 32,767 for RAW and VARCHAR2 parameters. Ensure that the allocated system resources are adequate to support buffer sizes for the given number of user sessions. Otherwise, the Oracle server raises the appropriate memory exceptions.

**Note:** BLOB and BFILE return RAW; the others return VARCHAR2.

### DBMS\_LOB.WRITE

Call the WRITE procedure to write piecewise a specified AMOUNT of data into a given LOB, from the user-specified BUFFER, starting from an absolute OFFSET from the beginning of the LOB value.

Make sure (especially with multibyte characters) that the amount in bytes corresponds to the amount of buffer data. WRITE has no means of checking whether they match, and it will write AMOUNT bytes of the buffer contents into the LOB.

# Initializing LOB Columns Added to a Table

- **Create the table with columns using the LOB type, or add the LOB columns using ALTER TABLE.**

```
ALTER TABLE employees
ADD (resume CLOB, picture BLOB);
```

- **Initialize the column LOB locator value with the DEFAULT option or DML statements using:**
  - **EMPTY\_CLOB () function for a CLOB column**
  - **EMPTY\_BLOB () function for a BLOB column**

```
CREATE TABLE emp_hiredata (
 employee_id NUMBER(6),
 full_name VARCHAR2(45),
 resume CLOB DEFAULT EMPTY_CLOB(),
 picture BLOB DEFAULT EMPTY_BLOB());
```

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## Initializing LOB Columns Added to a Table

LOB columns are defined by using SQL data definition language (DDL), as in the ALTER TABLE statement in the slide. The contents of a LOB column are stored in the LOB segment, whereas the column in the table contains only a reference to that specific storage area, called the LOB locator. In PL/SQL, you can define a variable of the LOB type, which contains only the value of the LOB locator. You can initialize the LOB locators using:

- **EMPTY\_CLOB ()** function to a LOB locator for a CLOB column
- **EMPTY\_BLOB ()** function to a LOB locator for a BLOB column

**Note:** These functions create the LOB locator value and not the LOB content. In general, you use the DBMS\_LOB package subroutines to populate the content. The functions are available in Oracle SQL DML, and are not part of the DBMS\_LOB package.

The last example in the slide shows how you can use the **EMPTY\_CLOB ()** and **EMPTY\_BLOB ()** functions in the **DEFAULT** option in a **CREATE TABLE** statement. In this way, the LOB locator values are populated in their respective columns when a row is inserted into the table and the LOB columns have not been specified in the **INSERT** statement.

The next page shows how to use the functions in **INSERT** and **UPDATE** statements to initialize the LOB locator values.

# Populating LOB Columns

- **Insert a row into a table with LOB columns:**

```
INSERT INTO emp_hiredata
(employee_id, full_name, resume, picture)
VALUES (405, 'Marvin Ellis', EMPTY_CLOB(), NULL);
```

- **Initialize a LOB using the EMPTY\_BLOB() function:**

```
UPDATE emp_hiredata
SET resume = 'Date of Birth: 8 February 1951',
 picture = EMPTY_BLOB()
WHERE employee_id = 405;
```

- **Update a CLOB column:**

```
UPDATE emp_hiredata
SET resume = 'Date of Birth: 1 June 1956'
WHERE employee_id = 170;
```

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## Populating LOB Columns

You can insert a value directly into a LOB column by using host variables in SQL or in PL/SQL, 3GL-embedded SQL, or OCI. You can use the special `EMPTY_BLOB()` and `EMPTY_CLOB()` functions in `INSERT` or `UPDATE` statements of SQL DML to initialize a `NULL` or non-`NULL` internal LOB to empty. To populate a LOB column, perform the following steps:

1. Initialize the LOB column to a non-`NULL` value—that is, set a LOB locator pointing to an empty or populated LOB value. This is done by using `EMPTY_BLOB()` and `EMPTY_CLOB()` functions.
2. Populate the LOB contents by using the `DBMS_LOB` package routines.

However, as shown in the slide examples, the two `UPDATE` statements initialize the `resume` LOB locator value and populate its contents by supplying a literal value. This can also be done in an `INSERT` statement. A LOB column can be updated to:

- Another LOB value
- A `NULL` value
- A LOB locator with empty contents by using the `EMPTY_*LOB()` built-in function

You can update the LOB by using a bind variable in embedded SQL. When assigning one LOB to another, a new copy of the LOB value is created. Use a `SELECT FOR UPDATE` statement to lock the row containing the LOB column before updating a piece of the LOB contents.

# Updating LOB by Using DBMS\_LOB in PL/SQL

```
DECLARE
 lobloc CLOB; -- serves as the LOB locator
 text VARCHAR2(50) := 'Resigned = 5 June 2000';
 amount NUMBER; -- amount to be written
 offset INTEGER; -- where to start writing
BEGIN
 SELECT resume INTO lobloc FROM emp_hiredata
 WHERE employee_id = 405 FOR UPDATE;
 offset := DBMS_LOB.GETLENGTH(lobloc) + 2;
 amount := length(text);
 DBMS_LOB.WRITE (lobloc, amount, offset, text);
 text := ' Resigned = 30 September 2000';
 SELECT resume INTO lobloc FROM emp_hiredata
 WHERE employee_id = 170 FOR UPDATE;
 amount := length(text);
 DBMS_LOB.WRITEAPPEND(lobloc, amount, text);
 COMMIT;
END;
```

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## Updating LOB by Using DBMS\_LOB in PL/SQL

In the example in the slide, the LOBLOC variable serves as the LOB locator, and the AMOUNT variable is set to the length of the text you want to add. The SELECT FOR UPDATE statement locks the row and returns the LOB locator for the RESUME LOB column. Finally, the PL/SQL WRITE package procedure is called to write the text into the LOB value at the specified offset. WRITEAPPEND appends to the existing LOB value.

The example shows how to fetch a CLOB column in releases before Oracle9i. In those releases, it was not possible to fetch a CLOB column directly into a character column. The column value needed to be bound to a LOB locator, which is accessed by the DBMS\_LOB package. An example later in this lesson shows that you can directly fetch a CLOB column by binding it to a character variable.

**Note:** Versions prior to Oracle9i did not allow LOBs in the WHERE clause of UPDATE and SELECT statements. Now SQL functions of LOBs are allowed in predicates of WHERE. An example is shown later in this lesson.

## Selecting CLOB Values by Using SQL

```
SELECT employee_id, full_name , resume -- CLOB
FROM emp_hiredata
WHERE employee_id IN (405, 170);
```

EMPLOYEE_ID	FULL_NAME	RESUME
405	Marvin Ellis	Date of Birth: 8 February 1951 Resigned = 5 June 2000
170	Joe Fox	Date of Birth: 1 June 1956 Resigned = 30 September 2000

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### Selecting CLOB Values by Using SQL

It is possible to see the data in a CLOB column by using a SELECT statement. It is not possible to see the data in a BLOB or BFILE column by using a SELECT statement in *iSQL\*Plus*. You have to use a tool that can display binary information for a BLOB, as well as the relevant software for a BFILE—for example, you can use Oracle Forms.

## Selecting CLOB Values by Using DBMS\_LOB

- **DBMS\_LOB.SUBSTR (lob, amount, start\_pos)**
- **DBMS\_LOB.INSTR (lob, pattern)**

```
SELECT DBMS_LOB.SUBSTR (resume, 5, 18),
 DBMS_LOB.INSTR (resume, ' = ')
FROM emp_hiredata
WHERE employee_id IN (170, 405);
```

DBMS_LOB.SUBSTR(RESUME,5,18)	DBMS_LOB.INSTR(RESUME,'=')
Febru	40
June	36

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### Selecting CLOB Values by Using DBMS\_LOB

#### **DBMS\_LOB.SUBSTR**

Use **DBMS\_LOB.SUBSTR** to display a part of a LOB. It is similar in functionality to the **SUBSTR** SQL function.

#### **DBMS\_LOB.INSTR**

Use **DBMS\_LOB.INSTR** to search for information within the LOB. This function returns the numerical position of the information.

**Note:** Starting with Oracle9i, you can also use the **SUBSTR** and **INSTR** SQL functions to perform the operations shown in the slide.



# Selecting CLOB Values in PL/SQL

```
SET LINESIZE 50 SERVEROUTPUT ON FORMAT WORD_WRAP
DECLARE
 text VARCHAR2(4001);
BEGIN
 SELECT resume INTO text
 FROM emp_hiredata
 WHERE employee_id = 170;
 DBMS_OUTPUT.PUT_LINE('text is: ' || text);
END;
/
```

text is: Date of Birth: 1 June 1956 Resigned = 30  
September 2000

PL/SQL procedure successfully completed.

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## Selecting CLOB Values in PL/SQL

The slide shows the code for accessing CLOB values that can be implicitly converted to VARCHAR2 in Oracle10g. When selected, the RESUME column value is implicitly converted from a CLOB into a VARCHAR2 to be stored in the TEXT variable. Prior to Oracle9i, you first retrieved the CLOB locator value into a CLOB variable, and then read the LOB contents specifying the amount and offset in the DBMS\_LOB.READ procedure:

```
DECLARE
 rlob CLOB;
 text VARCHAR2(4001);
 amt NUMBER := 4001;
 offset NUMBER := 1;
BEGIN
 SELECT resume INTO rlob FROM emp_hirdata
 WHERE employee_id = 170;
 DBMS_LOB.READ(rlob, amt, offset, text);
 DBMS_OUTPUT.PUT_LINE('text is: ' || text);
END;
/
text is: Date of Birth: 1 June 1956 Resigned = 30 September 2000
PL/SQL procedure successfully completed.
```

# Removing LOBs

- **Delete a row containing LOBs:**

```
DELETE
FROM emp_hiredata
WHERE employee_id = 405;
```

- **Disassociate a LOB value from a row:**

```
UPDATE emp_hiredata
SET resume = EMPTY_CLOB()
WHERE employee_id = 170;
```

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## Removing LOBs

A LOB instance can be deleted (destroyed) using appropriate SQL DML statements. The SQL statement `DELETE` deletes a row and its associated internal LOB value. To preserve the row and destroy only the reference to the LOB, you must update the row by replacing the LOB column value with `NULL` or an empty string, or by using the `EMPTY_B/CLOB()` function.

**Note:** Replacing a column value with `NULL` and using `EMPTY_B/CLOB` are not the same. Using `NULL` sets the value to null; using `EMPTY_B/CLOB` ensures that there is nothing in the column.

A LOB is destroyed when the row containing the LOB column is deleted, when the table is dropped or truncated, or when all the LOB data is updated.

You must explicitly remove the file associated with a `BFILE` using OS commands.

To erase part of an internal LOB, you can use `DBMS_LOB.ERASE`.

# Temporary LOBs

- **Temporary LOBs:**
  - **Provide an interface to support creation of LOBs that act like local variables**
  - **Can be BLOBs, CLOBs, or NCLOBs**
  - **Are not associated with a specific table**
  - **Are created using the `DBMS_LOB.CREATETEMPORARY` procedure**
  - **Use `DBMS_LOB` routines**
- **The lifetime of a temporary LOB is a session.**
- **Temporary LOBs are useful for transforming data in permanent internal LOBs.**

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## Temporary LOBs

Temporary LOBs provide an interface to support the creation and deletion of LOBs that act like local variables. Temporary LOBs can be BLOBs, CLOBs, or NCLOBs.

The following are the features of temporary LOBs:

- Data is stored in your temporary tablespace, not in tables.
- Temporary LOBs are faster than persistent LOBs because they do not generate any redo or rollback information.
- Temporary LOBs lookup is localized to each user's own session. Only the user who creates a temporary LOB can access it, and all temporary LOBs are deleted at the end of the session in which they were created.
- You can create a temporary LOB using `DBMS_LOB.CREATETEMPORARY`.

Temporary LOBs are useful when you want to perform some transformational operation on a LOB (for example, changing an image type from GIF to JPEG). A temporary LOB is empty when created and does not support the `EMPTY_B/CLOB` functions.

Use the `DBMS_LOB` package to use and manipulate temporary LOBs.

# Creating a Temporary LOB

## PL/SQL procedure to create and test a temporary LOB:

```
CREATE OR REPLACE PROCEDURE is_templob_open(
 lob IN OUT BLOB, retval OUT INTEGER) IS
BEGIN
 -- create a temporary LOB
 DBMS_LOB.CREATETEMPORARY (lob, TRUE);
 -- see if the LOB is open: returns 1 if open
 retval := DBMS_LOB.ISOPEN (lob);
 DBMS_OUTPUT.PUT_LINE (
 'The file returned a value...' || retval);
 -- free the temporary LOB
 DBMS_LOB.FREETEMPORARY (lob);
END;
/
```

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## Creating a Temporary LOB

The example in the slide shows a user-defined PL/SQL procedure, `is_templob_open`, which creates a temporary LOB. This procedure accepts a LOB locator as input, creates a temporary LOB, opens it, and tests whether the LOB is open.

The `is_templob_open` procedure uses the procedures and functions from the `DBMS_LOB` package as follows:

- The `CREATETEMPORARY` procedure is used to create the temporary LOB.
- The `ISOPEN` function is used to test whether a LOB is open: this function returns the value 1 if the LOB is open.
- The `FREETEMPORARY` procedure is used to free the temporary LOB. Memory increases incrementally as the number of temporary LOBs grows, and you can reuse temporary LOB space in your session by explicitly freeing temporary LOBs.

# Summary

**In this lesson, you should have learned how to:**

- **Identify four built-in types for large objects: BLOB, CLOB, NCLOB, and BFILE**
- **Describe how LOBs replace LONG and LONG RAW**
- **Describe two storage options for LOBs:**
  - **Oracle server (internal LOBs)**
  - **External host files (external LOBs)**
- **Use the DBMS\_LOB PL/SQL package to provide routines for LOB management**
- **Use temporary LOBs in a session**

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## Summary

There are four LOB data types:

- A BLOB is a binary large object.
- A CLOB is a character large object.
- An NCLOB stores multibyte national character set data.
- A BFILE is a large object stored in a binary file outside the database.

LOBs can be stored internally (in the database) or externally (in an OS file). You can manage LOBs by using the DBMS\_LOB package and its procedure.

Temporary LOBs provide an interface to support the creation and deletion of LOBs that act like local variables.

## Practice 9: Overview

**This practice covers the following topics:**

- **Creating object types using the CLOB and BLOB data types**
- **Creating a table with LOB data types as columns**
- **Using the DBMS\_LOB package to populate and interact with the LOB data**

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### Practice 9: Overview

In this practice, you create a table with both BLOB and CLOB columns. Then you use the DBMS\_LOB package to populate the table and manipulate the data.

## Practice 9

1. Create a table called PERSONNEL by executing the script file E:\labs\PLPU\labs\lab\_09\_01.sql. The table contains the following attributes and data types:

Column Name	Data Type	Length
ID	NUMBER	6
last_name	VARCHAR2	35
review	CLOB	N/A
picture	BLOB	N/A

2. Insert two rows into the PERSONNEL table, one each for employee 2034 (whose last name is Allen) and for employee 2035 (whose last name is Bond). Use the empty function for the CLOB, and provide NULL as the value for the BLOB.
3. Examine and execute the E:\labs\PLPU\labs\lab\_09\_03.sql script. The script creates a table named REVIEW\_TABLE. This table contains annual review information for each employee. The script also contains two statements to insert review details for two employees.
4. Update the PERSONNEL table.
  - a. Populate the CLOB for the first row, using this subquery in an UPDATE statement:

```
SELECT ann_review
FROM review_table
WHERE employee_id = 2034;
```
  - b. Populate the CLOB for the second row, using PL/SQL and the DBMS\_LOB package. Use the following SELECT statement to provide a value for the LOB locator.

```
SELECT ann_review
FROM review_table
WHERE employee_id = 2035;
```

### If you have time, complete the following exercise:

5. Create a procedure that adds a locator to a binary file into the PICTURE column of the COUNTRIES table. The binary file is a picture of the country flag. The image files are named after the country IDs. You need to load an image file locator into all rows in the Europe region (REGION\_ID = 1) in the COUNTRIES table. A DIRECTORY object called COUNTRY\_PIC referencing the location of the binary files has to be created for you.
  - a. Add the image column to the COUNTRIES table using:

```
ALTER TABLE countries ADD (picture BFILE);
```

Alternatively, use the E:\labs\PLPU\labs\Lab\_09\_05\_a.sql file.
  - b. Create a PL/SQL procedure called load\_country\_image that uses DBMS\_LOB.FILEEXISTS to test whether the country picture file exists. If the file exists, then set the BFILE locator for the file in the PICTURE column; otherwise, display a message that the file does not exist. Use the DBMS\_OUTPUT package to report file size information for each image associated with the PICTURE column.
  - c. Invoke the procedure by passing the name of the directory object COUNTRY\_PIC as a string literal parameter value.

