
Oracle9*i*: Program with PL/SQL

Electronic Presentation

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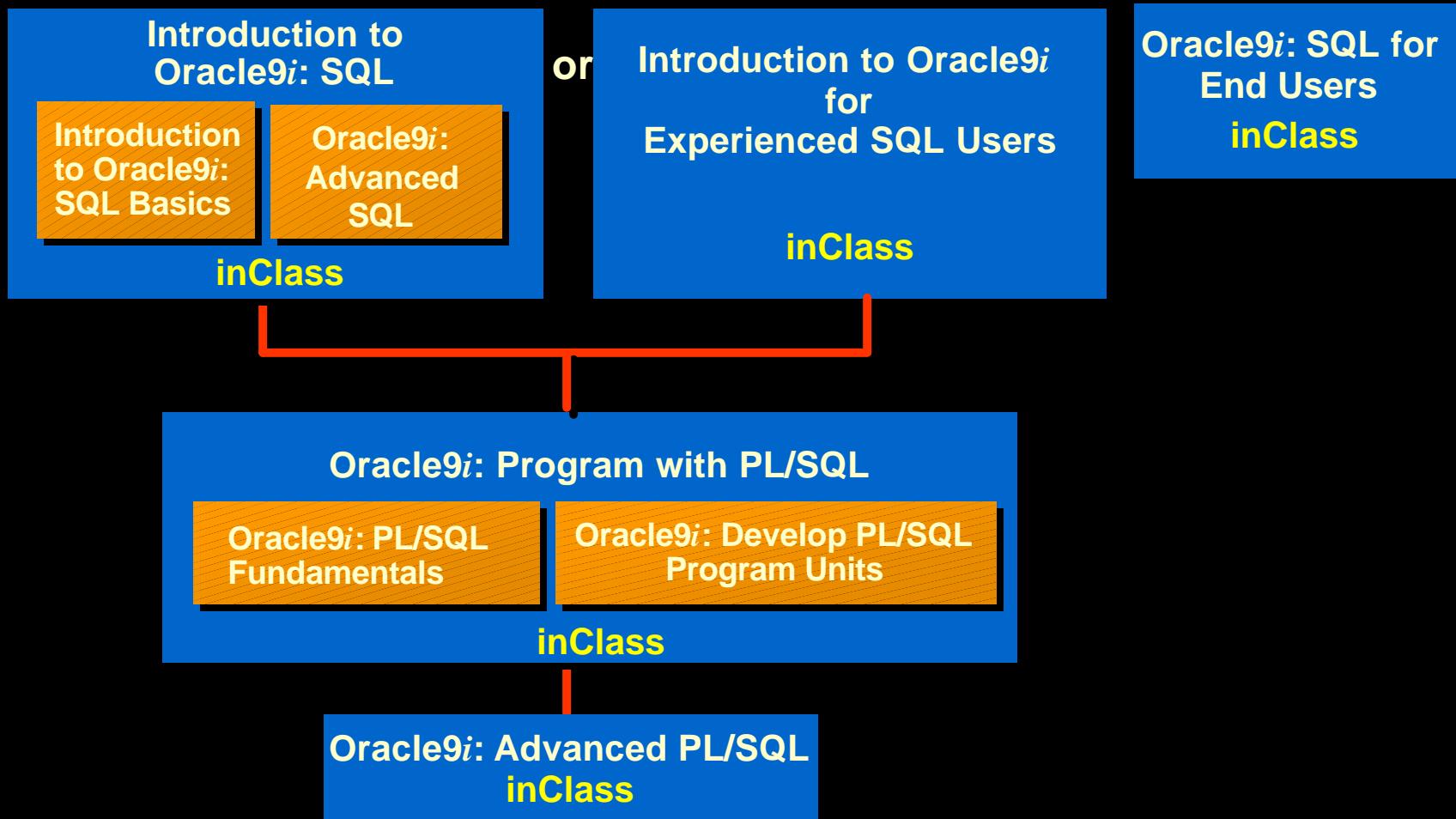
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Curriculum Map

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Languages Curriculum for Oracle9*i*



Overview of PL/SQL

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Course Objectives

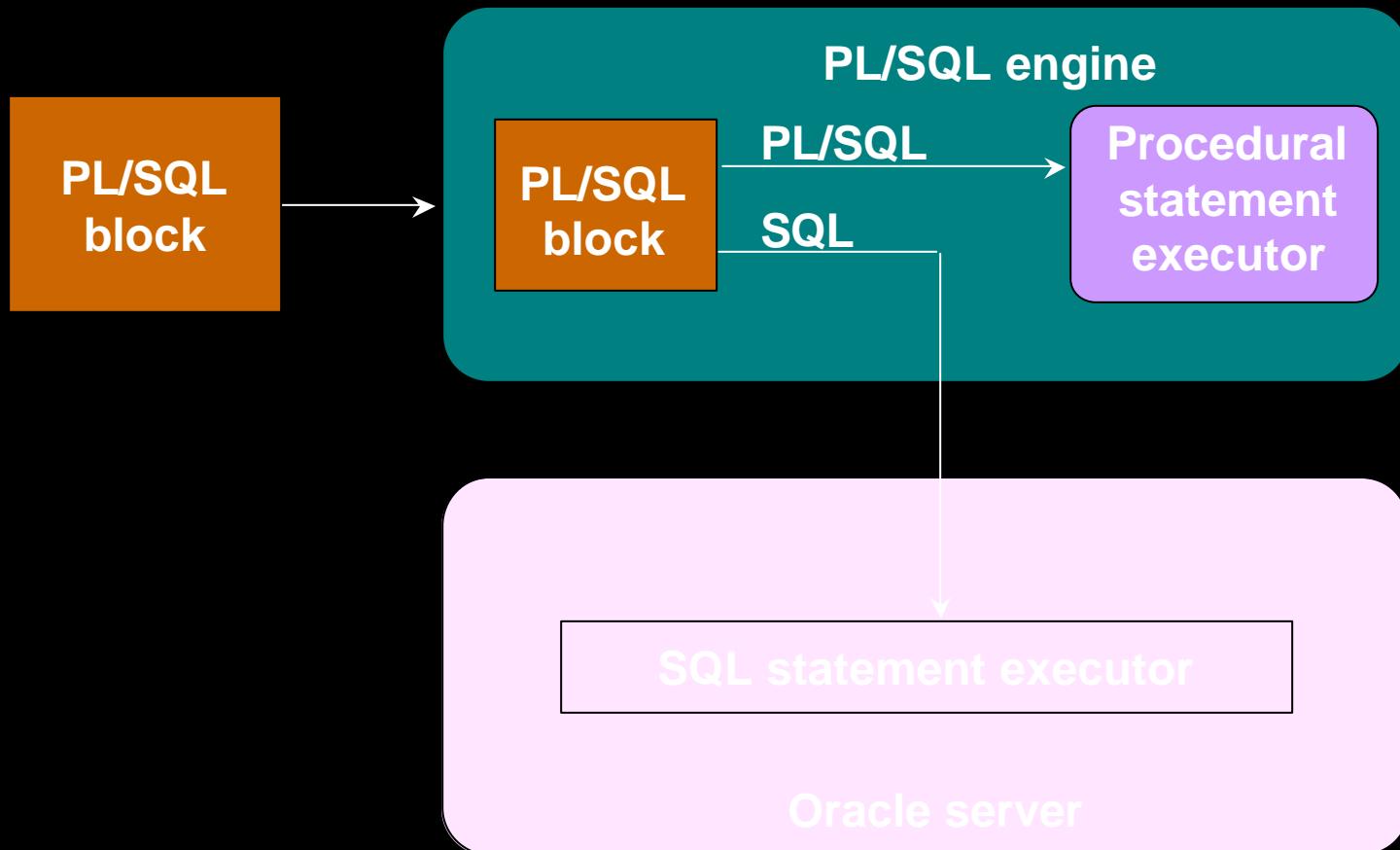
After completing this course, you should be able to do the following:

- **Describe the purpose of PL/SQL**
- **Describe the use of PL/SQL for the developer as well as the DBA**
- **Explain the benefits of PL/SQL**
- **Create, execute, and maintain procedures, functions, packages, and database triggers**
- **Manage PL/SQL subprograms and triggers**
- **Describe Oracle supplied packages**
- **Manipulate large objects (LOBs)**

About PL/SQL

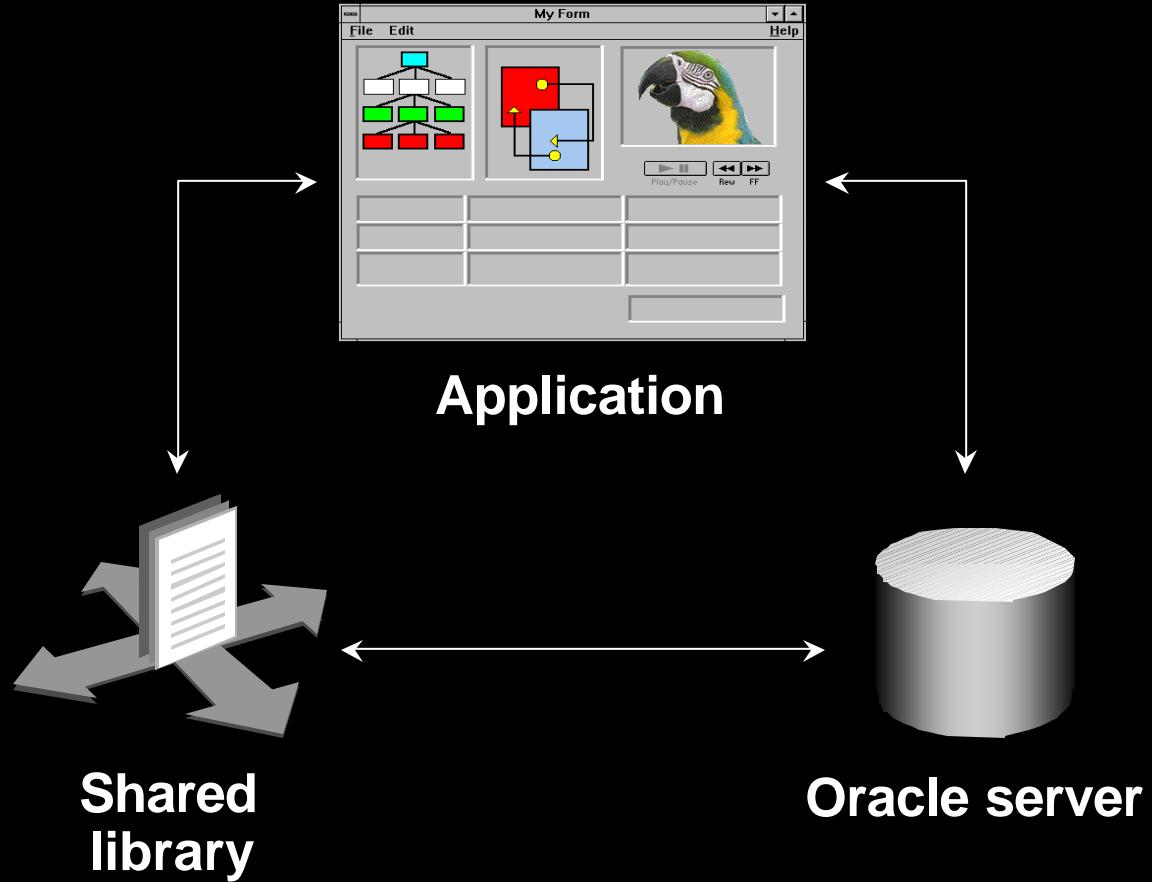
- **PL/SQL is the procedural extension to SQL with design features of programming languages.**
- **Data manipulation and query statements of SQL are included within procedural units of code.**

PL/SQL Environment



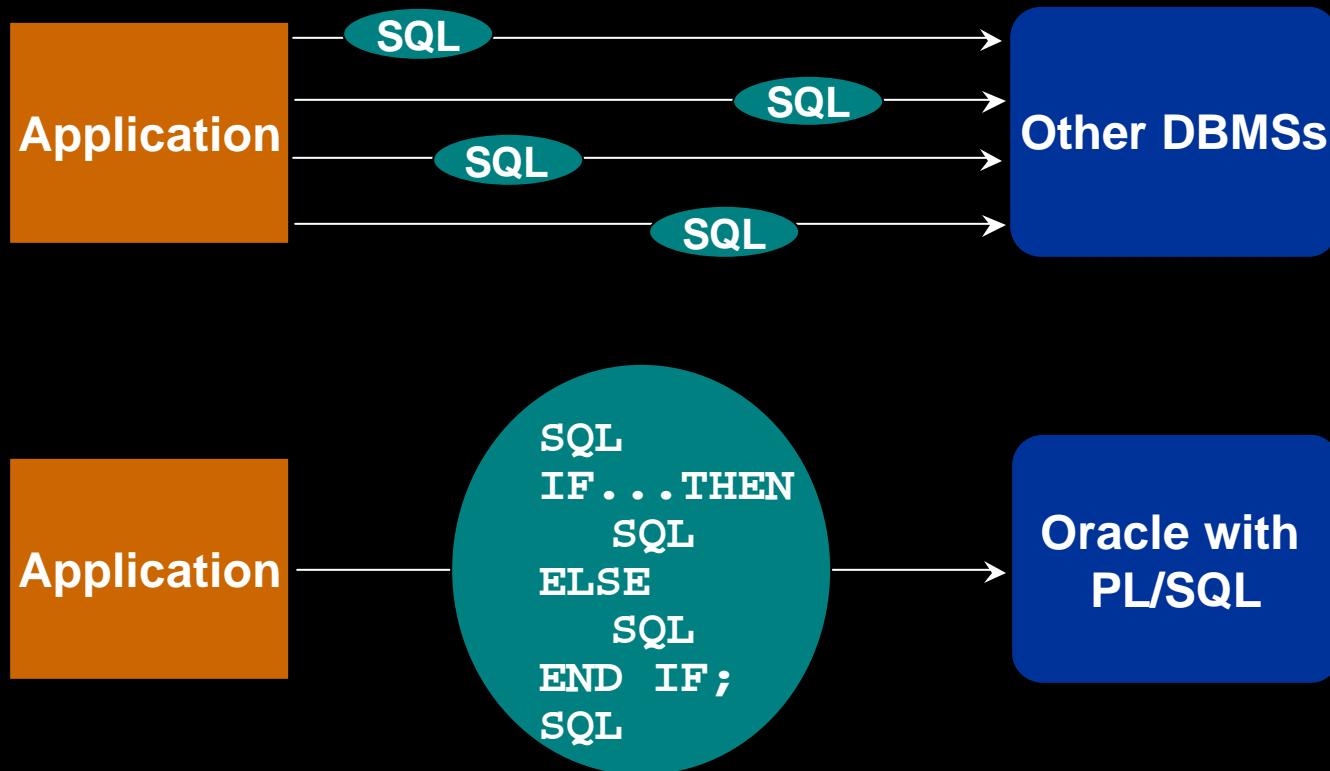
Benefits of PL/SQL

Integration



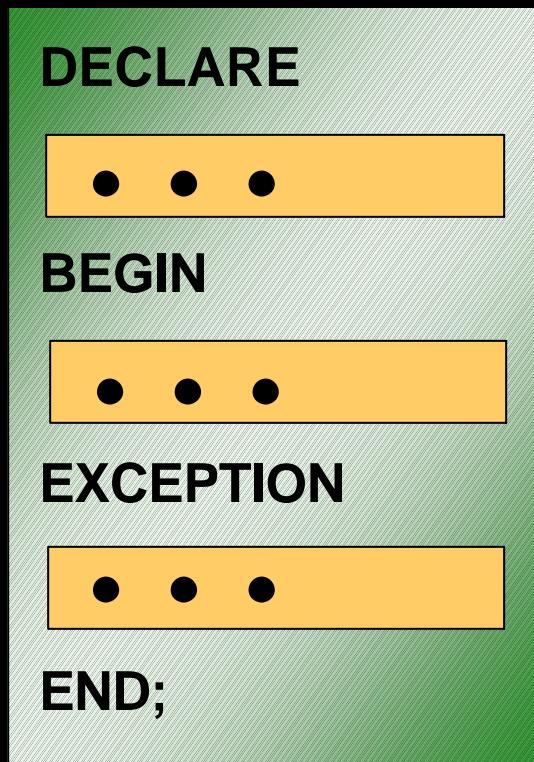
Benefits of PL/SQL

Improved performance



Benefits of PL/SQL

Modularize program development



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Benefits of PL/SQL

- **PL/SQL is portable.**
- **You can declare variables.**

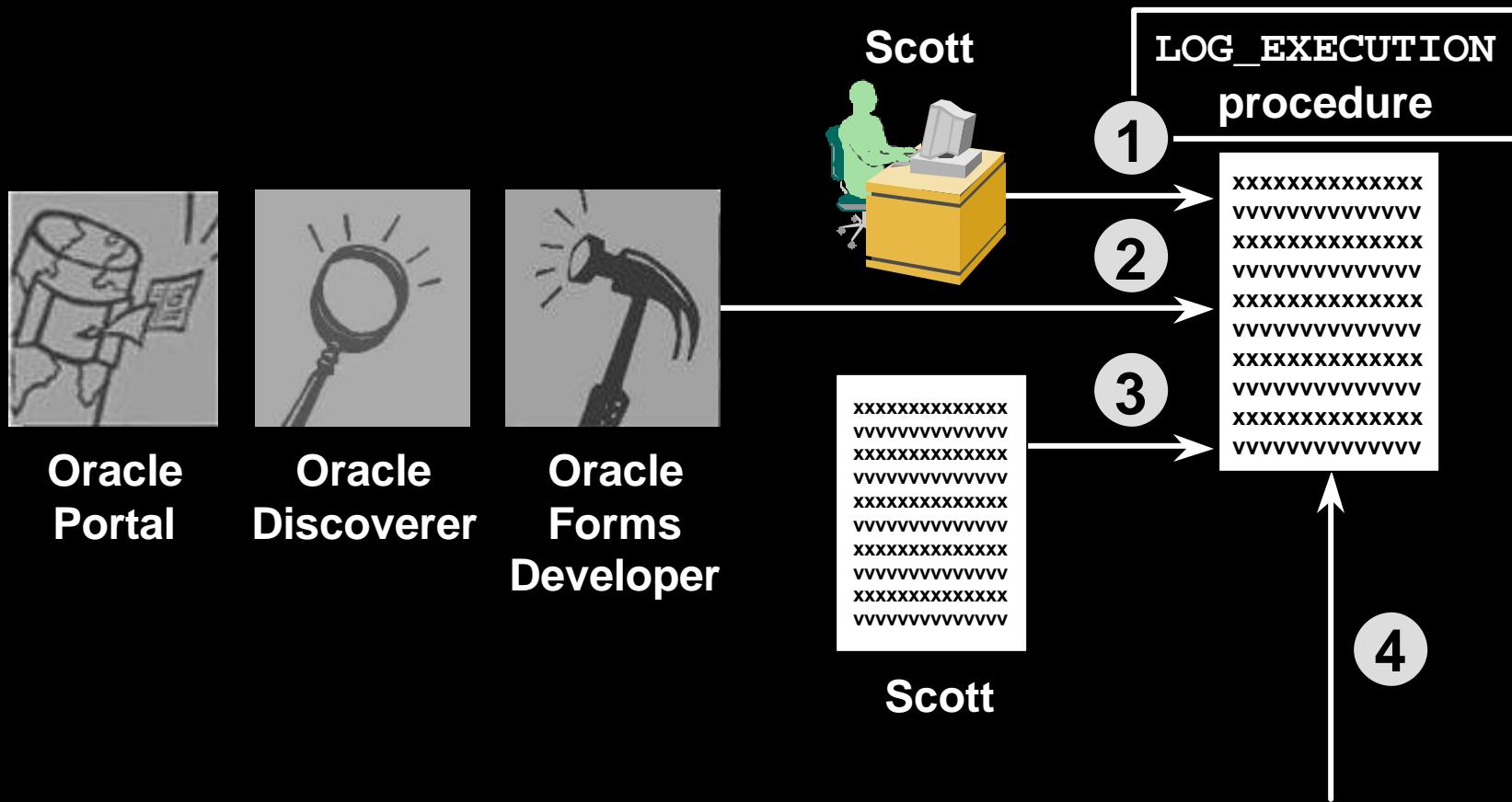
Benefits of PL/SQL

- You can program with procedural language control structures.
- PL/SQL can handle errors.

Benefits of Subprograms

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

Invoking Stored Procedures and Functions



Summary

- **PL/SQL is an extension to SQL.**
- **Blocks of PL/SQL code are passed to and processed by a PL/SQL engine.**
- **Benefits of PL/SQL:**
 - Integration
 - Improved performance
 - Portability
 - Modularity of program development
- **Subprograms are named PL/SQL blocks, declared as either procedures or functions.**
- **You can invoke subprograms from different environments.**

1

Declaring Variables

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Objectives

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

- **Recognize the basic PL/SQL block and its sections**
- **Describe the significance of variables in PL/SQL**
- **Declare PL/SQL variables**
- **Execute a PL/SQL block**

PL/SQL Block Structure

DECLARE (Optional)

Variables, cursors, user-defined exceptions

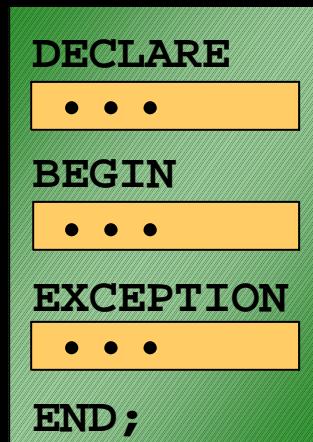
BEGIN (Mandatory)

- SQL statements
- PL/SQL statements

EXCEPTION (Optional)

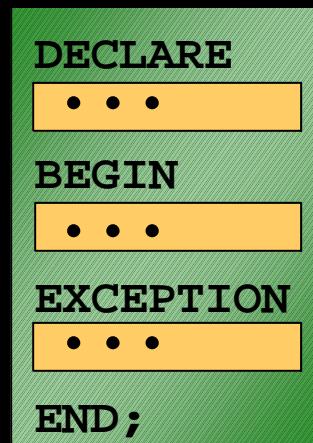
Actions to perform when errors occur

END; (Mandatory)



Executing Statements and PL/SQL Blocks

```
DECLARE
    v_variable  VARCHAR2(5);
BEGIN
    SELECT column_name
    INTO v_variable
    FROM table_name;
EXCEPTION
    WHEN exception_name THEN
        ...
END;
```



Block Types

Anonymous

```
[DECLARE]  
  
BEGIN  
  --statements  
  
[ EXCEPTION ]  
  
END;
```

Procedure

```
PROCEDURE name  
IS  
  
BEGIN  
  --statements  
  
[ EXCEPTION ]  
  
END;
```

Function

```
FUNCTION name  
RETURN datatype  
IS  
  
BEGIN  
  --statements  
  RETURN value;  
  
[ EXCEPTION ]  
  
END;
```

Program Constructs

```
DECLARE  
    • • •  
BEGIN  
    • • •  
EXCEPTION  
    • • •  
END;
```

Tools Constructs

Anonymous blocks

Application procedures or functions

Application packages

Application triggers

Object types

Database Server Constructs

Anonymous blocks

Stored procedures or functions

Stored packages

Database triggers

Object types

Use of Variables

Variables can be used for:

- **Temporary storage of data**
- **Manipulation of stored values**
- **Reusability**
- **Ease of maintenance**

Handling Variables in PL/SQL

- **Declare and initialize variables in the declaration section.**
- **Assign new values to variables in the executable section.**
- **Pass values into PL/SQL blocks through parameters.**
- **View results through output variables.**

Types of Variables

- **PL/SQL variables:**
 - Scalar
 - Composite
 - Reference
 - LOB (large objects)
- **Non-PL/SQL variables: Bind and host variables**

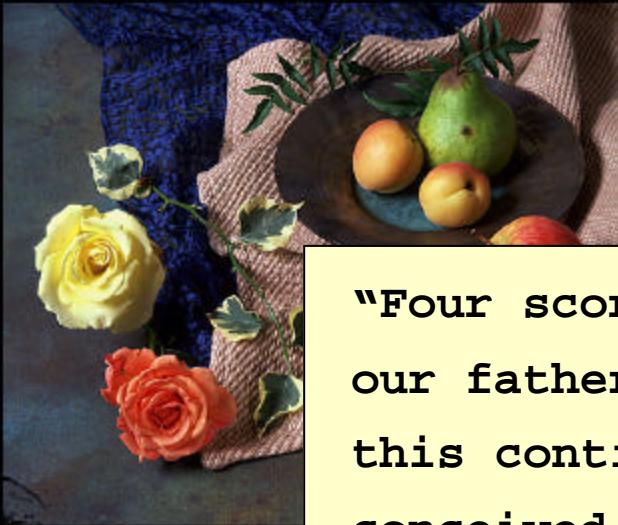
Using *i*SQL*Plus Variables Within PL/SQL Blocks

- PL/SQL does not have input or output capability of its own.
- You can reference substitution variables within a PL/SQL block with a preceding ampersand.
- *i*SQL*Plus host (or “bind”) variables can be used to pass run time values out of the PL/SQL block back to the *i*SQL*Plus environment.

Types of Variables

25-JAN-01

TRUE



"Four score and seven years ago
our fathers brought forth upon
this continent, a new nation,
conceived in LIBERTY, and dedicated
to the proposition that all men
are created equal."

256120.08



Atlanta

Declaring PL/SQL Variables

Syntax:

```
identifier [CONSTANT] datatype [NOT NULL]  
[ := | DEFAULT expr] ;
```

Examples:

```
DECLARE  
    v_hiredate      DATE;  
    v_deptno        NUMBER(2) NOT NULL := 10;  
    v_location       VARCHAR2(13) := 'Atlanta';  
    c_comm           CONSTANT NUMBER := 1400;
```

Guidelines for Declaring PL/SQL Variables

- Follow naming conventions.
- Initialize variables designated as NOT NULL and CONSTANT.
- Declare one identifier per line.
- Initialize identifiers by using the assignment operator (:=) or the DEFAULT reserved word.

```
identifier := expr;
```

Naming Rules

- Two variables can have the same name, provided they are in different blocks.
- The variable name (identifier) should not be the same as the name of table columns used in the block.

```
DECLARE
    employee_id  NUMBER(6);
BEGIN
    SELECT      employee_id
    INTO        employee_id
    FROM        employees
    WHERE       last_name = 'Kochhar';
END;
/
```

Adopt a naming convention for PL/SQL identifiers:
for example,
v_employee_id

Variable Initialization and Keywords

- Assignment operator (`:=`)
- DEFAULT keyword
- NOT NULL constraint

Syntax:

```
identifier := expr;
```

Examples:

```
v_hiredate := '01-JAN-2001';
```

```
v_ename := 'Maduro';
```

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Scalar Data Types

- Hold a single value
- Have no internal components

25-OCT-99

256120.08

"Four score and seven years ago our fathers brought forth upon this continent, a new nation, conceived in LIBERTY, and dedicated to the proposition that all men are created equal.

TRUE

Atlanta

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Base Scalar Data Types

- **CHAR [(*maximum_length*)]**
- **VARCHAR2 (*maximum_length*)**
- **LONG**
- **LONG RAW**
- **NUMBER [(*precision, scale*)]**
- **BINARY_INTEGER**
- **PLS_INTEGER**
- **BOOLEAN**

Base Scalar Data Types

- DATE
- TIMESTAMP
- TIMESTAMP WITH TIME ZONE
- TIMESTAMP WITH LOCAL TIME ZONE
- INTERVAL YEAR TO MONTH
- INTERVAL DAY TO SECOND

Scalar Variable Declarations

Examples:

```
DECLARE
    v_job          VARCHAR2(9);
    v_count        BINARY_INTEGER := 0;
    v_total_sal   NUMBER(9,2) := 0;
    v_orderdate   DATE := SYSDATE + 7;
    c_tax_rate    CONSTANT NUMBER(3,2) := 8.25;
    v_valid        BOOLEAN NOT NULL := TRUE;
    ...

```

The %TYPE Attribute

- **Declare a variable according to:**
 - A database column definition
 - Another previously declared variable
- **Prefix %TYPE with:**
 - The database table and column
 - The previously declared variable name

Declaring Variables with the %TYPE Attribute

Syntax:

```
identifier      Table.column_name%TYPE;
```

Examples:

```
...
  v_name          employees.last_name%TYPE;
  v_balance       NUMBER(7,2);
  v_min_balance   v_balance%TYPE := 10;
...

```

Declaring Boolean Variables

- Only the values TRUE, FALSE, and NULL can be assigned to a Boolean variable.
- The variables are compared by the logical operators AND, OR, and NOT.
- The variables always yield TRUE, FALSE, or NULL.
- Arithmetic, character, and date expressions can be used to return a Boolean value.

Composite Data Types

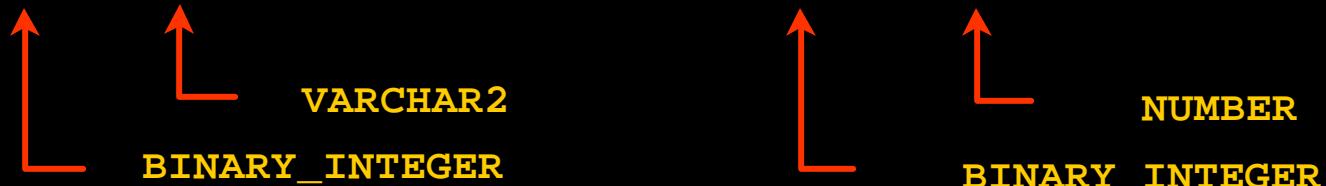
TRUE	23-DEC-98	ATLANTA	
------	-----------	---------	---

PL/SQL table structure

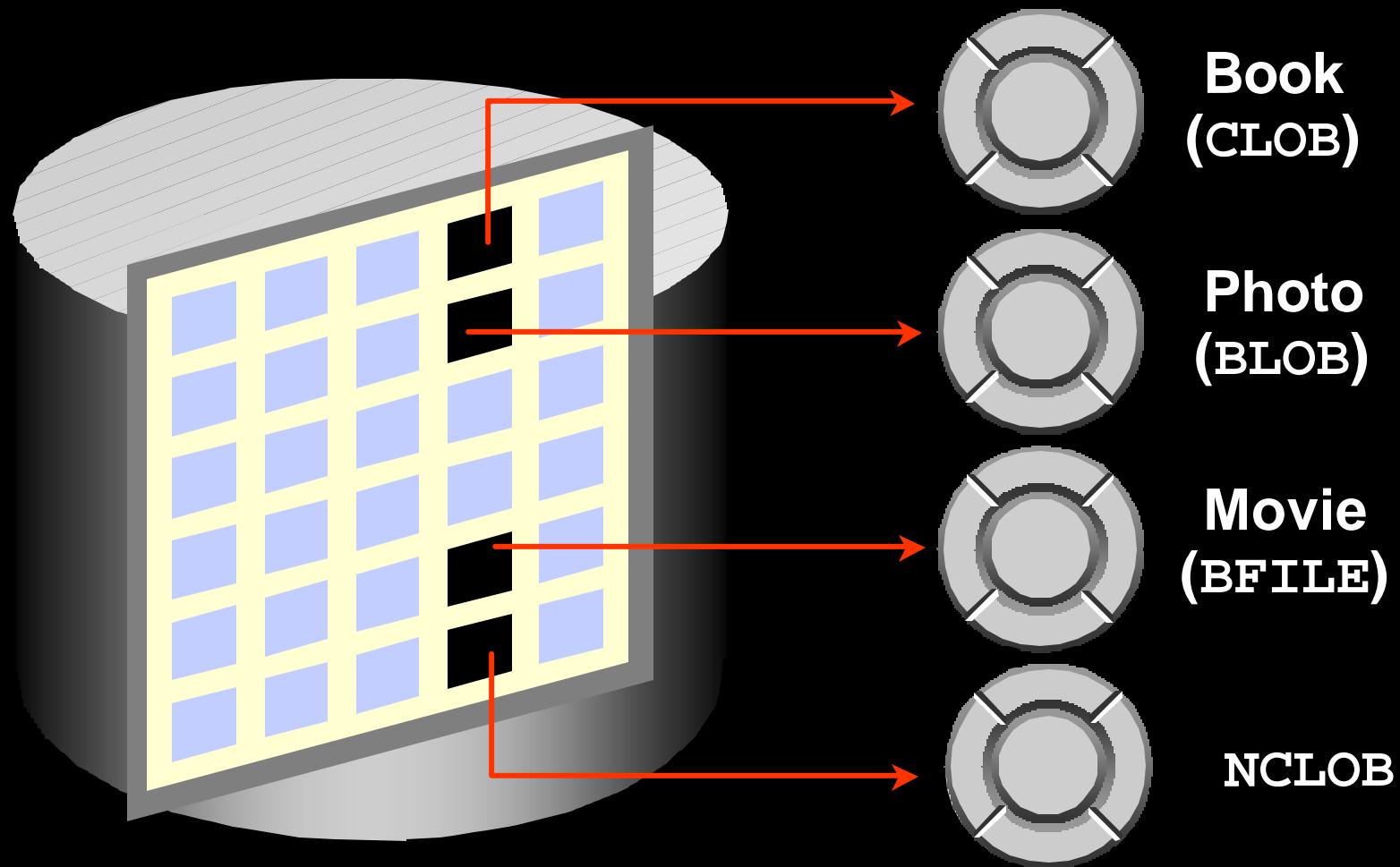
1	SMITH
2	JONES
3	NANCY
4	TIM

PL/SQL table structure

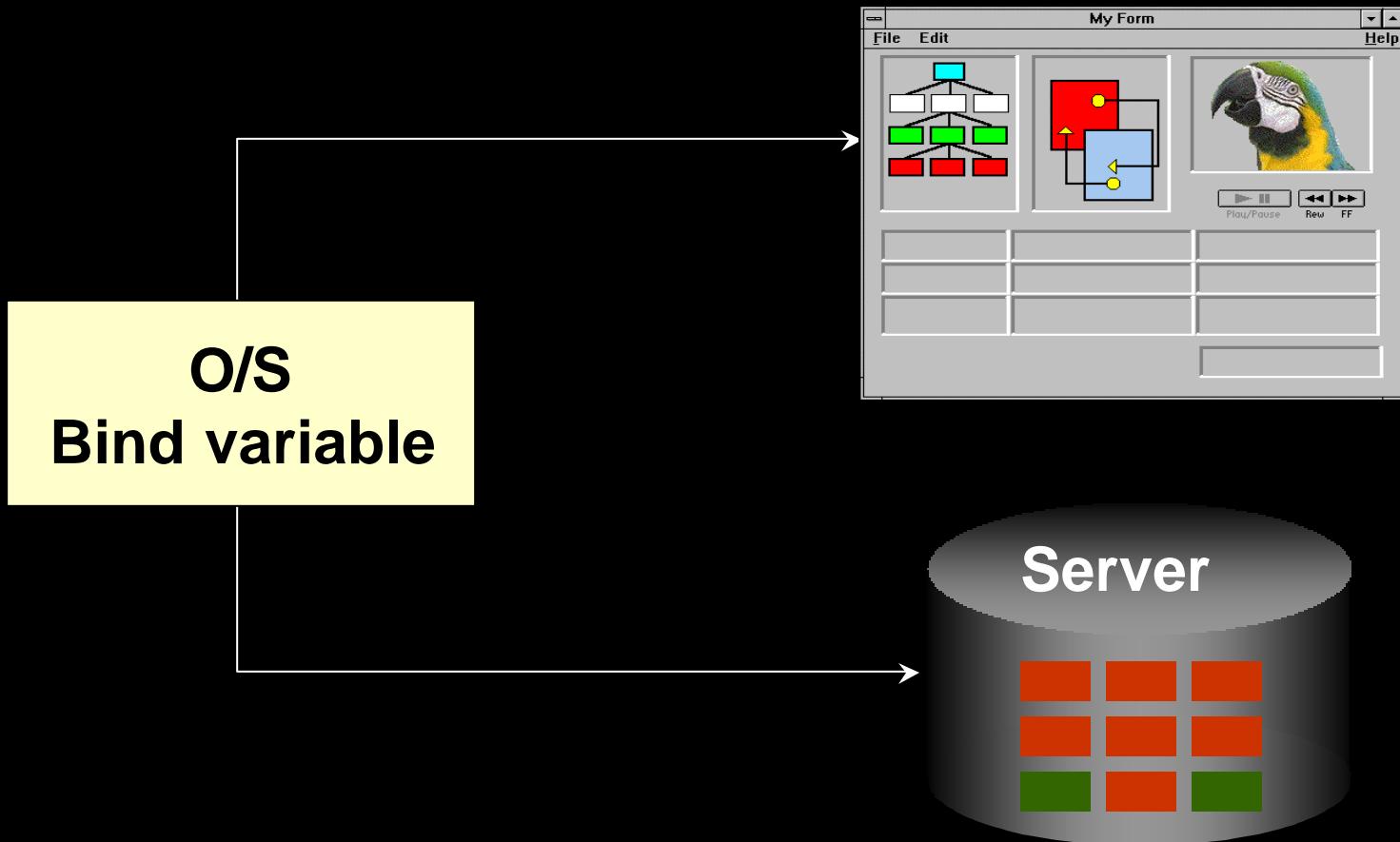
1	5000
2	2345
3	12
4	3456



LOB Data Type Variables



Bind Variables



Using Bind Variables

To reference a bind variable in PL/SQL, you must prefix its name with a colon (:).

Example:

```
VARIABLE      g_salary NUMBER
BEGIN
    SELECT      salary
    INTO        :g_salary
    FROM        employees
    WHERE       employee_id = 178;
END;
/
PRINT g_salary
```

Referencing Non-PL/SQL Variables

Store the annual salary into a *i*SQL*Plus host variable.

```
:g_monthly_sal := v_sal / 12;
```

- **Reference non-PL/SQL variables as host variables.**
- **Prefix the references with a colon (:).**

DBMS_OUTPUT.PUT_LINE

- An Oracle-supplied packaged procedure
- An alternative for displaying data from a PL/SQL block
- Must be enabled in iSQL*Plus with
SET SERVEROUTPUT ON

```
SET SERVEROUTPUT ON
DEFINE p_annual_sal = 60000
```

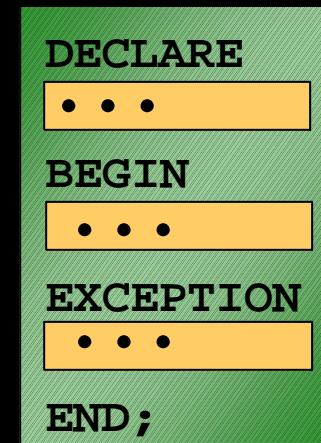
```
DECLARE
    v_sal NUMBER(9,2) := &p_annual_sal;
BEGIN
    v_sal := v_sal/12;
    DBMS_OUTPUT.PUT_LINE ('The monthly salary is ' ||
                          TO_CHAR(v_sal));
END;
/
```



Summary

In this lesson you should have learned that:

- PL/SQL blocks are composed of the following sections:
 - Declarative (optional)
 - Executable (required)
 - Exception handling (optional)
- A PL/SQL block can be an anonymous block, procedure, or function.



Summary

In this lesson you should have learned that:

- **PL/SQL identifiers:**
 - Are defined in the declarative section
 - Can be of scalar, composite, reference, or LOB data type
 - Can be based on the structure of another variable or database object
 - Can be initialized
- **Variables declared in an external environment such as iSQL*Plus are called host variables.**
- **Use DBMS_OUTPUT.PUT_LINE to display data from a PL/SQL block.**

Practice 1 Overview

This practice covers the following topics:

- Determining validity of declarations
- Declaring a simple PL/SQL block
- Executing a simple PL/SQL block

Writing Executable Statements

2

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Objectives

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

- **Describe the significance of the executable section**
- **Use identifiers correctly**
- **Write statements in the executable section**
- **Describe the rules of nested blocks**
- **Execute and test a PL/SQL block**
- **Use coding conventions**

PL/SQL Block Syntax and Guidelines

- **Statements can continue over several lines.**
- **Lexical units can be classified as:**
 - Delimiters
 - Identifiers
 - Literals
 - Comments

Identifiers

- Can contain up to 30 characters
- Must begin with an alphabetic character
- Can contain numerals, dollar signs, underscores, and number signs
- Cannot contain characters such as hyphens, slashes, and spaces
- Should not have the same name as a database table column name
- Should not be reserved words

PL/SQL Block Syntax and Guidelines

- **Literals**
 - Character and date literals must be enclosed in single quotation marks.

```
v_name := 'Henderson' ;
```
 - Numbers can be simple values or scientific notation.
- A slash (/) runs the PL/SQL block in a script file or in some tools such as *iSQL*PLUS*.

Commenting Code

- Prefix single-line comments with two dashes (--) .
- Place multiple-line comments between the symbols /* and */ .

Example:

```
DECLARE
  ...
  v_sal NUMBER (9,2);
BEGIN
  /* Compute the annual salary based on the
     monthly salary input from the user */
  v_sal := :g_monthly_sal * 12;
END;      -- This is the end of the block
```

SQL Functions in PL/SQL

- Available in procedural statements:
 - Single-row number
 - Single-row character
 - Data type conversion
 - Date
 - Timestamp
 - GREATEST and LEAST
 - Miscellaneous functions
 - Not available in procedural statements:
 - DECODE
 - Group functions
- 
- Same as in SQL

SQL Functions in PL/SQL: Examples

- Build the mailing list for a company.

```
v_mailing_address := v_name || CHR(10) ||  
                     v_address || CHR(10) || v_state ||  
                     CHR(10) || v_zip;
```

- Convert the employee name to lowercase.

```
v_ename      := LOWER(v_ename);
```

Data Type Conversion

- Convert data to comparable data types.
- Mixed data types can result in an error and affect performance.
- Conversion functions:
 - TO_CHAR
 - TO_DATE
 - TO_NUMBER

```
DECLARE
  v_date DATE := TO_DATE('12-JAN-2001', 'DD-MON-YYYY');
BEGIN
  . . .
```

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Data Type Conversion

This statement produces a compilation error if the variable v_date is declared as a DATE data type.

```
v_date := 'January 13, 2001';
```

Data Type Conversion

To correct the error, use the TO_DATE conversion function.

```
v_date := TO_DATE ('January 13, 2001',  
                     'Month DD, YYYY');
```

Nested Blocks and Variable Scope

- PL/SQL blocks can be nested wherever an executable statement is allowed.
- A nested block becomes a statement.
- An exception section can contain nested blocks.
- The scope of an identifier is that region of a program unit (block, subprogram, or package) from which you can reference the identifier.

Nested Blocks and Variable Scope

Example:

```
...
  x  BINARY_INTEGER;
BEGIN
  ...
DECLARE
  y  NUMBER;
BEGIN
  y := x;
END;
  ...
END;
```

Scope of x

Scope of y

Identifier Scope

An identifier is visible in the regions where you can reference the identifier without having to qualify it:

- A block can look up to the enclosing block.
- A block cannot look down to enclosed blocks.

Qualify an Identifier

- The qualifier can be the label of an enclosing block.
- Qualify an identifier by using the block label prefix.

```
<<outer>>
  DECLARE
    birthdate DATE;
  BEGIN
    DECLARE
      birthdate DATE;
    BEGIN
      ...
      outer.birthdate :=
        TO_DATE('03-AUG-1976',
        'DD-MON-YYYY');
    END;
    ...
  END;
```



Determining Variable Scope

Class Exercise

```
<<outer>>

DECLARE
    v_sal      NUMBER(7,2) := 60000;
    v_comm     NUMBER(7,2) := v_sal * 0.20;
    v_message  VARCHAR2(255) := ' eligible for commission';

BEGIN
    DECLARE
        v_sal      NUMBER(7,2) := 50000;
        v_comm     NUMBER(7,2) := 0;
        v_total_comp NUMBER(7,2) := v_sal + v_comm;
    BEGIN
        v_message := 'CLERK not' || v_message;
        outer.v_comm := v_sal * 0.30;
    END;
    v_message := ' SALESMAN' || v_message;
END;
```

The diagram illustrates the scope of variables in the PL/SQL code. A red arrow labeled '1' points from the assignment statement `outer.v_comm := v_sal * 0.30;` to the declaration of `v_comm` inside the inner `DECLARE` block, indicating that the assignment is visible within the inner block. A second red arrow labeled '2' points from the assignment statement `v_message := ' SALESMAN' || v_message;` to the declaration of `v_message` outside the inner block, indicating that the assignment is visible outside the inner block.

Operators in PL/SQL

- Logical
 - Arithmetic
 - Concatenation
 - Parentheses to control order of operations
 - Exponential operator (**)
- 
- Same as in SQL

Operators in PL/SQL

Examples:

- Increment the counter for a loop.

```
v_count      := v_count + 1;
```

- Set the value of a Boolean flag.

```
v_equal      := (v_n1 = v_n2);
```

- Validate whether an employee number contains a value.

```
v_valid      := (v_empno IS NOT NULL);
```

Programming Guidelines

Make code maintenance easier by:

- **Documenting code with comments**
- **Developing a case convention for the code**
- **Developing naming conventions for identifiers and other objects**
- **Enhancing readability by indenting**

Indenting Code

For clarity, indent each level of code.

Example:

```
BEGIN
    IF x=0 THEN
        y:=1;
    END IF;
END;
```

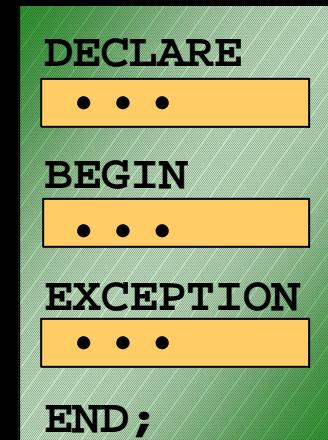
```
DECLARE
    v_deptno          NUMBER(4);
    v_location_id    NUMBER(4);
BEGIN
    SELECT department_id,
           location_id
      INTO v_deptno,
            v_location_id
     FROM departments
    WHERE department_name
          = 'Sales';

    ...
END;
/
```

Summary

In this lesson you should have learned that:

- PL/SQL block syntax and guidelines
- How to use identifiers correctly
- PL/SQL block structure: nesting blocks and scoping rules
- PL/SQL programming:
 - Functions
 - Data type conversions
 - Operators
 - Conventions and guidelines



Practice 2 Overview

This practice covers the following topics:

- **Reviewing scoping and nesting rules**
- **Developing and testing PL/SQL blocks**

3

Interacting with the Oracle Server

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Objectives

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

- Write a successful SELECT statement in PL/SQL
- Write DML statements in PL/SQL
- Control transactions in PL/SQL
- Determine the outcome of SQL data manipulation language (DML) statements

SQL Statements in PL/SQL

- Extract a row of data from the database by using the **SELECT command**.
- Make changes to rows in the database by using **DML commands**.
- Control a transaction with the **COMMIT, ROLLBACK, or SAVEPOINT command**.
- Determine DML outcome with **implicit cursor attributes**.

SELECT Statements in PL/SQL

Retrieve data from the database with a SELECT statement.

Syntax:

```
SELECT  select_list
INTO    {variable_name[, variable_name]...
        | record_name}
FROM    table
[WHERE  condition];
```

SELECT Statements in PL/SQL

- The **INTO clause is required.**
- **Queries must return one and only one row.**

Example:

```
DECLARE
    v_deptno          NUMBER(4);
    v_location_id    NUMBER(4);
BEGIN
    SELECT      department_id, location_id
    INTO        v_deptno, v_location_id
    FROM       departments
    WHERE      department_name = 'Sales';
    ...
END;
/
```

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Retrieving Data in PL/SQL

Retrieve the hire date and the salary for the specified employee.

Example:

```
DECLARE
    v_hire_date    employees.hire_date%TYPE;
    v_salary        employees.salary%TYPE;
BEGIN
    SELECT    hire_date, salary
    INTO      v_hire_date, v_salary
    FROM      employees
    WHERE     employee_id = 100;
    . . .
END;
/
```



Retrieving Data in PL/SQL

Return the sum of the salaries for all employees in the specified department.

Example:

```
SET SERVEROUTPUT ON
DECLARE
    v_sum_sal      NUMBER(10,2);
    v_deptno       NUMBER NOT NULL := 60;
BEGIN
    SELECT      SUM(salary)  -- group function
    INTO        v_sum_sal
    FROM        employees
    WHERE       department_id = v_deptno;
    DBMS_OUTPUT.PUT_LINE ('The sum salary is ' ||
                           TO_CHAR(v_sum_sal));
END;
/
```

Naming Conventions

```
DECLARE
    hire_date      employees.hire_date%TYPE;
    sysdate        hire_date%TYPE;
    employee_id   employees.employee_id%TYPE := 176;
BEGIN
    SELECT      hire_date, sysdate
    INTO        hire_date, sysdate
    FROM        employees
    WHERE       employee_id = employee_id;
END;
/
```

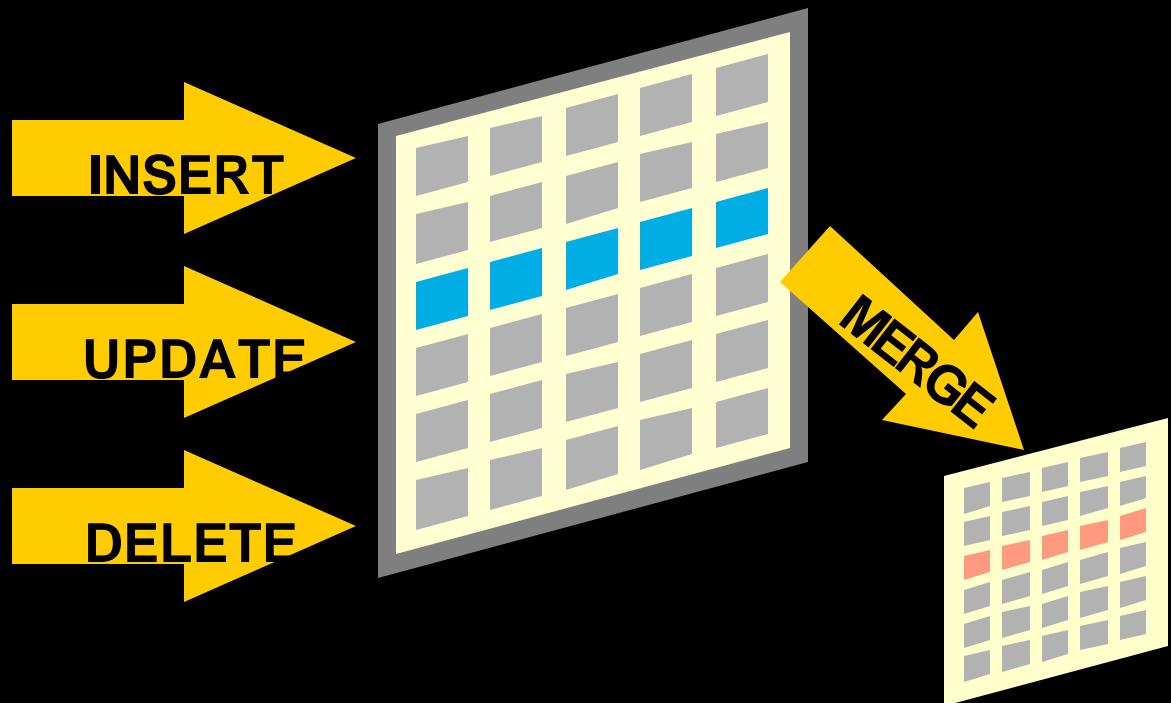
```
DECLARE
*
ERROR at line 1:
ORA-01422: exact fetch returns more than requested number of rows
ORA-06512: at line 6
```

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Manipulating Data Using PL/SQL

Make changes to database tables by using DML commands:

- INSERT
- UPDATE
- DELETE
- MERGE



Inserting Data

Add new employee information to the EMPLOYEES table.

Example:

```
BEGIN
    INSERT INTO employees
    (employee_id, first_name, last_name, email,
     hire_date, job_id, salary)
    VALUES
    (employees_seq.NEXTVAL, 'Ruth', 'Cores', 'RCORES',
     sysdate, 'AD_ASST', 4000);
END;
/
```

Updating Data

Increase the salary of all employees who are stock clerks.

Example:

```
DECLARE
    v_sal_increase    employees.salary%TYPE := 800;
BEGIN
    UPDATE      employees
    SET          salary = salary + v_sal_increas
    WHERE        job_id = 'ST_CLERK';
END;
/
```

Deleting Data

Delete rows that belong to department 10 from the EMPLOYEES table.

Example:

```
DECLARE
    v_deptno    employees.department_id%TYPE := 10;
BEGIN
    DELETE FROM    employees
    WHERE          department_id = v_deptno;
END;
/
```

Merging Rows

Insert or update rows in the COPY_EMP table to match the EMPLOYEES table.

```
DECLARE
    v_empno employees.employee_id%TYPE := 100;
BEGIN
MERGE INTO copy_emp c
    USING employees e
    ON (e.employee_id = v_empno)
WHEN MATCHED THEN
    UPDATE SET
        c.first_name      = e.first_name,
        c.last_name       = e.last_name,
        c.email           = e.email,
        . . .
WHEN NOT MATCHED THEN
    INSERT VALUES(e.employee_id, e.first_name, e.last_name,
        . . .,e.department_id);
END;
```

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Naming Conventions

- **Use a naming convention to avoid ambiguity in the WHERE clause.**
- **Database columns and identifiers should have distinct names.**
- **Syntax errors can arise because PL/SQL checks the database first for a column in the table.**
- **The names of local variables and formal parameters take precedence over the names of database tables.**
- **The names of database table columns take precedence over the names of local variables.**

SQL Cursor

- A cursor is a private SQL work area.
- There are two types of cursors:
 - Implicit cursors
 - Explicit cursors
- The Oracle server uses implicit cursors to parse and execute your SQL statements.
- Explicit cursors are explicitly declared by the programmer.

SQL Cursor Attributes

Using SQL cursor attributes, you can test the outcome of your SQL statements.

SQL%ROWCOUNT	Number of rows affected by the most recent SQL statement (an integer value)
SQL%FOUND	Boolean attribute that evaluates to TRUE if the most recent SQL statement affects one or more rows
SQL%NOTFOUND	Boolean attribute that evaluates to TRUE if the most recent SQL statement does not affect any rows
SQL%ISOPEN	Always evaluates to FALSE because PL/SQL closes implicit cursors immediately after they are executed

SQL Cursor Attributes

Delete rows that have the specified employee ID from the EMPLOYEES table. Print the number of rows deleted.

Example:

```
VARIABLE rows_deleted VARCHAR2( 30 )
DECLARE
    v_employee_id employees.employee_id%TYPE := 176;
BEGIN
    DELETE FROM employees
    WHERE employee_id = v_employee_id;
    :rows_deleted := (SQL%ROWCOUNT ||
                      ' row deleted.');
END;
/
PRINT rows_deleted
```

Transaction Control Statements

- **Initiate a transaction with the first DML command to follow a COMMIT or ROLLBACK.**
- **Use COMMIT and ROLLBACK SQL statements to terminate a transaction explicitly.**

Summary

In this lesson you should have learned how to:

- **Embed SQL in the PL/SQL block using SELECT, INSERT, UPDATE, DELETE, and MERGE**
- **Embed transaction control statements in a PL/SQL block COMMIT, ROLLBACK, and SAVEPOINT**

Summary

In this lesson you should have learned that:

- **There are two cursor types: implicit and explicit.**
- **Implicit cursor attributes are used to verify the outcome of DML statements:**
 - SQL%ROWCOUNT
 - SQL%FOUND
 - SQL%NOTFOUND
 - SQL%ISOPEN
- **Explicit cursors are defined by the programmer.**

Practice 3 Overview

This practice covers creating a PL/SQL block to:

- **Select data from a table**
- **Insert data into a table**
- **Update data in a table**
- **Delete a record from a table**

Writing Control Structures

4

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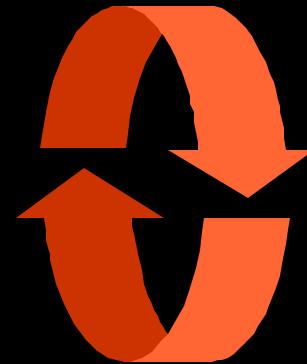
Objectives

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

- **Identify the uses and types of control structures**
- **Construct an IF statement**
- **Use CASE expressions**
- **Construct and identify different loop statements**
- **Use logic tables**
- **Control block flow using nested loops and labels**

Controlling PL/SQL Flow of Execution

- You can change the logical execution of statements using conditional IF statements and loop control structures.
- Conditional IF statements:
 - IF-THEN-END IF
 - IF-THEN-ELSE-END IF
 - IF-THEN-ELSIF-END IF



IF Statements

Syntax:

```
IF condition THEN  
    statements;  
[ELSIF condition THEN  
    statements;]  
[ELSE  
    statements;]  
END IF;
```

If the employee name is Gietz, set the Manager ID to 102.

```
IF UPPER(v_last_name) = 'GIETZ' THEN  
    v_mgr := 102;  
END IF;
```

Simple IF Statements

If the last name is Vargas:

- Set job ID to SA_REP
- Set department number to 80

```
• • •  
IF v_ename      = 'Vargas' THEN  
    v_job        := 'SA_REP';  
    v_deptno     := 80;  
END IF;  
• • •
```

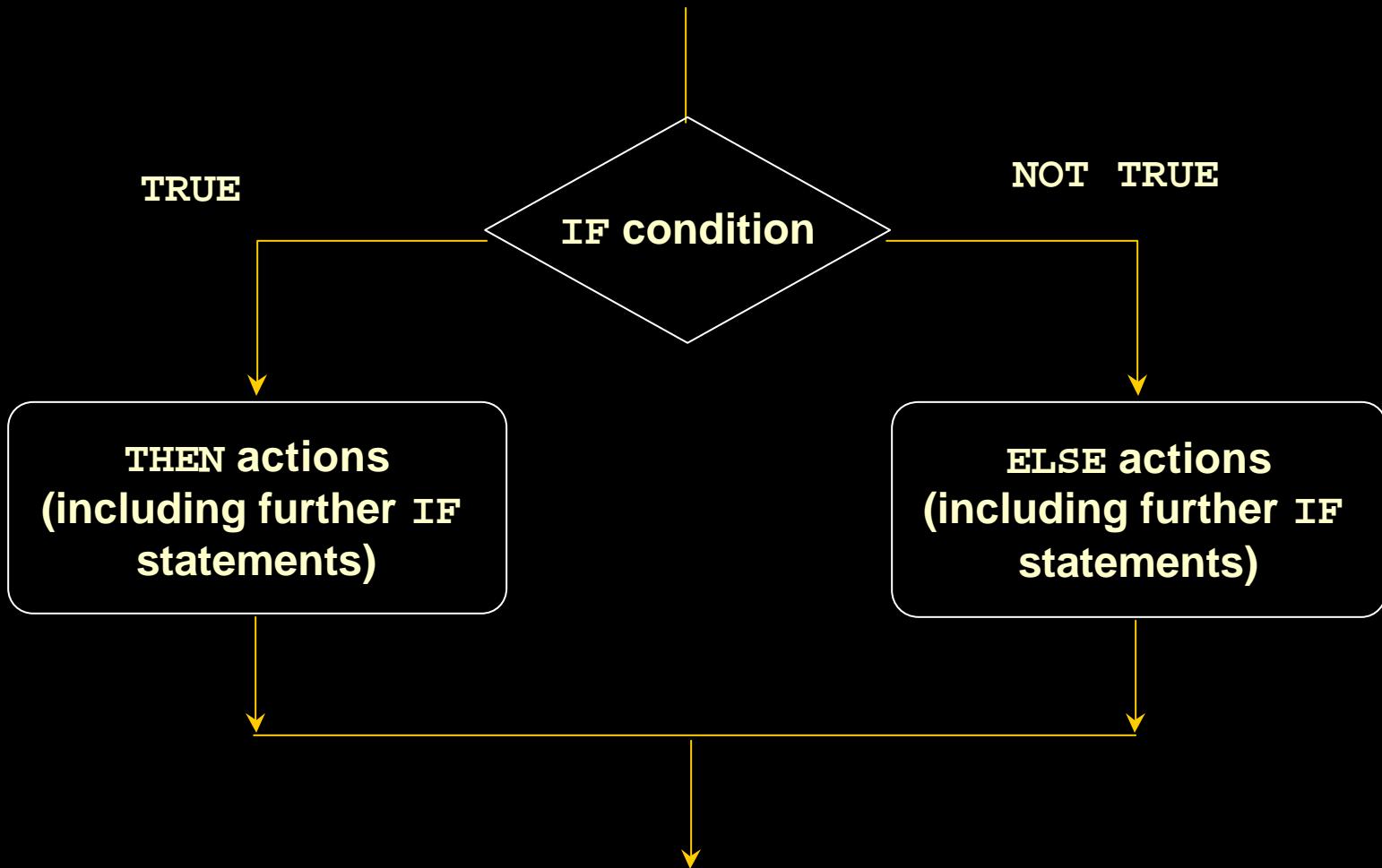
Compound IF Statements

If the last name is Vargas and the salary is more than 6500:

Set department number to 60.

```
• • •  
IF v_ename = 'Vargas' AND salary > 6500 THEN  
    v_deptno := 60;  
END IF;  
• • •
```

IF-THEN-ELSE Statement Execution Flow



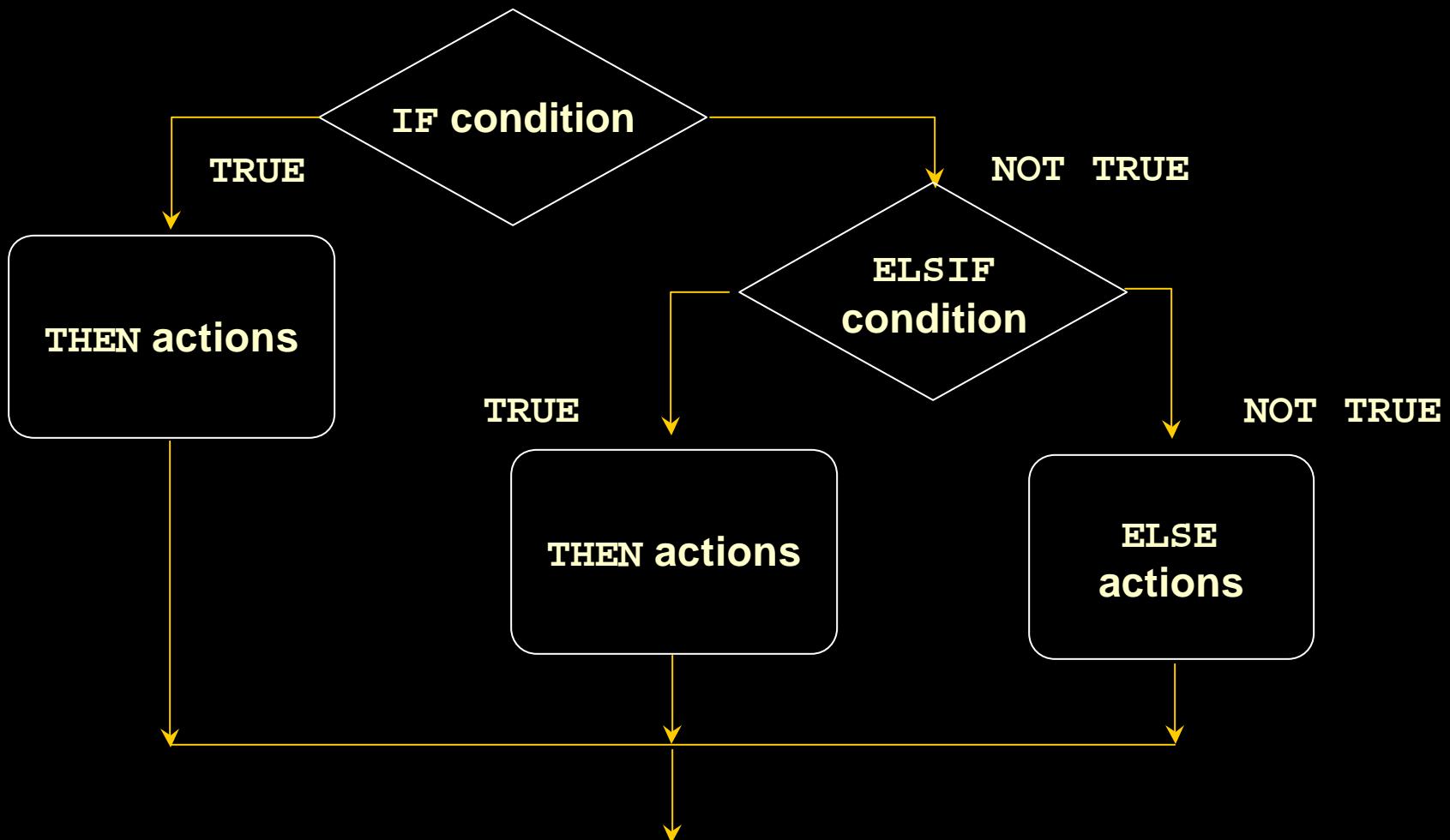
IF-THEN-ELSE Statements

Set a Boolean flag to TRUE if the hire date is greater than five years; otherwise, set the Boolean flag to FALSE.

```
DECLARE
    v_hire_date    DATE := '12-Dec-1990';
    v_five_years   BOOLEAN;
BEGIN
    . . .
    IF MONTHS_BETWEEN(SYSDATE,v_hire_date)/12 > 5 THEN
        v_five_years := TRUE;
    ELSE
        v_five_years := FALSE;
    END IF;
    . . .
```

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IF-THEN-ELSIF Statement Execution Flow



IF-THEN-ELSIF Statements

For a given value, calculate a percentage of that value based on a condition.

Example:

```
• • •  
IF      v_start > 100 THEN  
        v_start := 0.2 * v_start;  
ELSIF  v_start >= 50 THEN  
        v_start := 0.5 * v_start;  
ELSE  
        v_start := 0.1 * v_start;  
END IF;  
• • •
```

CASE Expressions

- A CASE expression selects a result and returns it.
- To select the result, the CASE expression uses an expression whose value is used to select one of several alternatives.

```
CASE selector
    WHEN expression1 THEN result1
    WHEN expression2 THEN result2
    ...
    WHEN expressionN THEN resultN
    [ELSE resultN+1;]
END;
```

CASE Expressions: Example

```
SET SERVEROUTPUT ON
DECLARE
    v_grade CHAR(1) := UPPER('&p_grade');
    v_appraisal VARCHAR2(20);
BEGIN
    v_appraisal :=
        CASE v_grade
            WHEN 'A' THEN 'Excellent'
            WHEN 'B' THEN 'Very Good'
            WHEN 'C' THEN 'Good'
            ELSE 'No such grade'
        END;
    DBMS_OUTPUT.PUT_LINE ('Grade: '|| v_grade || ' '
                           Appraisal ' || v_appraisal);
END;
/
```



Handling Nulls

When working with nulls, you can avoid some common mistakes by keeping in mind the following rules:

- **Simple comparisons involving nulls always yield NULL.**
- **Applying the logical operator NOT to a null yields NULL.**
- **In conditional control statements, if the condition yields NULL, its associated sequence of statements is not executed.**

Logic Tables

Build a simple Boolean condition with a comparison operator.

AND	TRUE	FALSE	NULL	OR	TRUE	FALSE	NULL	NOT	
TRUE	TRUE	FALSE	NULL	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	NULL	FALSE	TRUE
NULL	NULL	FALSE	NULL	NULL	TRUE	NULL	NULL	NULL	NULL

Boolean Conditions

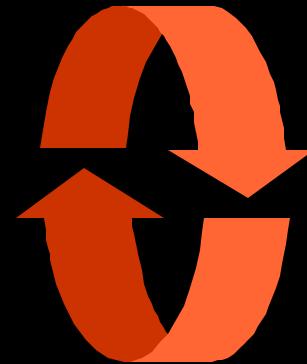
What is the value of v_flag in each case?

```
v_flag := v_reorder_flag AND v_available_flag;
```

V_REORDER_FLAG	V_AVAILABLE_FLAG	V_FLAG
TRUE	TRUE	?
TRUE	FALSE	?
NULL	TRUE	?
NULL	FALSE	?

Iterative Control: LOOP Statements

- Loops repeat a statement or sequence of statements multiple times.
- There are three loop types:
 - Basic loop
 - FOR loop
 - WHILE loop



Basic Loops

Syntax:

```
LOOP                                -- delimiter  
  statement1;  
  . . .  
  EXIT [WHEN condition];          -- EXIT statement  
END LOOP;                            -- delimiter
```

condition is a Boolean variable or expression (TRUE, FALSE, or NULL);

Basic Loops

Example:

```
DECLARE
    v_country_id      locations.country_id%TYPE := 'CA';
    v_location_id     locations.location_id%TYPE;
    v_counter         NUMBER(2) := 1;
    v_city            locations.city%TYPE := 'Montreal';
BEGIN
    SELECT MAX(location_id) INTO v_location_id FROM locations
    WHERE country_id = v_country_id;
    LOOP
        INSERT INTO locations(location_id, city, country_id)
        VALUES((v_location_id + v_counter),v_city, v_country_id);
        v_counter := v_counter + 1;
        EXIT WHEN v_counter > 3;
    END LOOP;
END;
/
```

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WHILE Loops

Syntax:

```
WHILE condition LOOP ←  
  statement1;  
  statement2;  
  . . .  
END LOOP;
```

Condition is evaluated at the beginning of each iteration.

Use the WHILE loop to repeat statements while a condition is TRUE.

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WHILE Loops

Example:

```
DECLARE
    v_country_id      locations.country_id%TYPE := 'CA';
    v_location_id     locations.location_id%TYPE;
    v_city             locations.city%TYPE := 'Montreal';
    v_counter          NUMBER    := 1;

BEGIN
    SELECT MAX(location_id) INTO v_location_id FROM locations
    WHERE country_id = v_country_id;
    WHILE v_counter <= 3 LOOP
        INSERT INTO locations(location_id, city, country_id)
        VALUES((v_location_id + v_counter), v_city, v_country_id);
        v_counter := v_counter + 1;
    END LOOP;
END;
/
```

FOR Loops

Syntax:

```
FOR counter IN [REVERSE]
    lower_bound..upper_bound LOOP
        statement1;
        statement2;
        . . .
    END LOOP;
```

- Use a **FOR loop** to shortcut the test for the number of iterations.
- Do not declare the counter; it is declared implicitly.
- '**lower_bound .. upper_bound**' is required syntax.

FOR Loops

Insert three new locations IDs for the country code of CA and the city of Montreal.

```
DECLARE
    v_country_id      locations.country_id%TYPE := 'CA';
    v_location_id     locations.location_id%TYPE;
    v_city            locations.city%TYPE := 'Montreal';
BEGIN
    SELECT MAX(location_id) INTO v_location_id
        FROM locations
        WHERE country_id = v_country_id;
    FOR i IN 1..3 LOOP
        INSERT INTO locations(location_id, city, country_id)
        VALUES((v_location_id + i), v_city, v_country_id );
    END LOOP;
END;
/
```



FOR Loops

Guidelines

- Reference the counter within the loop only; it is undefined outside the loop.
- Do *not* reference the counter as the target of an assignment.

Guidelines While Using Loops

- Use the **basic loop** when the statements inside the loop must execute at least once.
- Use the **WHILE loop** if the condition has to be evaluated at the start of each iteration.
- Use a **FOR loop** if the number of iterations is known.

Nested Loops and Labels

- Nest loops to multiple levels.
- Use labels to distinguish between blocks and loops.
- Exit the outer loop with the EXIT statement that references the label.

Nested Loops and Labels

```
...
BEGIN
  <<Outer_loop>>
  LOOP
    v_counter := v_counter+1;
  EXIT WHEN v_counter>10;
  <<Inner_loop>>
  LOOP
    ...
    EXIT Outer_loop WHEN total_done = 'YES';
    -- Leave both loops
    EXIT WHEN inner_done = 'YES';
    -- Leave inner loop only
    ...
  END LOOP Inner_loop;
  ...
END LOOP Outer_loop;
END;
```

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Summary

In this lesson you should have learned to:

Change the logical flow of statements by using control structures.

- **Conditional (IF statement)**
- **CASE Expressions**
- **Loops:**
 - **Basic loop**
 - **FOR loop**
 - **WHILE loop**
- **EXIT statements**

Practice 4 Overview

This practice covers the following topics:

- **Performing conditional actions using the IF statement**
- **Performing iterative steps using the loop structure**

Working with Composite Data Types

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Objectives

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

- **Create user-defined PL/SQL records**
- **Create a record with the %ROWTYPE attribute**
- **Create an INDEX BY table**
- **Create an INDEX BY table of records**
- **Describe the difference between records, tables, and tables of records**

Composite Data Types

- **Are of two types:**
 - **PL/SQL RECORDS**
 - **PL/SQL Collections**
 - **INDEX BY Table**
 - **Nested Table**
 - **VARRAY**
- **Contain internal components**
- **Are reusable**

PL/SQL Records

- Must contain one or more components of any scalar, RECORD, or INDEX BY table data type, called fields
- Are similar in structure to records in a third generation language (3GL)
- Are not the same as rows in a database table
- Treat a collection of fields as a logical unit
- Are convenient for fetching a row of data from a table for processing

Creating a PL/SQL Record

Syntax:

```
TYPE type_name IS RECORD  
    (field_declaration[, field_declaration]...);  
identifier      type_name;
```

Where *field_declaration* is:

```
field_name {field_type | variable%TYPE  
          | table.column%TYPE | table%ROWTYPE}  
        [[NOT NULL] {:= | DEFAULT} expr]
```

Creating a PL/SQL Record

Declare variables to store the name, job, and salary of a new employee.

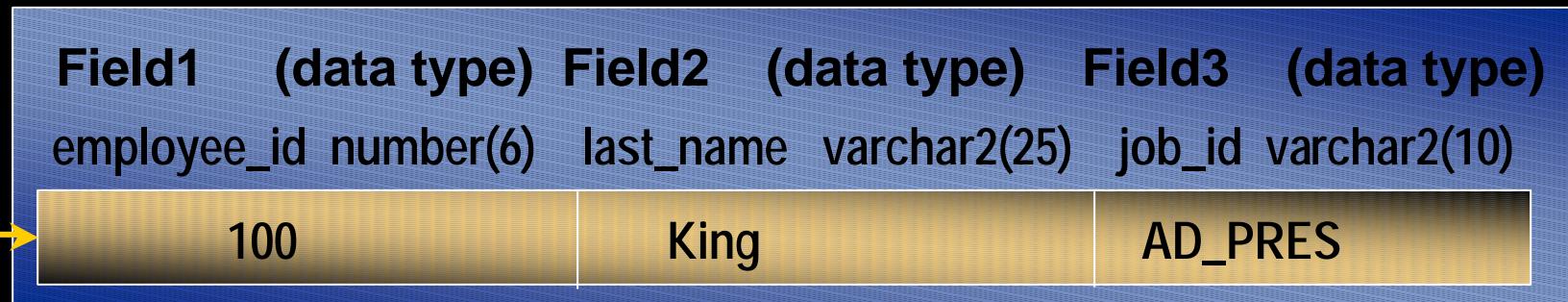
Example:

```
...
TYPE emp_record_type IS RECORD
  (last_name    VARCHAR2(25),
   job_id       VARCHAR2(10),
   salary        NUMBER(8,2));
emp_record      emp_record_type;
...
```

PL/SQL Record Structure



Example:



The %ROWTYPE Attribute

- **Declare a variable according to a collection of columns in a database table or view.**
- **Prefix %ROWTYPE with the database table.**
- **Fields in the record take their names and data types from the columns of the table or view.**

Advantages of Using %ROWTYPE

- The number and data types of the underlying database columns need not be known.
- The number and data types of the underlying database column may change at run time.
- The attribute is useful when retrieving a row with the `SELECT * statement`.

The %ROWTYPE Attribute

Examples:

Declare a variable to store the information about a department from the DEPARTMENTS table.

```
dept_record    departments%ROWTYPE;
```

Declare a variable to store the information about an employee from the EMPLOYEES table.

```
emp_record    employees%ROWTYPE;
```

INDEX BY Tables

- Are composed of two components:
 - Primary key of data type `BINARY_INTEGER`
 - Column of scalar or record data type
- Can increase in size dynamically because they are unconstrained

Creating an INDEX BY Table

Syntax:

```
TYPE type_name IS TABLE OF
  {column_type | variable%TYPE
   | table.column%TYPE} [NOT NULL]
   | table.%ROWTYPE
   [ INDEX BY BINARY_INTEGER];
identifier      type_name;
```

Declare an INDEX BY table to store names.

Example:

```
...
TYPE ename_table_type IS TABLE OF
  employees.last_name%TYPE
  INDEX BY BINARY_INTEGER;
ename_table ename_table_type;
...
```

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INDEX BY Table Structure

Unique identifier

...
1
2
3
...

Column

...
Jones
Smith
Maduro
...

BINARY_INTEGER

Scalar

Creating an INDEX BY Table

```
DECLARE
    TYPE ename_table_type IS TABLE OF
        employees.last_name%TYPE
        INDEX BY BINARY_INTEGER;
    TYPE hiredate_table_type IS TABLE OF DATE
        INDEX BY BINARY_INTEGER;
    ename_table      ename_table_type;
    hiredate_table   hiredate_table_type;

BEGIN
    ename_table(1)      := 'CAMERON';
    hiredate_table(8)   := SYSDATE + 7;
    IF ename_table.EXISTS(1) THEN
        INSERT INTO ...
        ...
END;
/
```



Using INDEX BY Table Methods

The following methods make INDEX BY tables easier to use:

- EXISTS
- COUNT
- FIRST and LAST
- PRIOR
- NEXT
- TRIM
- DELETE

INDEX BY Table of Records

- Define a TABLE variable with a permitted PL/SQL data type.
- Declare a PL/SQL variable to hold department information.

Example:

```
DECLARE
  TYPE dept_table_type IS TABLE OF
    departments%ROWTYPE
    INDEX BY BINARY_INTEGER;
  dept_table dept_table_type;
  -- Each element of dept_table is a record
```

Example of INDEX BY Table of Records

```
SET SERVEROUTPUT ON
DECLARE
    TYPE emp_table_type is table of
        employees%ROWTYPE INDEX BY BINARY_INTEGER;
    my_emp_table  emp_table_type;
    v_count       NUMBER(3):= 104;
BEGIN
    FOR i IN 100..v_count
    LOOP
        SELECT * INTO my_emp_table(i) FROM employees
        WHERE employee_id = i;
    END LOOP;
    FOR i IN my_emp_table.FIRST..my_emp_table.LAST
    LOOP
        DBMS_OUTPUT.PUT_LINE(my_emp_table(i).last_name);
    END LOOP;
END;
```



Summary

In this lesson, you should have learned to:

- **Define and reference PL/SQL variables of composite data types:**
 - **PL/SQL records**
 - **INDEX BY tables**
 - **INDEX BY table of records**
- **Define a PL/SQL record by using the %ROWTYPE attribute**

Practice 5 Overview

This practice covers the following topics:

- Declaring INDEX BY tables
- Processing data by using INDEX BY tables
- Declaring a PL/SQL record
- Processing data by using a PL/SQL record

Writing Explicit Cursors

Objectives

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

- **Distinguish between an implicit and an explicit cursor**
- **Discuss when and why to use an explicit cursor**
- **Use a PL/SQL record variable**
- **Write a cursor FOR loop**

About Cursors

Every SQL statement executed by the Oracle Server has an individual cursor associated with it:

- **Implicit cursors: Declared for all DML and PL/SQL SELECT statements**
- **Explicit cursors: Declared and named by the programmer**

Explicit Cursor Functions

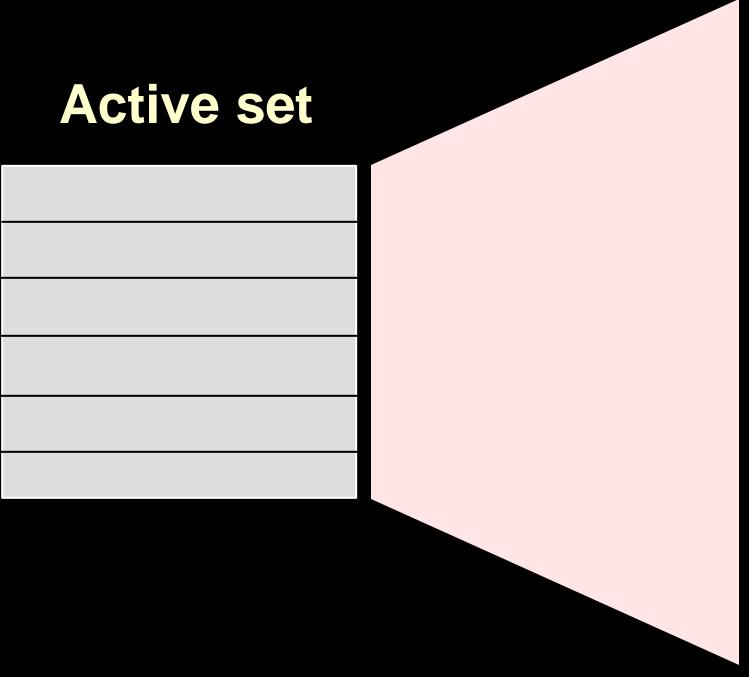
Table

100	King	AD_PRES
101	Kochhar	AD_VP
102	De Haan	AD_VP
.	.	.
.	.	.
.	.	.
139	Seo	ST_CLERK
140	Patel	ST_CLERK
.	.	.

Cursor

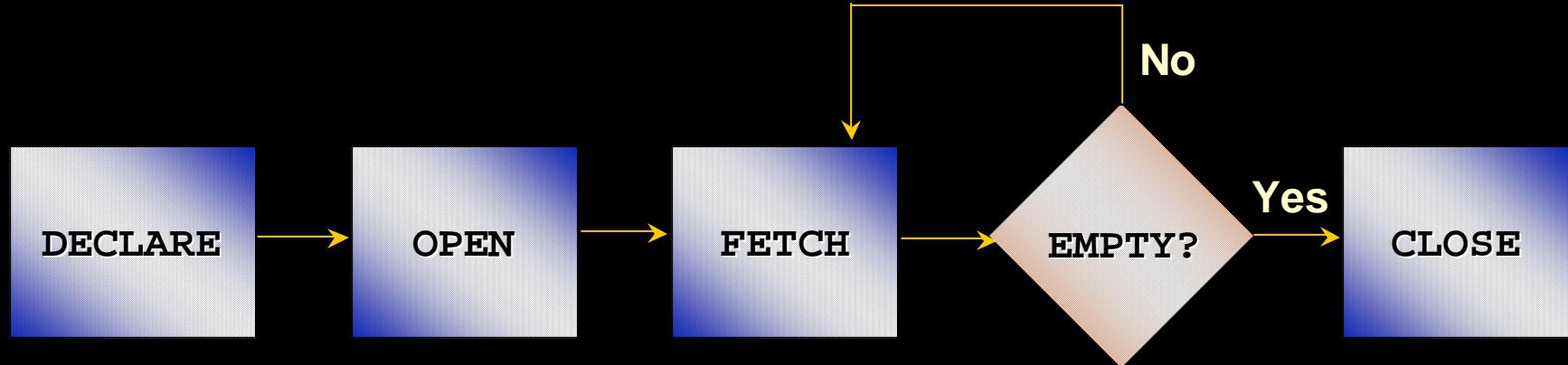


Active set



The diagram illustrates the relationship between a cursor and a database table. On the left, a yellow box labeled "Cursor" has a red arrow pointing to a vertical stack of six gray rectangular boxes labeled "Active set". This stack is positioned next to a large pink wedge that points from the "Active set" towards a table on the right. The table contains eight rows of data, with ellipses indicating more rows. The columns represent employee ID (e.g., 100, 101, 102, 139, 140), name (e.g., King, Kochhar, De Haan, Seo, Patel), and job title (e.g., AD_PRES, AD_VP, AD_VP, ST_CLERK, ST_CLERK).

Controlling Explicit Cursors

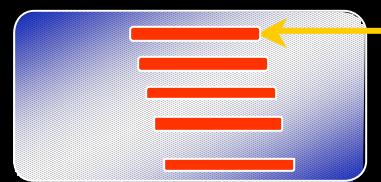


- Create a named SQL area
- Identify the active set
- Load the current row into variables
- Test for existing rows
- Return to **FETCH** if rows are found
- Release the active set

Controlling Explicit Cursors

1. Open the cursor
2. Fetch a row
3. Close the Cursor

1. Open the cursor.

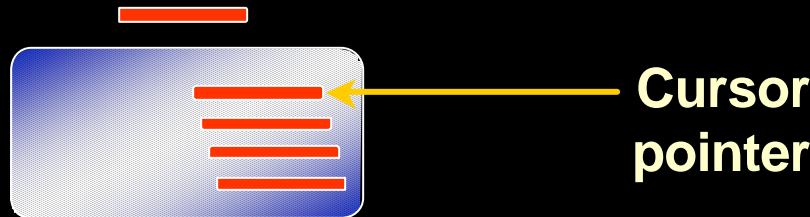


Cursor
pointer

Controlling Explicit Cursors

1. Open the cursor
2. Fetch a row
3. Close the Cursor

2. Fetch a row using the cursor.

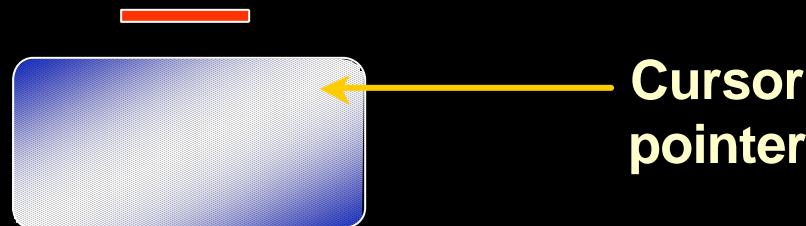


Continue until empty.

Controlling Explicit Cursors

1. Open the cursor
2. Fetch a row
3. Close the Cursor

3. Close the cursor.



Declaring the Cursor

Syntax:

```
CURSOR cursor_name IS  
    select_statement;
```

- **Do not include the INTO clause in the cursor declaration.**
- **If processing rows in a specific sequence is required, use the ORDER BY clause in the query.**

Declaring the Cursor

Example:

```
DECLARE
    CURSOR emp_cursor IS
        SELECT employee_id, last_name
        FROM employees;

    CURSOR dept_cursor IS
        SELECT *
        FROM departments
        WHERE location_id = 170;

BEGIN
    ...

```

Opening the Cursor

Syntax:

```
OPEN  cursor_name;
```

- Open the cursor to execute the query and identify the active set.
- If the query returns no rows, no exception is raised.
- Use cursor attributes to test the outcome after a fetch.

Fetching Data from the Cursor

Syntax:

```
FETCH cursor_name INTO [variable1, variable2, ...]  
    / record_name;
```

- Retrieve the current row values into variables.
- Include the same number of variables.
- Match each variable to correspond to the columns positionally.
- Test to see whether the cursor contains rows.

Fetching Data from the Cursor

Example:

```
LOOP
  FETCH emp_cursor INTO v_empno,v_ename;
  EXIT WHEN ...;
  ...
  -- Process the retrieved data
  ...
END LOOP;
```

Closing the Cursor

Syntax:

```
CLOSE      cursor_name;
```

- Close the cursor after completing the processing of the rows.
- Reopen the cursor, if required.
- Do not attempt to fetch data from a cursor after it has been closed.

Explicit Cursor Attributes

Obtain status information about a cursor.

Attribute	Type	Description
<code>%ISOPEN</code>	Boolean	Evaluates to TRUE if the cursor is open
<code>%NOTFOUND</code>	Boolean	Evaluates to TRUE if the most recent fetch does not return a row
<code>%FOUND</code>	Boolean	Evaluates to TRUE if the most recent fetch returns a row; complement of <code>%NOTFOUND</code>
<code>%ROWCOUNT</code>	Number	Evaluates to the total number of rows returned so far

The %ISOPEN Attribute

- Fetch rows only when the cursor is open.
- Use the %ISOPEN cursor attribute before performing a fetch to test whether the cursor is open.

Example:

```
IF NOT emp_cursor%ISOPEN THEN
    OPEN emp_cursor;
END IF;
LOOP
    FETCH emp_cursor...
```

Controlling Multiple Fetches

- **Process several rows from an explicit cursor using a loop.**
- **Fetch a row with each iteration.**
- **Use explicit cursor attributes to test the success of each fetch.**

The %NOTFOUND and %ROWCOUNT Attributes

- Use the **%ROWCOUNT** cursor attribute to retrieve an exact number of rows.
- Use the **%NOTFOUND** cursor attribute to determine when to exit the loop.

Example

```
DECLARE
    v_empno employees.employee_id%TYPE;
    v_ename employees.last_name%TYPE;
    CURSOR emp_cursor IS
        SELECT employee_id, last_name
        FROM   employees;
BEGIN
    OPEN emp_cursor;
    LOOP
        FETCH emp_cursor INTO v_empno, v_ename;
        EXIT WHEN emp_cursor%ROWCOUNT > 10 OR
                           emp_cursor%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE (TO_CHAR(v_empno)
                             || ' ' || v_ename);
    END LOOP;
    CLOSE emp_cursor;
END ;
```



Cursors and Records

Process the rows of the active set by fetching values into a PL/SQL RECORD.

```
DECLARE
    CURSOR emp_cursor IS
        SELECT employee_id, last_name
        FROM employees;
    emp_record    emp_cursor%ROWTYPE;
BEGIN
    OPEN emp_cursor;
    LOOP
        FETCH emp_cursor INTO emp_record;
        ...
    END LOOP;
END;
```

emp_record

employee_id

last_name

100

King

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Cursor FOR Loops

Syntax:

```
FOR record_name IN cursor_name LOOP  
    statement1;  
    statement2;  
    . . .  
END LOOP;
```

- The cursor FOR loop is a shortcut to process explicit cursors.
- Implicit open, fetch, exit, and close occur.
- The record is implicitly declared.



Cursor FOR Loops

Print a list of the employees who work for the sales department.

```
DECLARE
    CURSOR emp_cursor IS
        SELECT last_name, department_id
        FROM   employees;
BEGIN
    FOR emp_record IN emp_cursor LOOP
        -- implicit open and implicit fetch occur
        IF emp_record.department_id = 80 THEN
            ...
        END LOOP; -- implicit close occurs
END;
/
```

Cursor FOR Loops Using Subqueries

No need to declare the cursor.

Example:

```
BEGIN
    FOR emp_record IN (SELECT last_name, department_id
                        FROM employees) LOOP
        -- implicit open and implicit fetch occur
        IF emp_record.department_id = 80 THEN
            ...
        END LOOP; -- implicit close occurs
    END;
```

Summary

In this lesson you should have learned to:

- **Distinguish cursor types:**
 - **Implicit cursors:** used for all DML statements and single-row queries
 - **Explicit cursors:** used for queries of zero, one, or more rows
- **Manipulate explicit cursors**
- **Evaluate the cursor status by using cursor attributes**
- **Use cursor FOR loops**

Practice 6 Overview

This practice covers the following topics:

- Declaring and using explicit cursors to query rows of a table
- Using a cursor FOR loop
- Applying cursor attributes to test the cursor status



Advanced Explicit Cursor Concepts

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Objectives

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

- **Write a cursor that uses parameters**
- **Determine when a FOR UPDATE clause in a cursor is required**
- **Determine when to use the WHERE CURRENT OF clause**
- **Write a cursor that uses a subquery**

Cursors with Parameters

Syntax:

```
CURSOR cursor_name
  [ (parameter_name datatype, ... ) ]
IS
  select_statement;
```

- Pass parameter values to a cursor when the cursor is opened and the query is executed.
- Open an explicit cursor several times with a different active set each time.

```
OPEN cursor_name(parameter_value,....) ;
```

Cursors with Parameters

Pass the department number and job title to the WHERE clause, in the cursor SELECT statement.

```
DECLARE
  CURSOR emp_cursor
  (p_deptno NUMBER, p_job VARCHAR2) IS
    SELECT employee_id, last_name
    FROM employees
    WHERE department_id = p_deptno
    AND job_id = p_job;
BEGIN
  OPEN emp_cursor (80, 'SA_REP');
  . . .
  CLOSE emp_cursor;
  OPEN emp_cursor (60, 'IT_PROG');
  . . .
END;
```

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The FOR UPDATE Clause

Syntax:

```
SELECT ...
FROM      ...
FOR UPDATE [OF column_reference] [NOWAIT];
```

- Use explicit locking to deny access for the duration of a transaction.
- Lock the rows *before* the update or delete.

The FOR UPDATE Clause

Retrieve the employees who work in department 80 and update their salary.

```
DECLARE
  CURSOR emp_cursor IS
    SELECT employee_id, last_name, department_name
    FROM   employees,departments
    WHERE  employees.department_id =
           departments.department_id
    AND   employees.department_id = 80
    FOR UPDATE OF salary NOWAIT;
```

The WHERE CURRENT OF Clause

Syntax:

```
WHERE CURRENT OF cursor ;
```

- Use cursors to update or delete the current row.
- Include the FOR UPDATE clause in the cursor query to lock the rows first.
- Use the WHERE CURRENT OF clause to reference the current row from an explicit cursor.

The WHERE CURRENT OF Clause

```
DECLARE
CURSOR sal_cursor IS
SELECT e.department_id, employee_id, last_name, salary
FROM employees e, departments d
WHERE d.department_id = e.department_id
and d.department_id = 60
FOR UPDATE OF salary NOWAIT;
BEGIN
FOR emp_record IN sal_cursor
LOOP
IF emp_record.salary < 5000 THEN
    UPDATE employees
    SET salary = emp_record.salary * 1.10
    WHERE CURRENT OF sal_cursor;
END IF;
END LOOP;
END;
/
```



Cursors with Subqueries

Example:

```
DECLARE
  CURSOR my_cursor IS
    SELECT t1.department_id, t1.department_name,
           t2.staff
      FROM departments t1, (SELECT department_id,
                                         COUNT(*) AS STAFF
                                    FROM employees
                                   GROUP BY department_id) t2
     WHERE t1.department_id = t2.department_id
       AND t2.staff >= 3;
...
...
```

Summary

In this lesson, you should have learned to:

- **Return different active sets using cursors with parameters.**
- **Define cursors with subqueries and correlated subqueries.**
- **Manipulate explicit cursors with commands using the:**
 - **FOR UPDATE clause**
 - **WHERE CURRENT OF clause**

Practice 7 Overview

This practice covers the following topics:

- Declaring and using explicit cursors with parameters
- Using a FOR UPDATE cursor

Handling Exceptions

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Objectives

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

- **Define PL/SQL exceptions**
- **Recognize unhandled exceptions**
- **List and use different types of PL/SQL exception handlers**
- **Trap unanticipated errors**
- **Describe the effect of exception propagation in nested blocks**
- **Customize PL/SQL exception messages**

Handling Exceptions with PL/SQL

- An exception is an identifier in PL/SQL that is raised during execution.
- How is it raised?
 - An Oracle error occurs.
 - You raise it explicitly.
- How do you handle it?
 - Trap it with a handler.
 - Propagate it to the calling environment.

Handling Exceptions

Trap the exception

Exception
is raised

Exception
is trapped

```
DECLARE
  [REDACTED]
BEGIN
  [REDACTED]
EXCEPTION
  [REDACTED]
END;
```

Propagate the exception

Exception
is raised

Exception
is not
trapped

Exception
propagates to calling
environment

Exception Types

- Predefined Oracle Server
 - Nonpredefined Oracle Server
 - User-defined
- } **Implicitly raised**
- Explicitly raised**

Trapping Exceptions

Syntax:

```
EXCEPTION  
  WHEN exception1 [OR exception2 . . .] THEN  
    statement1;  
    statement2;  
    . . .  
  [WHEN exception3 [OR exception4 . . .] THEN  
    statement1;  
    statement2;  
    . . .]  
  [WHEN OTHERS THEN  
    statement1;  
    statement2;  
    . . .]
```

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Trapping Exceptions Guidelines

- The **EXCEPTION** keyword starts exception-handling section.
- Several exception handlers are allowed.
- Only one handler is processed before leaving the block.
- **WHEN OTHERS** is the last clause.

Trapping Predefined Oracle Server Errors

- Reference the standard name in the exception-handling routine.
- Sample predefined exceptions:
 - NO_DATA_FOUND
 - TOO_MANY_ROWS
 - INVALID_CURSOR
 - ZERO_DIVIDE
 - DUP_VAL_ON_INDEX

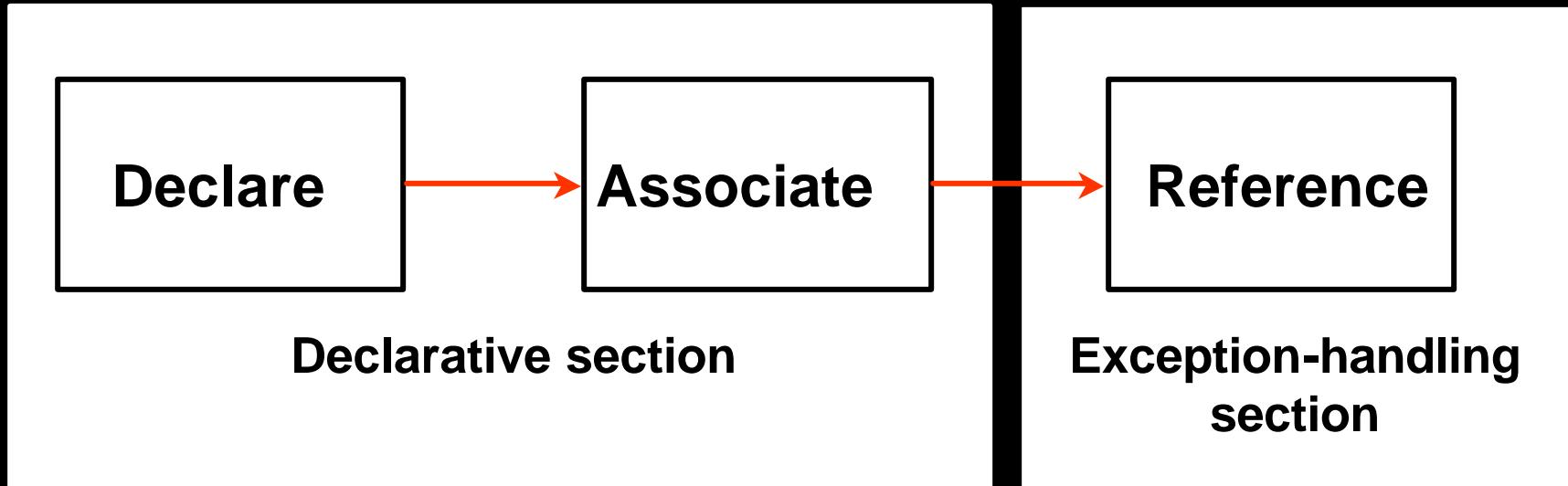
Predefined Exceptions

Syntax:

```
BEGIN  
  . . .  
EXCEPTION  
  WHEN NO_DATA_FOUND THEN  
    statement1;  
    statement2;  
  
  WHEN TOO_MANY_ROWS THEN  
    statement1;  
WHEN OTHERS THEN  
  statement1;  
  statement2;  
  statement3;  
END;
```

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Trapping Nonpredefined Oracle Server Errors



Name the exception

Code the PRAGMA EXCEPTION_INIT

Handle the raised exception

Nonpredefined Error

Trap for Oracle server error number -2292, an integrity constraint violation.

```
DEFINE p_deptno = 10

DECLARE
    e_emps_remaining EXCEPTION;
    PRAGMA EXCEPTION_INIT
        (e_emps_remaining, -2292);

BEGIN
    DELETE FROM departments
    WHERE department_id = &p_deptno;
    COMMIT;

EXCEPTION
    WHEN e_emps_remaining THEN
        DBMS_OUTPUT.PUT_LINE ('Cannot remove dept ' ||
            TO_CHAR(&p_deptno) || '. Employees exist. ');
END;
```

1

2

3

Functions for Trapping Exceptions

- **SQLCODE:** Returns the numeric value for the error code
- **SQLERRM:** Returns the message associated with the error number

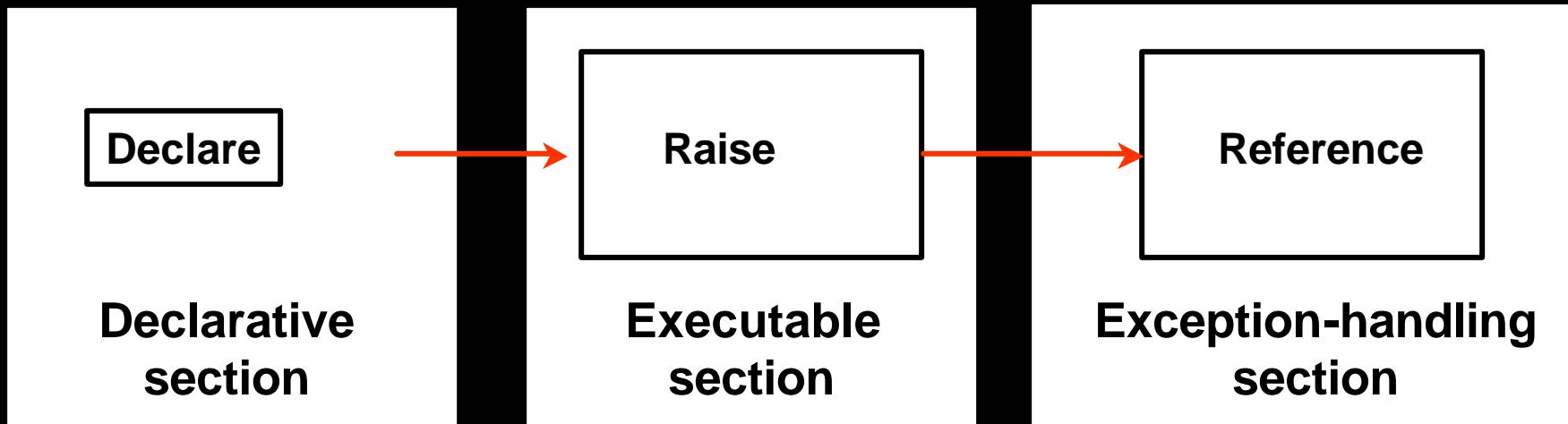
Functions for Trapping Exceptions

Example:

```
DECLARE
    v_error_code      NUMBER;
    v_error_message   VARCHAR2( 255 );
BEGIN
    ...
EXCEPTION
    ...
    WHEN OTHERS THEN
        ROLLBACK;
        v_error_code := SQLCODE ;
        v_error_message := SQLERRM ;
        INSERT INTO errors
            VALUES(v_error_code, v_error_message);
END;
```



Trapping User-Defined Exceptions



Name the exception.

Explicitly raise the exception by using the **RAISE** statement.

Handle the raised exception.

User-Defined Exceptions

Example:

```
DEFINE p_department_desc = 'Information Technology '
DEFINE P_department_number = 300
```

```
DECLARE
    e_invalid_department EXCEPTION;
1
BEGIN
    UPDATE      departments
    SET         department_name = '&p_department_desc'
    WHERE       department_id = &p_department_number;
    IF SQL%NOTFOUND THEN
        RAISE e_invalid_department;
2
    END IF;
    COMMIT;
EXCEPTION
    WHEN e_invalid_department THEN
        DBMS_OUTPUT.PUT_LINE('No such department id.');
3
END;
```

Calling Environments

iSQL*Plus	Displays error number and message to screen
Procedure Builder	Displays error number and message to screen
Oracle Developer Forms	Accesses error number and message in a trigger by means of the <code>ERROR_CODE</code> and <code>ERROR_TEXT</code> packaged functions
Precompiler application	Accesses exception number through the <code>SQLCA</code> data structure
An enclosing PL/SQL block	Traps exception in exception-handling routine of enclosing block

Propagating Exceptions

Subblocks can handle an exception or pass the exception to the enclosing block.

```
DECLARE
    . . .
    e_no_rows      exception;
    e_integrity     exception;
    PRAGMA EXCEPTION_INIT (e_integrity, -2292);
BEGIN
    FOR c_record IN emp_cursor LOOP
        BEGIN
            SELECT ...
            UPDATE ...
            IF SQL%NOTFOUND THEN
                RAISE e_no_rows;
            END IF;
        END;
    END LOOP;
EXCEPTION
    WHEN e_integrity THEN ...
    WHEN e_no_rows THEN ...
END;
```

The RAISE_APPLICATION_ERROR Procedure

Syntax:

```
raise_application_error (error_number,  
                         message[, {TRUE | FALSE}]);
```

- You can use this procedure to issue user-defined error messages from stored subprograms.
- You can report errors to your application and avoid returning unhandled exceptions.

The RAISE_APPLICATION_ERROR Procedure

- Used in two different places:
 - Executable section
 - Exception section
- Returns error conditions to the user in a manner consistent with other Oracle server errors

RAISE_APPLICATION_ERROR

Executable section:

```
BEGIN  
    ...  
    DELETE FROM employees  
        WHERE manager_id = v_mgr;  
    IF SQL%NOTFOUND THEN  
        RAISE_APPLICATION_ERROR(-20202,  
            'This is not a valid manager');  
    END IF;  
    ...
```

Exception section:

```
...  
EXCEPTION  
    WHEN NO_DATA_FOUND THEN  
        RAISE_APPLICATION_ERROR (-20201,  
            'Manager is not a valid employee.');
```

END;

Summary

In this lesson, you should have learned that:

- **Exception types:**
 - Predefined Oracle server error
 - Nonpredefined Oracle server error
 - User-defined error
- **Exception trapping**
- **Exception handling:**
 - Trap the exception within the PL/SQL block.
 - Propagate the exception.

Practice 8 Overview

This practice covers the following topics:

- **Handling named exceptions**
- **Creating and invoking user-defined exceptions**

9

Creating Procedures

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Objectives

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

- **Distinguish anonymous PL/SQL blocks from named PL/SQL blocks (subprograms)**
- **Describe subprograms**
- **List the benefits of using subprograms**
- **List the different environments from which subprograms can be invoked**

Objectives

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

- **Describe PL/SQL blocks and subprograms**
- **Describe the uses of procedures**
- **Create procedures**
- **Differentiate between formal and actual parameters**
- **List the features of different parameter modes**
- **Create procedures with parameters**
- **Invoke a procedure**
- **Handle exceptions in procedures**
- **Remove a procedure**

PL/SQL Program Constructs

Tools Constructs
Anonymous blocks
Application procedures or functions
Application packages
Application triggers
Object types

```
<header> IS | AS  
or DECLARE  
    * * *  
BEGIN  
    * * *  
EXCEPTION  
    * * *  
END;
```

Database Server Constructs
Anonymous blocks
Stored procedures or functions
Stored packages
Database triggers
Object types

Overview of Subprograms

A subprogram:

- Is a named PL/SQL block that can accept parameters and be invoked from a calling environment
- Is of two types:
 - A procedure that performs an action
 - A function that computes a value
- Is based on standard PL/SQL block structure
- Provides modularity, reusability, extensibility, and maintainability
- Provides easy maintenance, improved data security and integrity, improved performance, and improved code clarity



Block Structure for Anonymous PL/SQL Blocks

DECLARE **(optional)**

Declare PL/SQL objects to be used
within this block

BEGIN **(mandatory)**

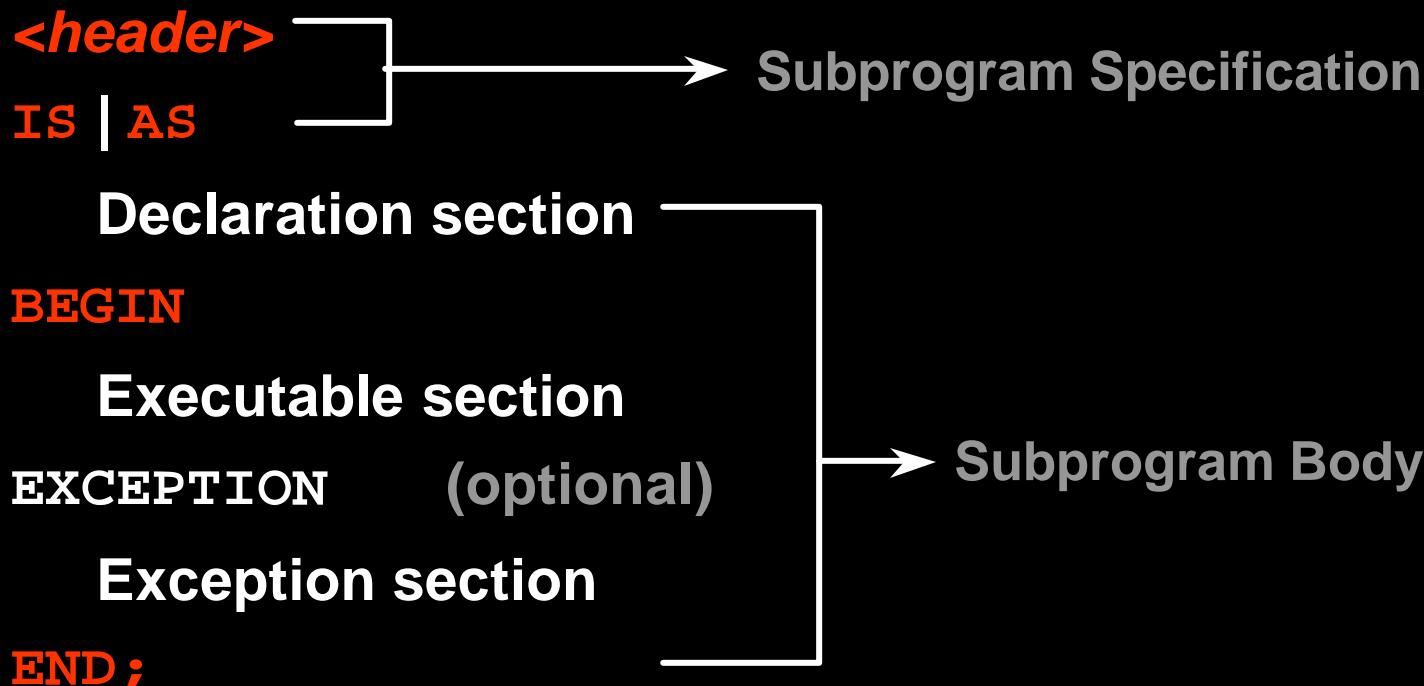
Define the executable statements

EXCEPTION **(optional)**

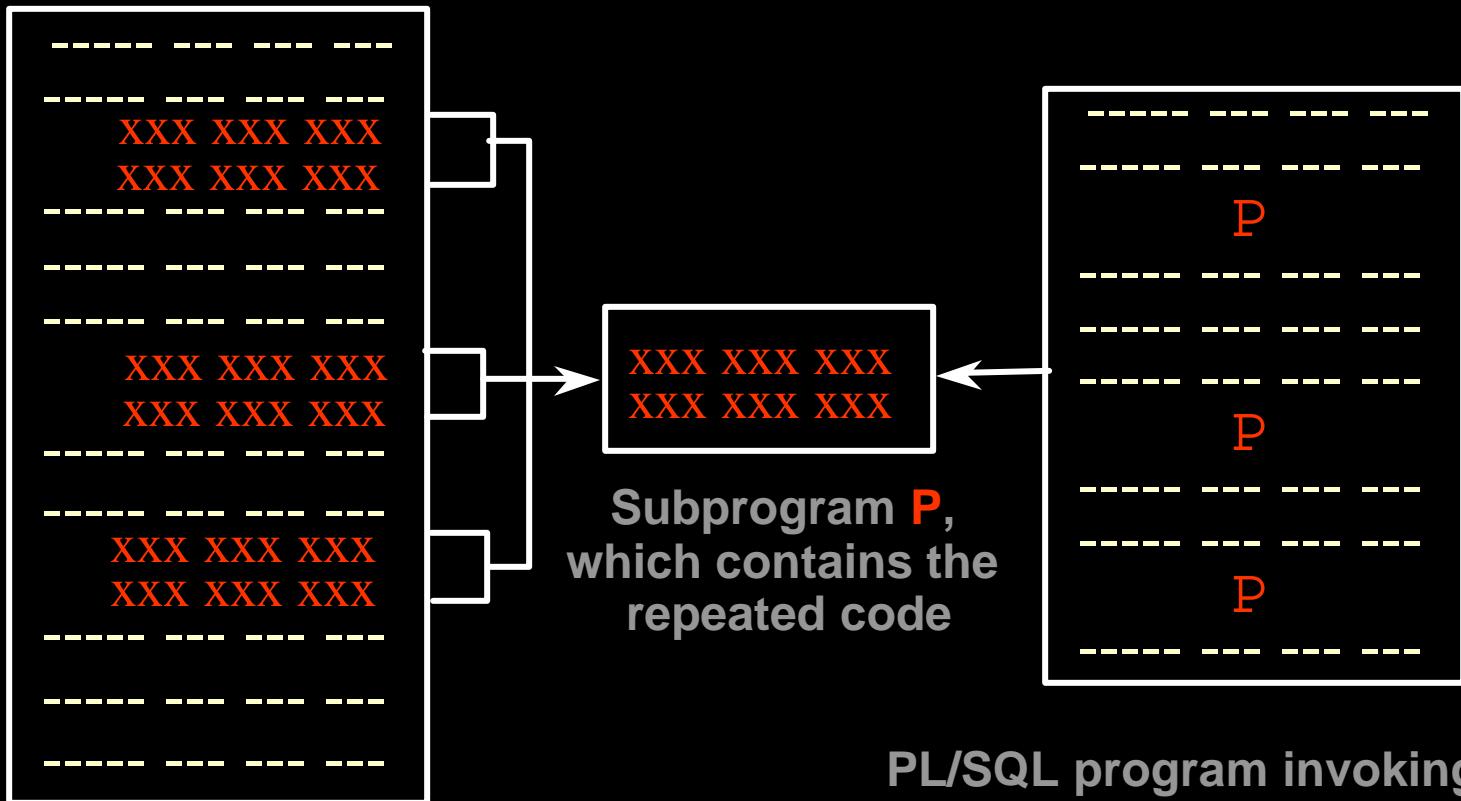
Define the actions that take place if
an error or exception arises

END ; **(mandatory)**

Block Structure for PL/SQL Subprograms



PL/SQL Subprograms



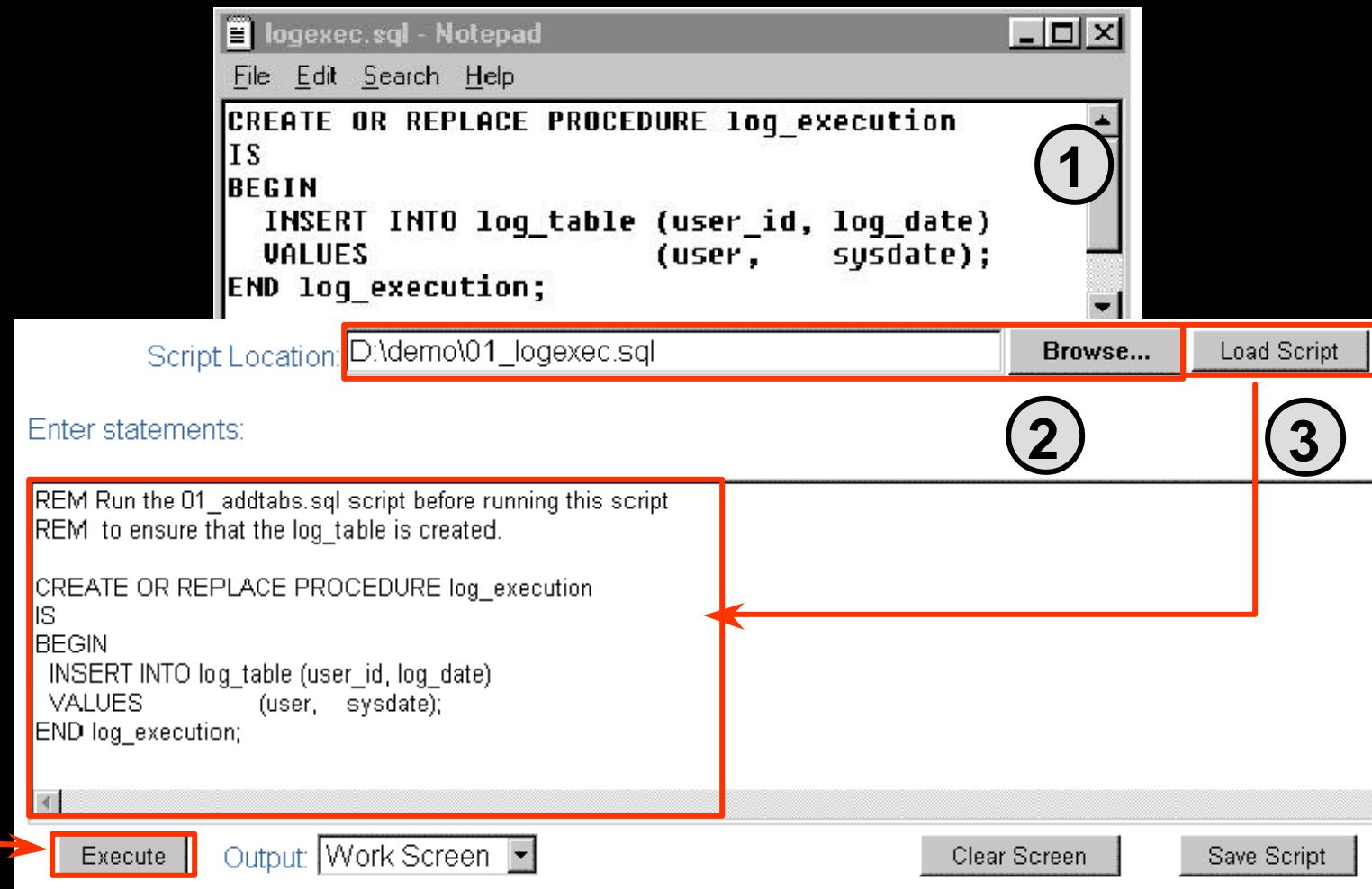
Code repeated more than once in a PL/SQL program

PL/SQL program invoking the subprogram at multiple locations

Benefits of Subprograms

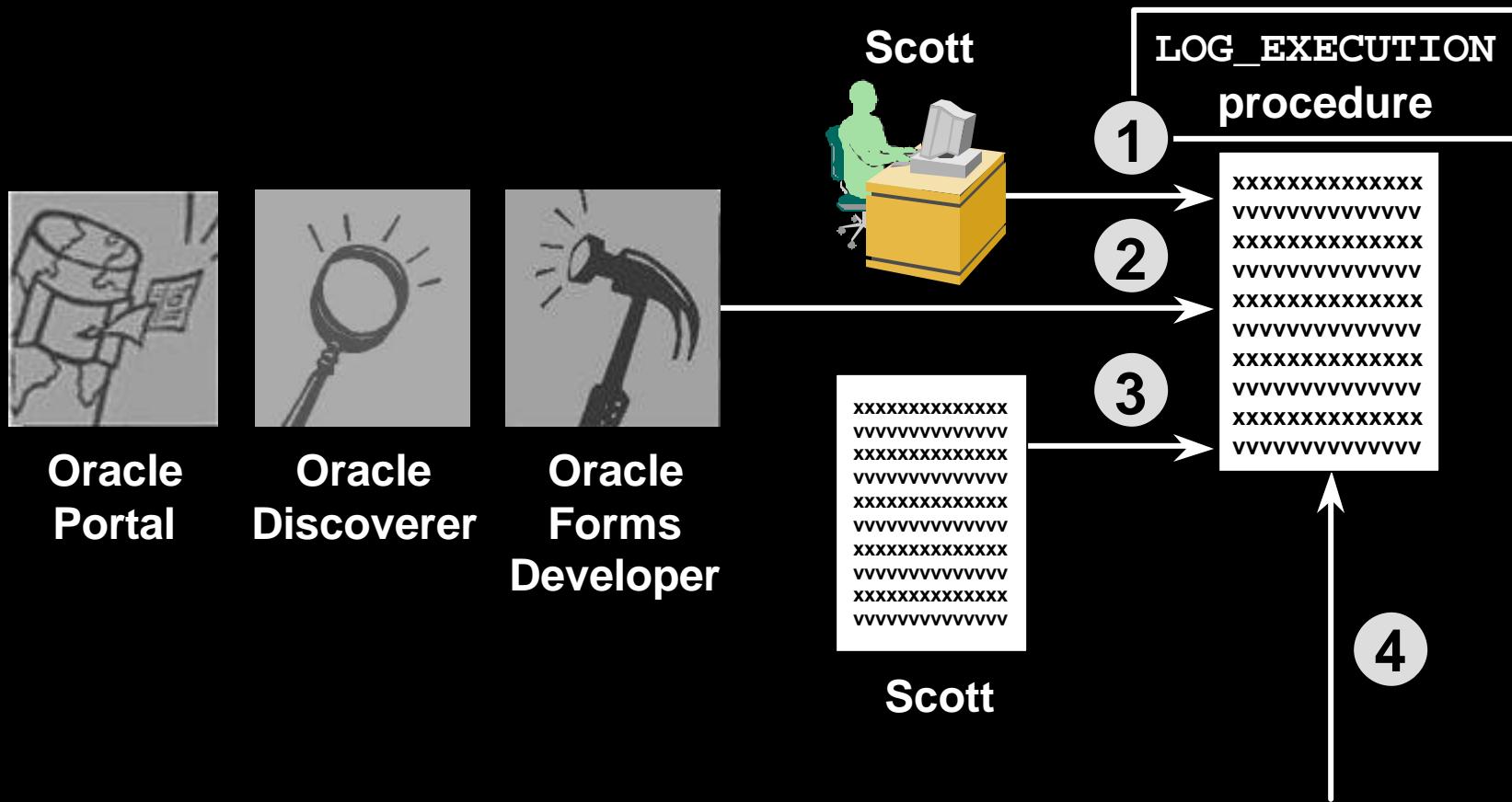
- Easy maintenance
- Improved data security and integrity
- Improved performance
- Improved code clarity

Developing Subprograms by Using iSQL*Plus



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Invoking Stored Procedures and Functions



What Is a Procedure?

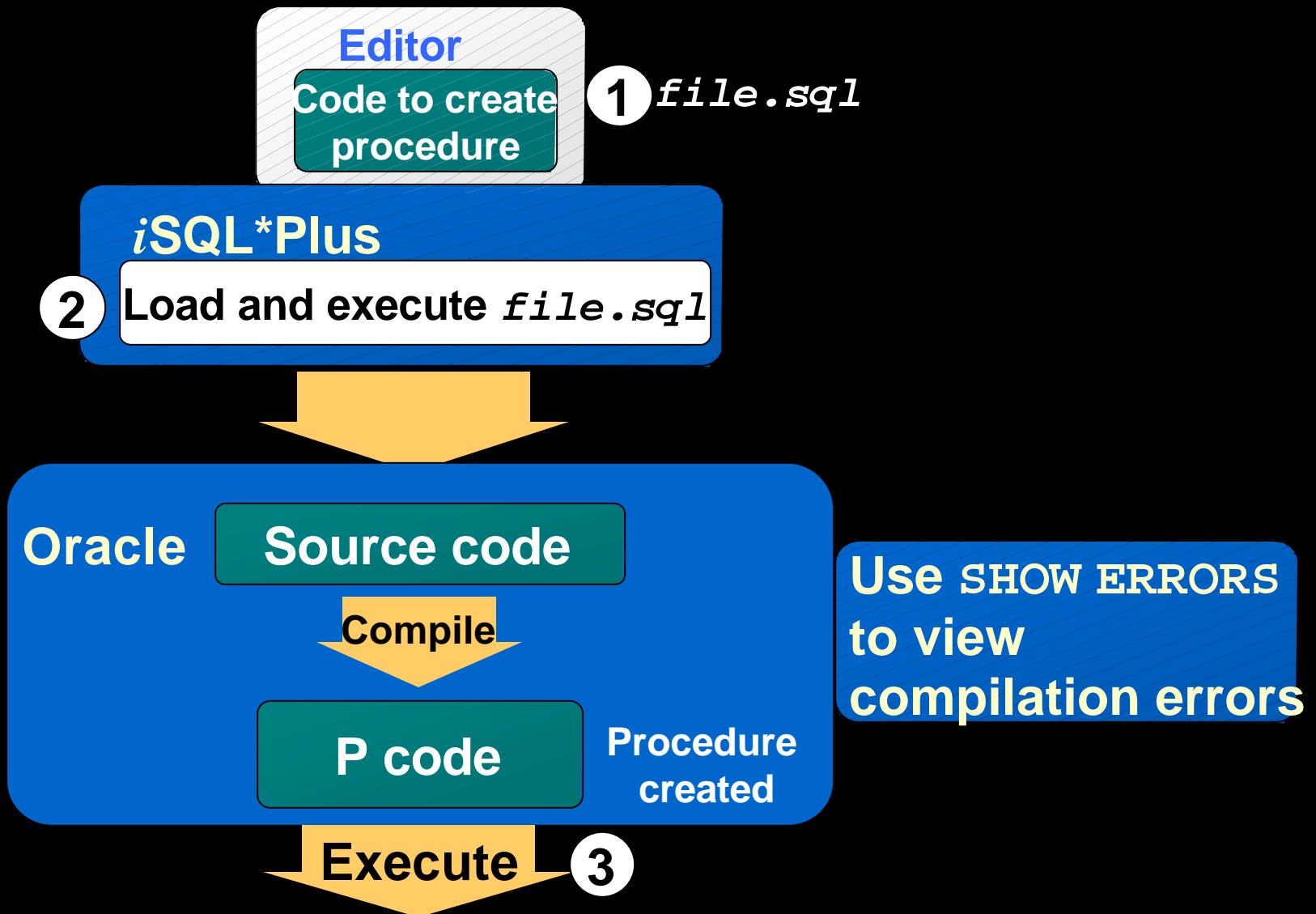
- A procedure is a type of subprogram that performs an action.
- A procedure can be stored in the database, as a schema object, for repeated execution.

Syntax for Creating Procedures

```
CREATE [OR REPLACE] PROCEDURE procedure_name
[(parameter1 [mode1] datatype1,
  parameter2 [mode2] datatype2,
  . . .)]
IS | AS
PL/SQL Block;
```

- The **REPLACE** option indicates that if the procedure exists, it will be dropped and replaced with the new version created by the statement.
- PL/SQL block starts with either **BEGIN** or the declaration of local variables and ends with either **END** or **END *procedure_name***.

Developing Procedures



Formal Versus Actual Parameters

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

Example:

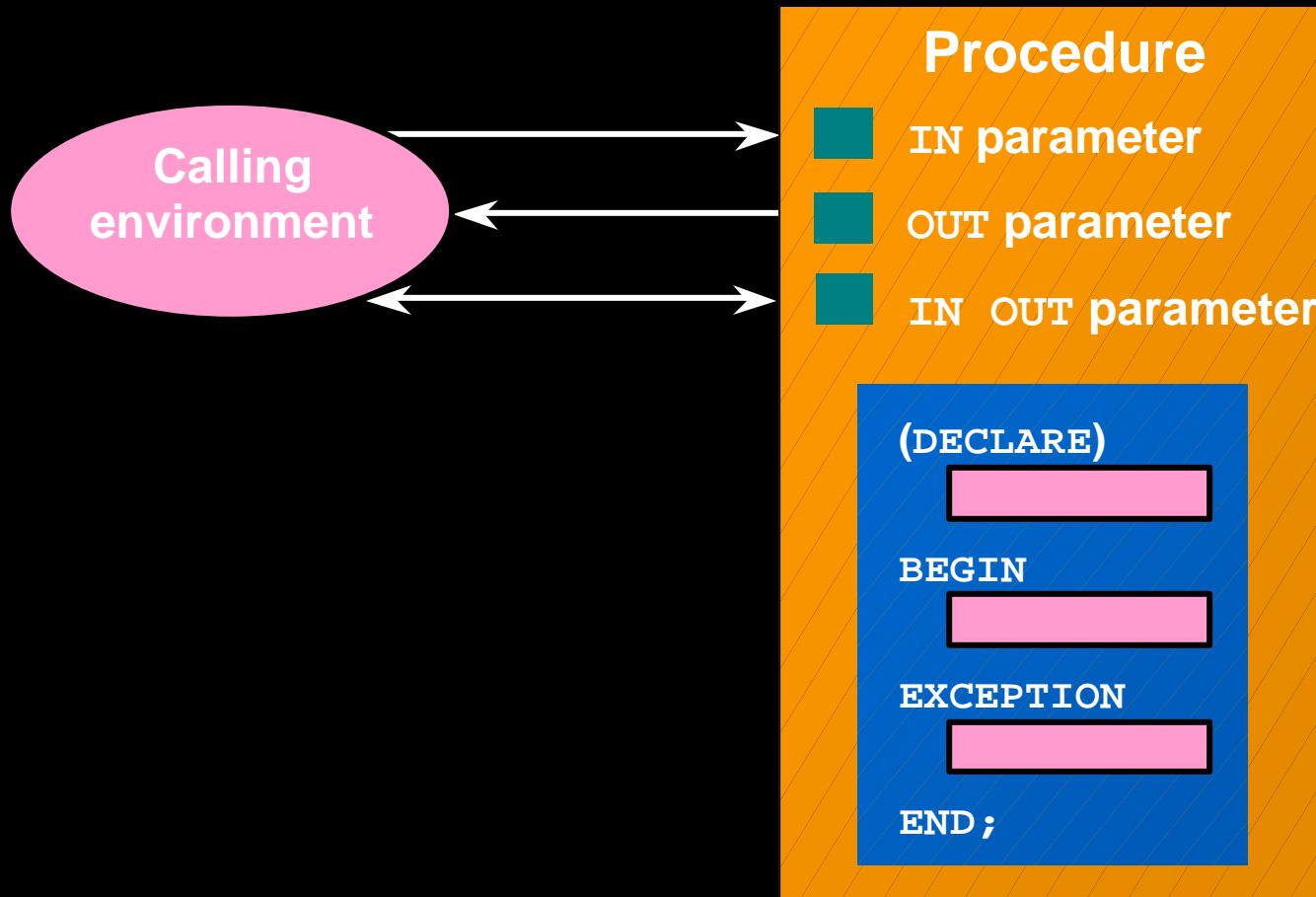
```
CREATE PROCEDURE raise_sal(p_id NUMBER, p_amount NUMBER)  
...  
END raise_sal;
```

- **Actual parameters:** variables or expressions referenced in the parameter list of a subprogram call

Example:

```
raise_sal(v_id, 2000)
```

Procedural Parameter Modes



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Creating Procedures with Parameters

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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IN Parameters: Example



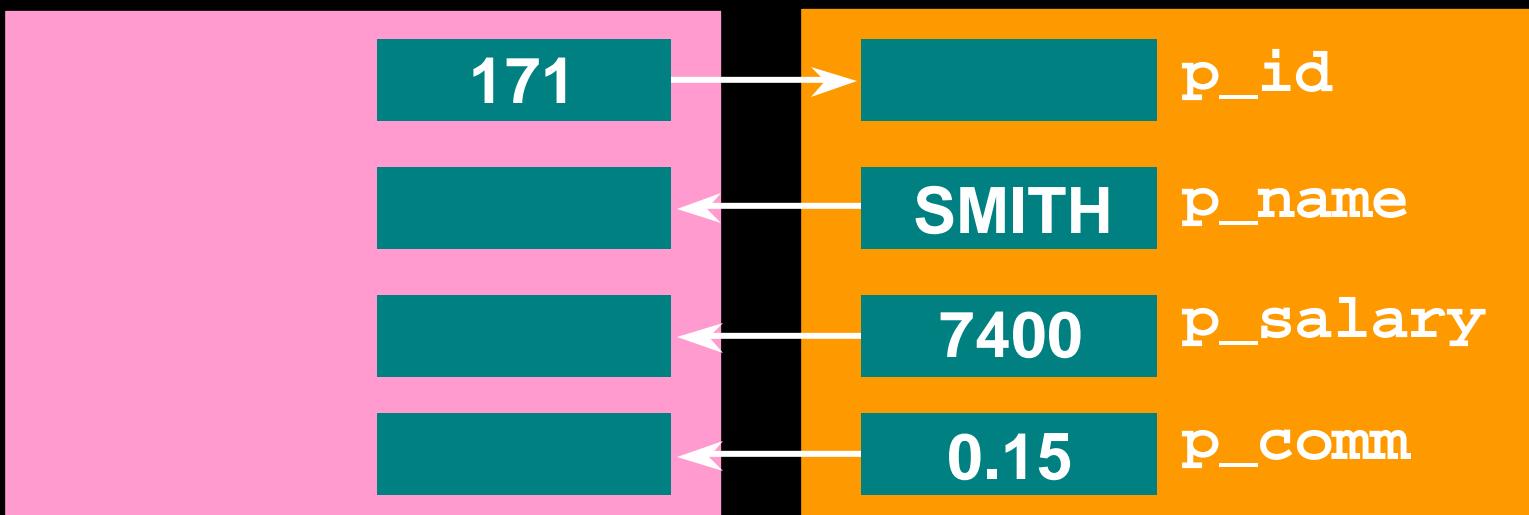
```
CREATE OR REPLACE PROCEDURE raise_salary
  (p_id IN employees.employee_id%TYPE)
IS
BEGIN
  UPDATE employees
  SET      salary = salary * 1.10
  WHERE   employee_id = p_id;
END raise_salary;
/
```

Procedure created.

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OUT Parameters: Example

Calling environment QUERY_EMP procedure



OUT Parameters: Example

emp_query.sql

```
CREATE OR REPLACE PROCEDURE query_emp
(p_id      IN employees.employee_id%TYPE,
 p_name    OUT employees.last_name%TYPE,
 p_salary  OUT employees.salary%TYPE,
 p_comm    OUT employees.commission_pct%TYPE)
IS
BEGIN
  SELECT last_name, salary, commission_pct
  INTO   p_name, p_salary, p_comm
  FROM   employees
  WHERE  employee_id = p_id;
END query_emp;
/
```

Procedure created.

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Viewing OUT Parameters

- Load and run the `emp_query.sql` script file to create the `QUERY_EMP` procedure.
- Declare host variables, execute the `QUERY_EMP` procedure, and print the value of the global `G_NAME` variable.

```
VARIABLE g_name      VARCHAR2( 25 )
VARIABLE g_sal       NUMBER
VARIABLE g_comm      NUMBER

EXECUTE query_emp(171, :g_name, :g_sal, :g_comm)

PRINT g_name
```

PL/SQL procedure successfully completed.

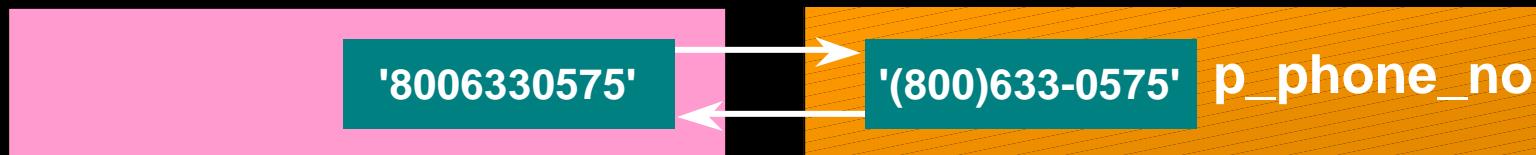
G_NAME
Smith

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IN OUT Parameters

Calling environment

FORMAT_PHONE procedure



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

Procedure created.

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Viewing IN OUT Parameters

```
VARIABLE g_phone_no VARCHAR2(15)
BEGIN
  :g_phone_no := '8006330575';
END;
/
PRINT g_phone_no
EXECUTE format_phone (:g_phone_no)
PRINT g_phone_no
```

PL/SQL procedure successfully completed.

G_PHONE_NO
8006330575

PL/SQL procedure successfully completed.

G_PHONE_NO
(800)633-0575

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Methods for Passing Parameters

- **Positional:** List actual parameters in the same order as formal parameters.
- **Named:** List actual parameters in arbitrary order by associating each with its corresponding formal parameter.
- **Combination:** List some of the actual parameters as positional and some as named.

DEFAULT Option for Parameters

```
CREATE OR REPLACE PROCEDURE add_dept
  (p_name    IN departments.department_name%TYPE
   DEFAULT 'unknown',
   p_loc      IN departments.location_id%TYPE
   DEFAULT 1700)
IS
BEGIN
  INSERT INTO departments(department_id,
                         department_name, location_id)
  VALUES (departments_seq.NEXTVAL, p_name, p_loc);
END add_dept;
/
```

Procedure created.



Examples of Passing Parameters

```
BEGIN
    add_dept;
    add_dept ('TRAINING', 2500);
    add_dept ( p_loc => 2400, p_name =>'EDUCATION' );
    add_dept ( p_loc => 1200) ;
END;
/
SELECT department_id, department_name, location_id
FROM departments;
```

PL/SQL procedure successfully completed.

DEPARTMENT_ID	DEPARTMENT_NAME	LOCATION_ID
10	Administration	1700
20	Marketing	1800
30	Purchasing	1700
40	Human Resources	2400
...		
290	TRAINING	2500
300	EDUCATION	2400
310	unknown	1200

31 rows selected.

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Declaring Subprograms

`leave_emp2.sql`

```
CREATE OR REPLACE PROCEDURE leave_emp2
  (p_id  IN employees.employee_id%TYPE)
IS
  PROCEDURE log_exec
  IS
  BEGIN
    INSERT INTO log_table (user_id, log_date)
    VALUES (USER, SYSDATE);
  END log_exec;
BEGIN
  DELETE FROM employees
  WHERE employee_id = p_id;
  log_exec;
END leave_emp2;
/
```

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Invoking a Procedure from an Anonymous PL/SQL Block

```
DECLARE
    v_id NUMBER := 163;
BEGIN
    raise_salary(v_id);      --invoke procedure
    COMMIT;
    ...
END;
```



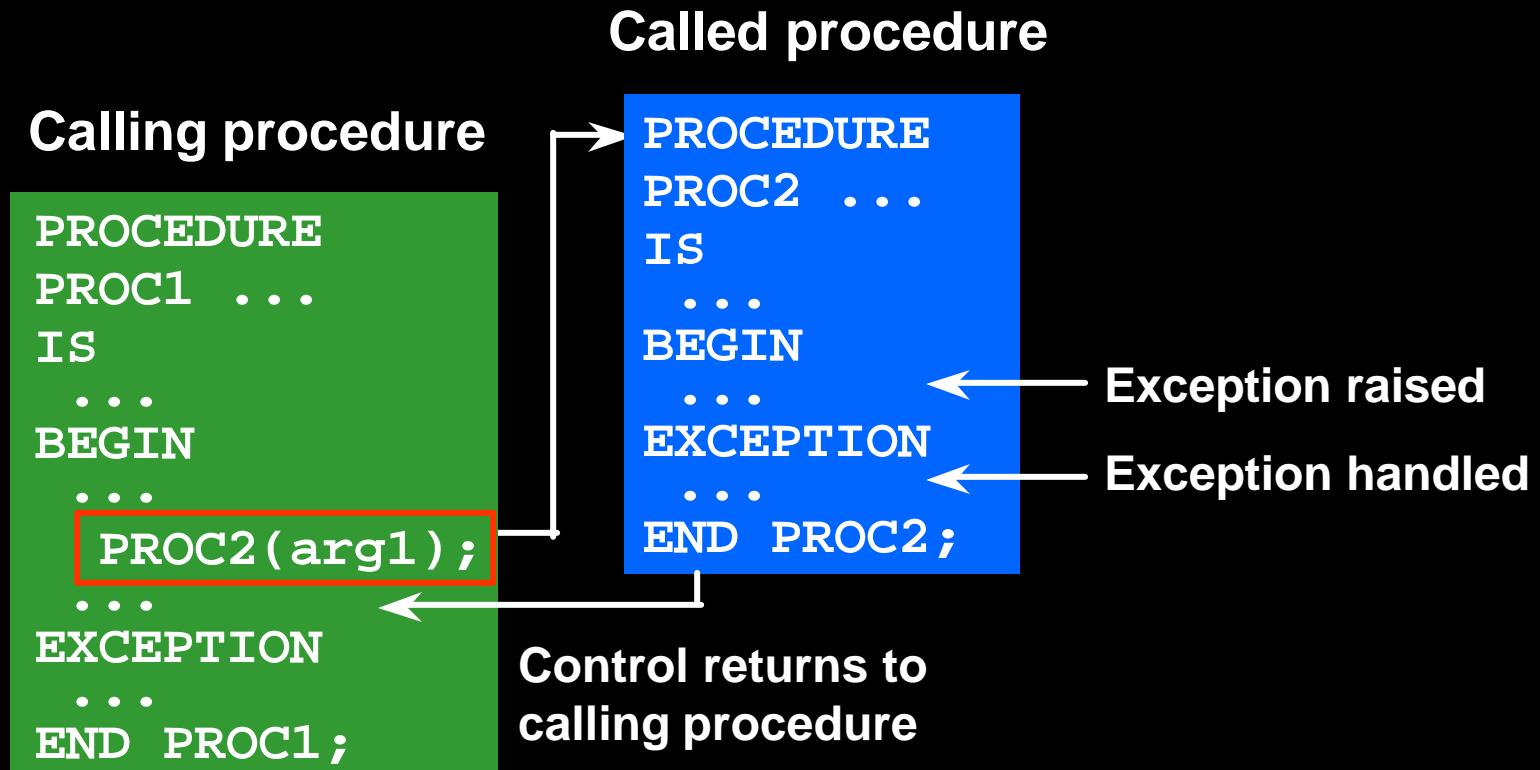
Invoking a Procedure from Another Procedure

process_emps.sql

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



Handled Exceptions



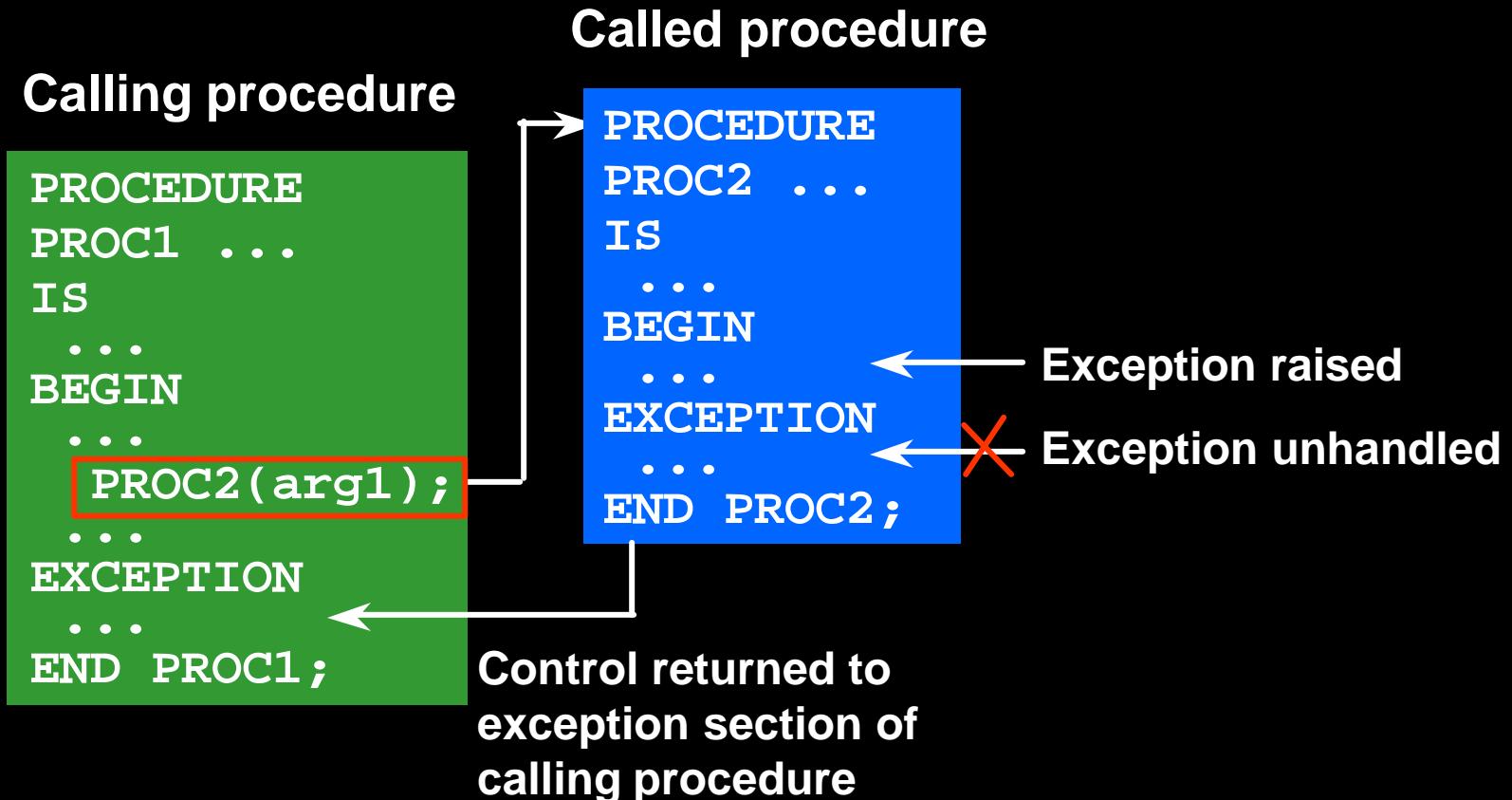
Handled Exceptions

```
CREATE PROCEDURE p2_ins_dept(p_locid NUMBER) IS
  v_did NUMBER(4);
BEGIN
  DBMS_OUTPUT.PUT_LINE('Procedure p2_ins_dept started');
  INSERT INTO departments VALUES (5, 'Dept 5', 145, p_locid);
  SELECT department_id INTO v_did FROM employees
    WHERE employee_id = 999;
END;
```

```
CREATE PROCEDURE p1_ins_loc(p_lid NUMBER, p_city VARCHAR2)
IS
  v_city VARCHAR2(30); v_dname VARCHAR2(30);
BEGIN
  DBMS_OUTPUT.PUT_LINE('Main Procedure p1_ins_loc');
  INSERT INTO locations (location_id, city) VALUES (p_lid, p_city);
  SELECT city INTO v_city FROM locations WHERE location_id = p_lid;
  DBMS_OUTPUT.PUT_LINE('Inserted city '||v_city);
  DBMS_OUTPUT.PUT_LINE('Invoking the procedure p2_ins_dept ...');
  p2_ins_dept(p_lid);
EXCEPTION
  WHEN NO_DATA_FOUND THEN
    DBMS_OUTPUT.PUT_LINE('No such dept/loc for any employee');
END;
```

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Unhandled Exceptions



Unhandled Exceptions

```
CREATE PROCEDURE p2_noexcep(p_locid NUMBER) IS
  v_did NUMBER(4);
BEGIN
  DBMS_OUTPUT.PUT_LINE('Procedure p2_noexcep started');
  INSERT INTO departments VALUES (6, 'Dept 6', 145, p_locid);
  SELECT department_id INTO v_did FROM employees
    WHERE employee_id = 999;
END;
```

```
CREATE PROCEDURE p1_noexcep(p_lid NUMBER, p_city VARCHAR2)
IS
  v_city VARCHAR2(30); v_dname VARCHAR2(30);
BEGIN
  DBMS_OUTPUT.PUT_LINE(' Main Procedure p1_noexcep');
  INSERT INTO locations (location_id, city) VALUES (p_lid, p_city);
  SELECT city INTO v_city FROM locations WHERE location_id = p_lid;
  DBMS_OUTPUT.PUT_LINE('Inserted new city '||v_city);
  DBMS_OUTPUT.PUT_LINE('Invoking the procedure p2_noexcep ...');
  p2_noexcep(p_lid);
END;
```

Removing Procedures

Drop a procedure stored in the database.

Syntax:

```
DROP PROCEDURE procedure_name
```

Example:

```
DROP PROCEDURE raise_salary;
```

```
Procedure dropped.
```

Summary

In this lesson, you should have learned that:

- **A procedure is a subprogram that performs an action.**
- **You create procedures by using the CREATE PROCEDURE command.**
- **You can compile and save a procedure in the database.**
- **Parameters are used to pass data from the calling environment to the procedure.**
- **There are three parameter modes: IN, OUT, and IN OUT .**

Summary

- Local subprograms are programs that are defined within the declaration section of another program.
- Procedures can be invoked from any tool or language that supports PL/SQL.
- You should be aware of the effect of handled and unhandled exceptions on transactions and calling procedures.
- You can remove procedures from the database by using the `DROP PROCEDURE` command.
- Procedures can serve as building blocks for an application.

Practice 9 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 matching with 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**



10

Creating Functions

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**

Overview of Stored Functions

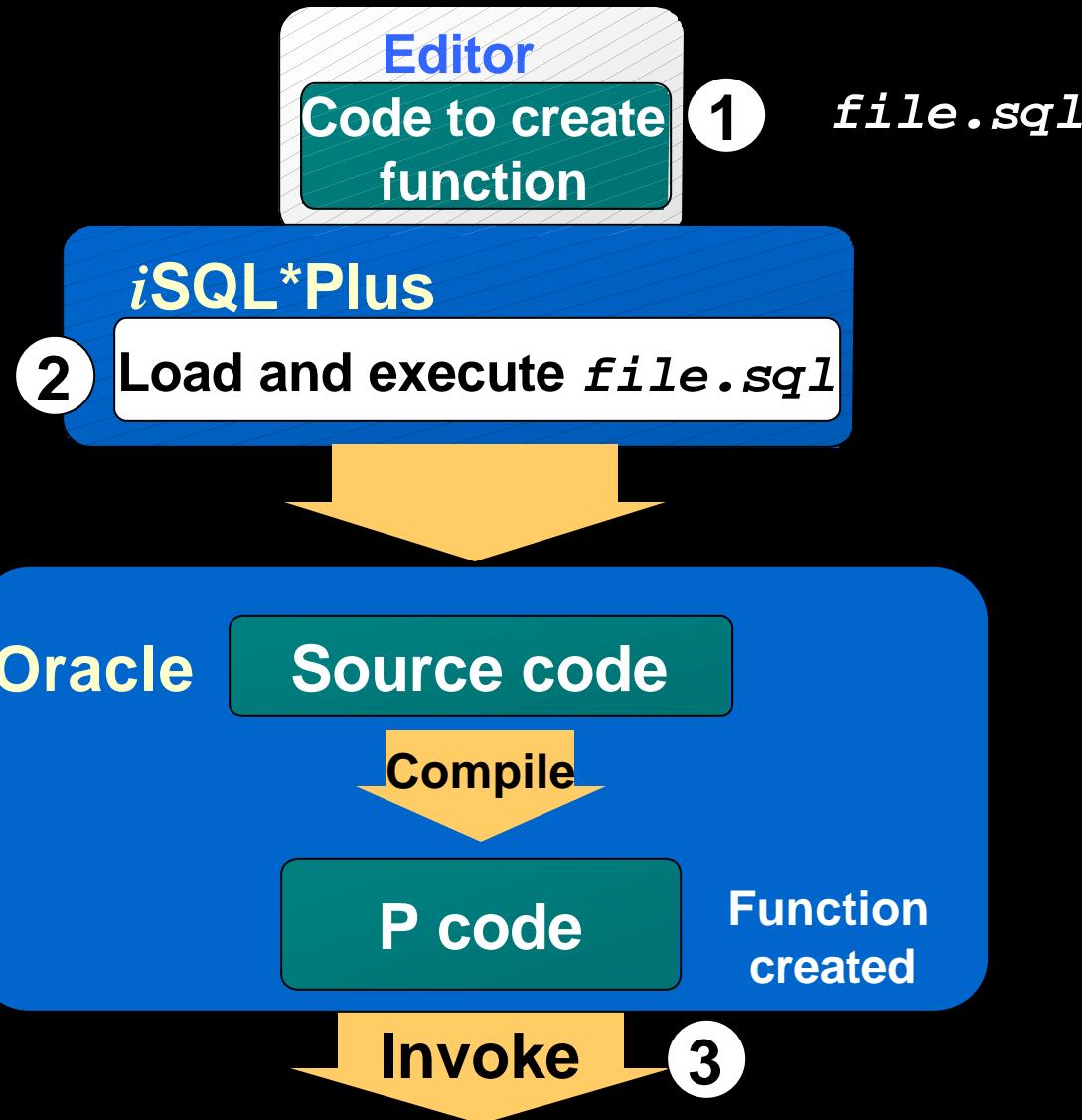
- A function is a named PL/SQL block that returns a value.
- A function can be stored in the database as a schema object for repeated execution.
- A function is called as part of an expression.

Syntax for Creating Functions

```
CREATE [OR REPLACE] FUNCTION function_name
[(parameter1 [mode1] datatype1,
  parameter2 [mode2] datatype2,
  . . .)]
RETURN datatype
IS|AS
PL/SQL Block;
```

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

Creating a Function



Creating a Stored Function by Using *i*SQL*Plus

- 1. Enter the text of the CREATE FUNCTION statement in an editor and save it as a SQL script file.**
- 2. Run the script file to store the source code and compile the function.**
- 3. Use SHOW ERRORS to see compilation errors.**
- 4. When successfully compiled, invoke the function.**

Creating a Stored Function by Using *i*SQL*Plus: Example

get_salary.sql

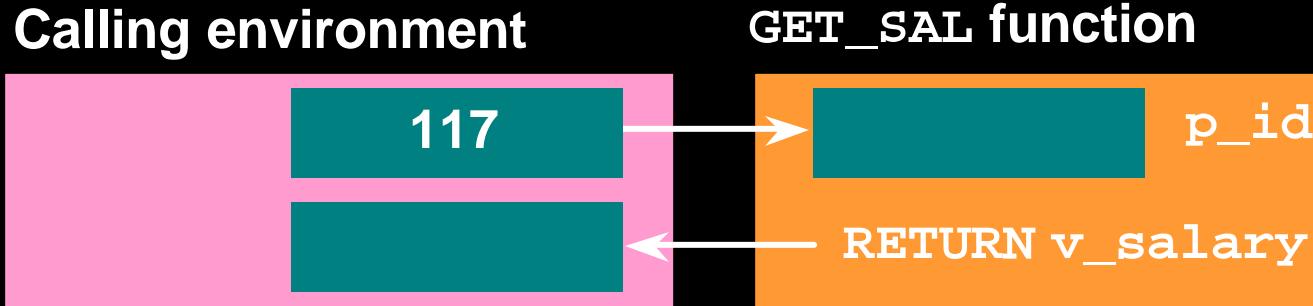
```
CREATE OR REPLACE FUNCTION get_sal
  (p_id    IN employees.employee_id%TYPE)
  RETURN NUMBER
IS
  v_salary employees.salary%TYPE :=0;
BEGIN
  SELECT salary
  INTO   v_salary
  FROM   employees
  WHERE  employee_id = p_id;
  RETURN v_salary;
END get_sal;
/
```



Executing Functions

- **Invoke a function as part of a PL/SQL expression.**
- **Create a variable to hold the returned value.**
- **Execute the function. The variable will be populated by the value returned through a RETURN statement.**

Executing Functions: Example



1. Load and run the `get_salary.sql` file to create the function

2 → `VARIABLE g_salary NUMBER`

3 → `EXECUTE :g_salary := get_sal(117)`

4 → `PRINT g_salary`

PL/SQL procedure successfully completed.

G_SALARY

2800

Advantages of User-Defined Functions in SQL Expressions

- 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 character strings

Invoking Functions in SQL Expressions: Example

```
CREATE OR REPLACE FUNCTION tax(p_value IN NUMBER)
  RETURN NUMBER IS
BEGIN
  RETURN (p_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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Locations to Call User-Defined Functions

- **Select list of a SELECT command**
- **Condition of the WHERE and HAVING clauses**
- **CONNECT BY, START WITH, ORDER BY, and GROUP BY clauses**
- **VALUES clause of the INSERT command**
- **SET clause of the UPDATE command**

Restrictions on Calling Functions from SQL Expressions

To be callable from SQL expressions, a user-defined function must:

- **Be a stored function**
- **Accept only IN parameters**
- **Accept only valid SQL data types, not PL/SQL specific types, as parameters**
- **Return data types that are valid SQL data types, not PL/SQL specific types**

Restrictions on Calling Functions from SQL Expressions

- **Functions called from SQL expressions cannot contain DML statements.**
- **Functions called from UPDATE/DELETE statements on a table T cannot contain DML on the same table T.**
- **Functions called from an UPDATE or a DELETE statement on a table T cannot query the same table.**
- **Functions called from SQL statements cannot contain statements that end the transactions.**
- **Calls to subprograms that break the previous restriction are not allowed in the function.**

Restrictions on Calling from SQL

```
CREATE OR REPLACE FUNCTION dml_call_sql (p_sal NUMBER)
  RETURN NUMBER IS
BEGIN
  INSERT INTO employees(employee_id, last_name, email,
                        hire_date, job_id, salary)
    VALUES(1, 'employee 1', 'empl@company.com',
           SYSDATE, 'SA_MAN', 1000);
  RETURN (p_sal + 100);
END;
/
```

Function created.

```
UPDATE employees SET salary = dml_call_sql(2000)
 WHERE employee_id = 170;
```

```
UPDATE employees SET salary = dml_call_sql(2000)
 *
```

ERROR at line 1:

ORA-04091: table PLSQL.EMPLOYEES is mutating, trigger/function may not see it

ORA-06512: at "PLSQL.DML_CALL_SQL", line 4



Removing Functions

Drop a stored function.

Syntax:

```
DROP FUNCTION function_name
```

Example:

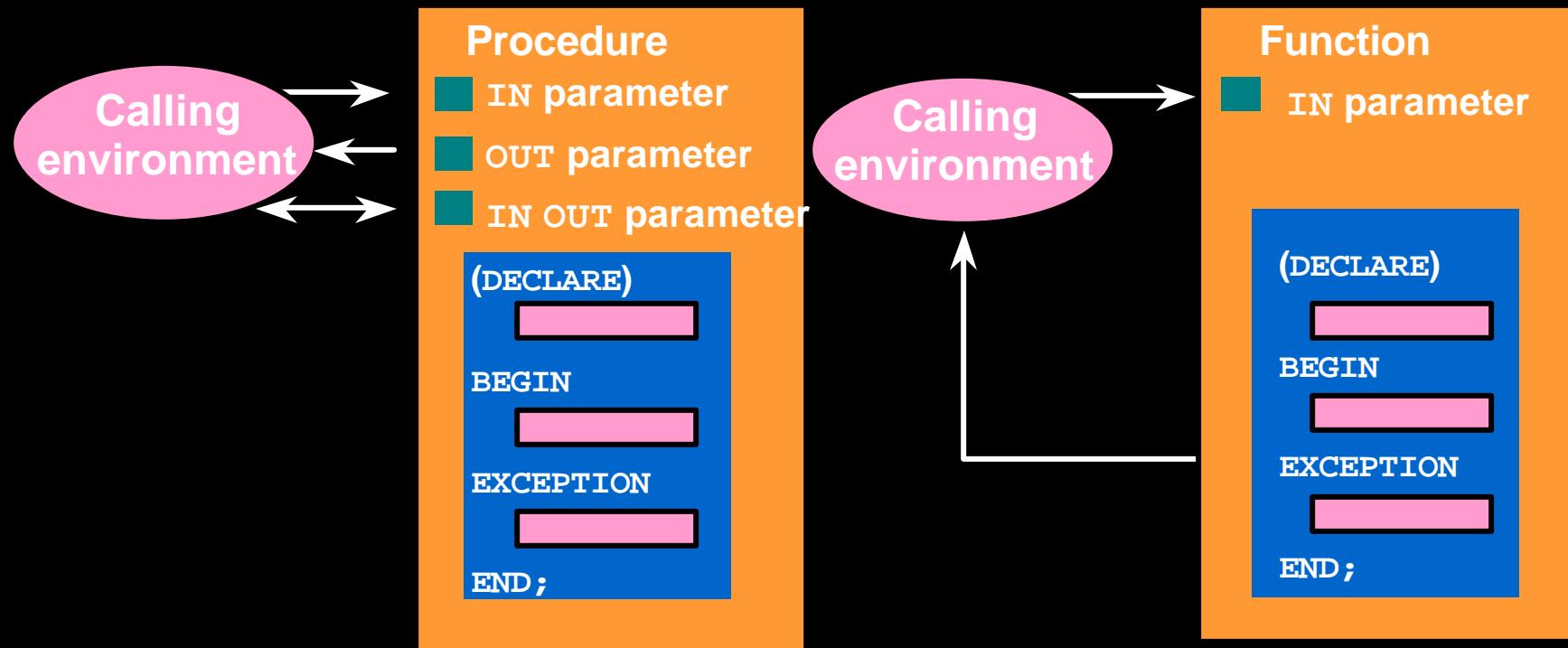
```
DROP FUNCTION get_sal;
```

Function dropped.

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

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Procedure or Function?



Comparing Procedures and 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 none, one, or many values	Must return a single value
Can contain a RETURN statement	Must contain at least one RETURN statement

Benefits of Stored Procedures and Functions

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

Summary

In this lesson, you should have learned that:

- A function is a named PL/SQL block that must return a value.
- A function is created by using the CREATE FUNCTION syntax.
- A function is invoked as part of an expression.
- A function stored in the database can be called in SQL statements.
- A function can be removed from the database by using the DROP FUNCTION syntax.
- Generally, you use a procedure to perform an action and a function to compute a value.

Practice 10 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**



11

Managing Subprograms

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Objectives

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

- **Contrast system privileges with object privileges**
- **Contrast invokers rights with definers rights**
- **Identify views in the data dictionary to manage stored objects**
- **Describe how to debug subprograms by using the DBMS_OUTPUT package**

Required Privileges

System privileges

DBA grants



```
CREATE (ANY) PROCEDURE  
ALTER ANY PROCEDURE  
DROP ANY PROCEDURE  
EXECUTE ANY PROCEDURE
```

Object privileges

Owner grants



```
EXECUTE
```

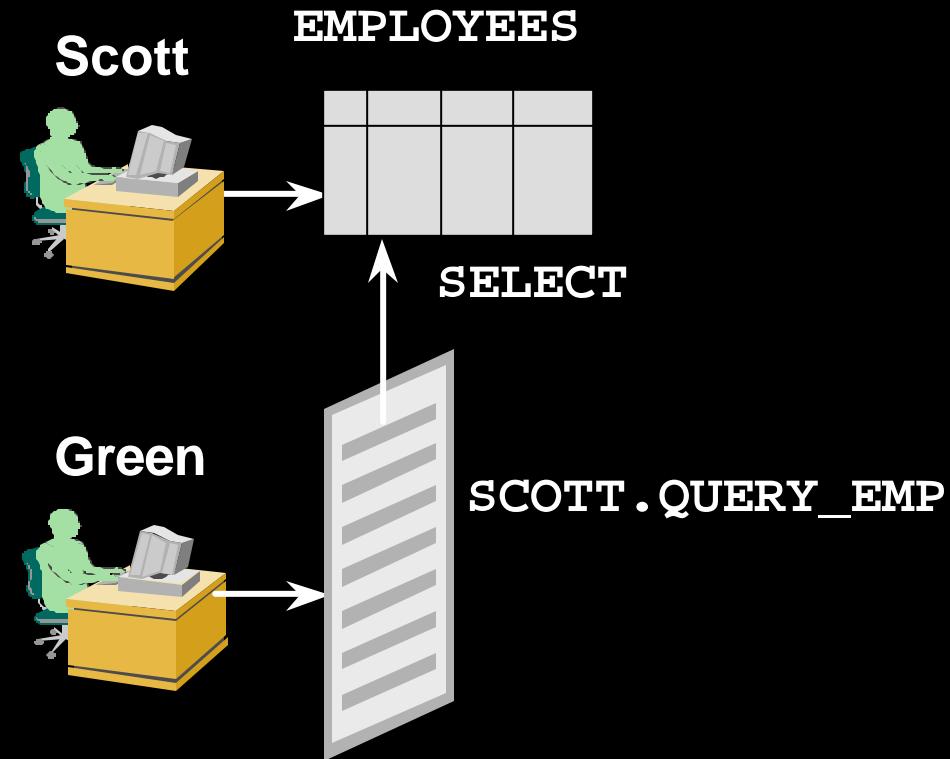
To be able to refer and access objects from a different schema in a subprogram, you must be granted access to the referred objects explicitly, not through a role.

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Granting Access to Data

Direct access:

```
GRANT SELECT  
ON employees  
TO scott;  
Grant Succeeded.
```



Indirect access:

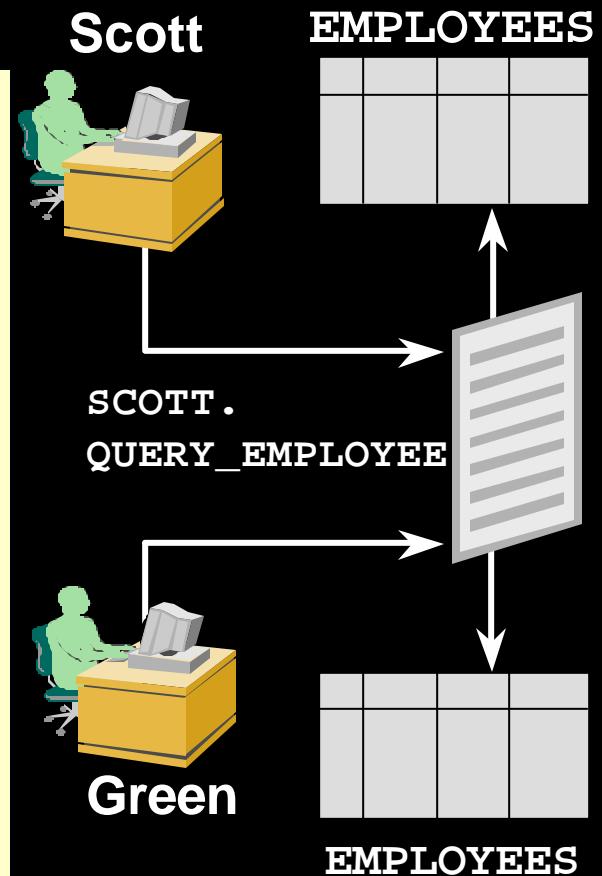
```
GRANT EXECUTE  
ON query_emp  
TO green;  
Grant Succeeded.
```

The procedure executes with the privileges of the owner (default).

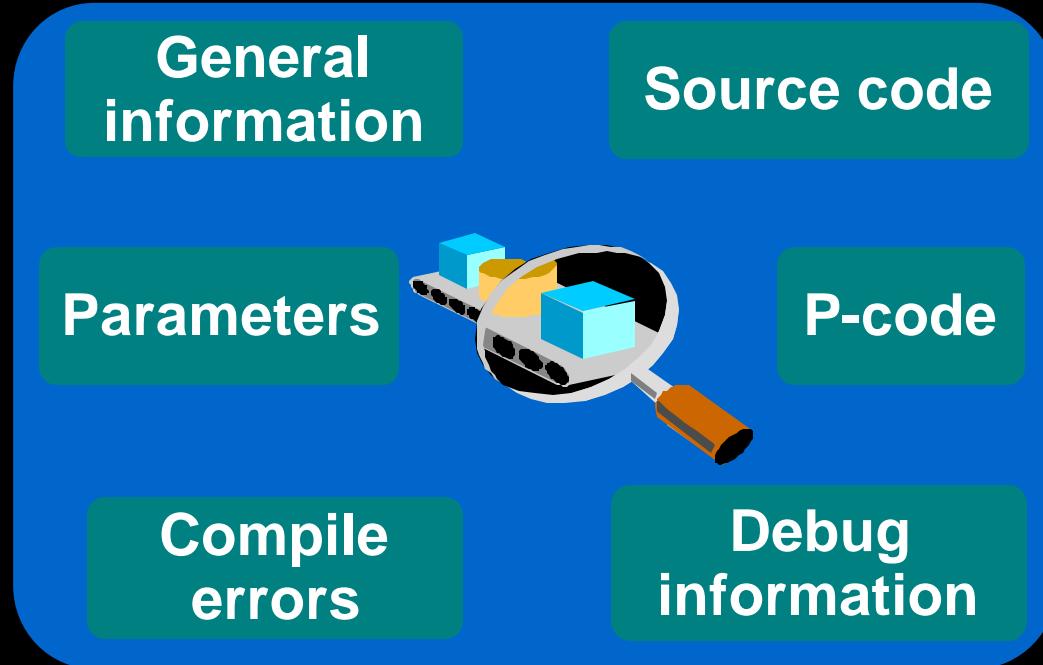
Using Invoker's-Rights

The procedure executes with the privileges of the user.

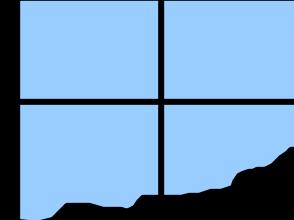
```
CREATE PROCEDURE query_employee
(p_id IN employees.employee_id%TYPE,
 p_name OUT employees.last_name%TYPE,
 p_salary OUT employees.salary%TYPE,
 p_comm OUT
    employees.commission_pct%TYPE)
AUTHID CURRENT_USER
IS
BEGIN
  SELECT last_name, salary,
         commission_pct
    INTO p_name, p_salary, p_comm
   FROM employees
  WHERE employee_id=p_id;
END query_employee;
/
```



Managing Stored PL/SQL Objects



Data dictionary



USER_OBJECTS

Column	Column Description
OBJECT_NAME	Name of the object
OBJECT_ID	Internal identifier for the object
OBJECT_TYPE	Type of object, for example, TABLE, PROCEDURE, FUNCTION, PACKAGE, PACKAGE BODY, TRIGGER
CREATED	Date when the object was created
LAST_DDL_TIME	Date when the object was last modified
TIMESTAMP	Date and time when the object was last recompiled
STATUS	VALID or INVALID

*Abridged column list

List All Procedures and Functions

```
SELECT object_name, object_type  
FROM user_objects  
WHERE object_type in ('PROCEDURE','FUNCTION')  
ORDER BY object_name;
```

OBJECT_NAME	OBJECT_TYPE
ADD_DEPT	PROCEDURE
ADD_JOB	PROCEDURE
ADD_JOB_HISTORY	PROCEDURE
ANNUAL_COMP	FUNCTION
DEL_JOB	PROCEDURE
DML_CALL_SQL	FUNCTION
...	
TAX	FUNCTION
UPD_JOB	PROCEDURE
VALID_DEPTID	FUNCTION

24 rows selected.

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USER_SOURCE Data Dictionary View

Column	Column Description
NAME	Name of the object
TYPE	Type of object, for example, PROCEDURE, FUNCTION, PACKAGE, PACKAGE BODY
LINE	Line number of the source code
TEXT	Text of the source code line

List the Code of Procedures and Functions

```
SELECT  text
FROM    user_source
WHERE   name = 'QUERY_EMPLOYEE'
ORDER BY line;
```

TEXT
PROCEDURE query_employee
(p_id IN employees.employee_id%TYPE, p_name OUT employees.last_name%TYPE,
p_salary OUT employees.salary%TYPE, p_comm OUT employees.commission_pct%TYPE)
AUTHID CURRENT_USER
IS
BEGIN
SELECT last_name, salary, commission_pct
INTO p_name,p_salary,p_comm
FROM employees
WHERE employee_id=p_id;
END query_employee;

11 rows selected.

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USER_ERRORS

Column	Column Description
NAME	Name of the object
TYPE	Type of object, for example, PROCEDURE, FUNCTION, PACKAGE, PACKAGE BODY, TRIGGER
SEQUENCE	Sequence number, for ordering
LINE	Line number of the source code at which the error occurs
POSITION	Position in the line at which the error occurs
TEXT	Text of the error message

Detecting Compilation Errors: Example

```
CREATE OR REPLACE PROCEDURE log_execution
IS
BEGIN
  INPUT INTO log_table (user_id, log_date)
          -- wrong
  VALUES (USER, SYSDATE);
END;
/
```

Warning: Procedure created with compilation errors.



List Compilation Errors by Using USER_ERRORS

```
SELECT line || '/' || position POS, text
FROM   user_errors
WHERE  name = 'LOG_EXECUTION'
ORDER BY line;
```

POS	TEXT
4/7	PLS-00103: Encountered the symbol "INTO" when expecting one of the following: := . (@ % ;
5/1	PLS-00103: Encountered the symbol "VALUES" when expecting one of the following: . (, % ; limit The symbol "VALUES" was ignored.
6/1	PLS-00103: Encountered the symbol "END"

List Compilation Errors by Using SHOW ERRORS

```
SHOW ERRORS PROCEDURE log_execution
```

Errors for PROCEDURE LOG_EXECUTION:

LINE/COL	ERROR
4/7	PLS-00103: Encountered the symbol "INTO" when expecting one of the following: := . (@ % ;
5/1	PLS-00103: Encountered the symbol "VALUES" when expecting one of the following: . (, % ; limit The symbol "VALUES" was ignored.
6/1	PLS-00103: Encountered the symbol "END"

DESCRIBE in iSQL*Plus

```
DESCRIBE query_employee  
DESCRIBE add_dept  
DESCRIBE tax
```

PROCEDURE QUERY_EMPLOYEE

Argument Name	Type	In/Out	Default?
P_ID	NUMBER(6)	IN	
P_NAME	VARCHAR2(25)	OUT	
P_SALARY	NUMBER(8,2)	OUT	
P_COMM	NUMBER(2,2)	OUT	

PROCEDURE ADD_DEPT

Argument Name	Type	In/Out	Default?
P_NAME	VARCHAR2(30)	IN	DEFAULT
P_LOC	NUMBER(4)	IN	DEFAULT

FUNCTION TAX RETURNS NUMBER

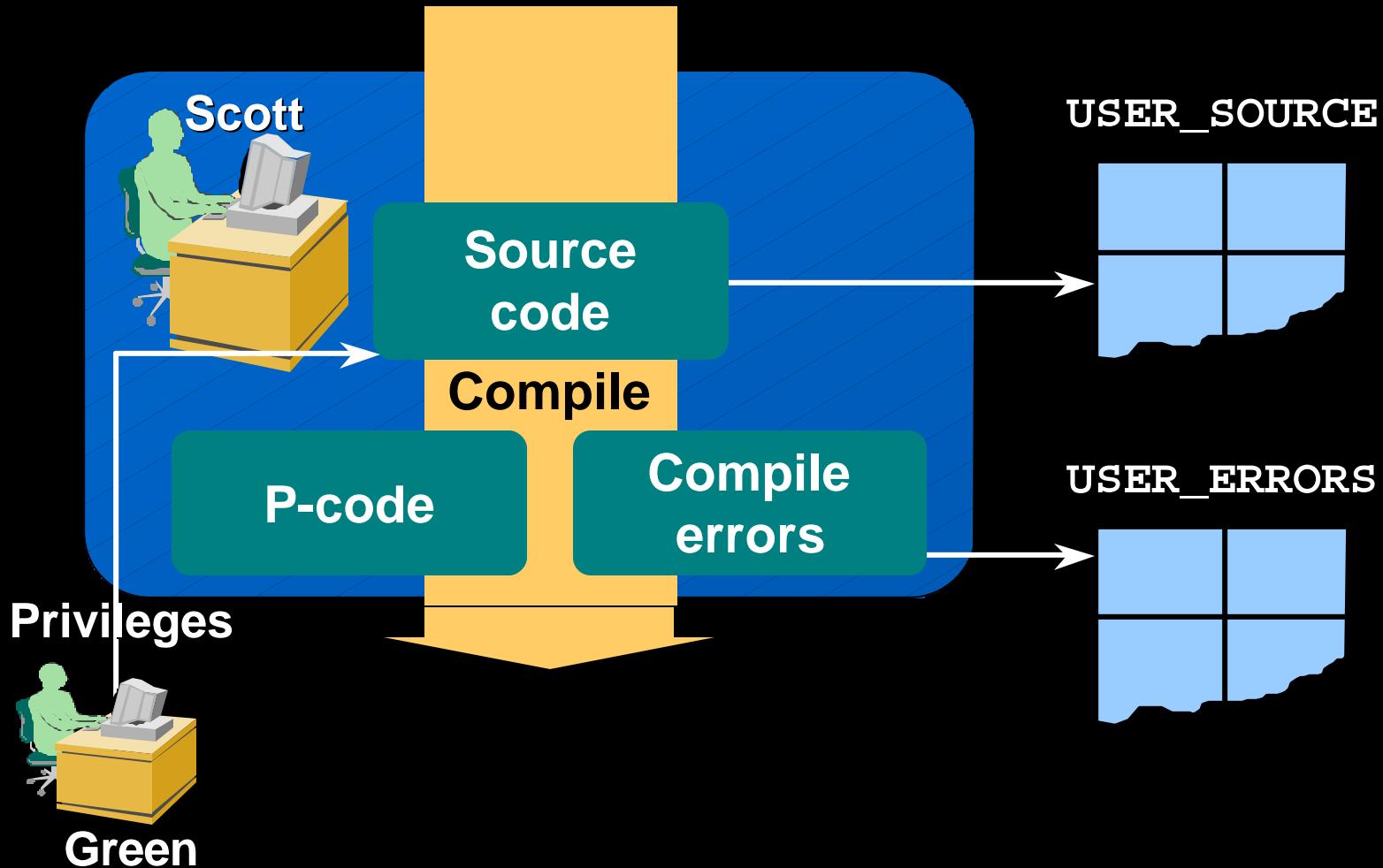
Argument Name	Type	In/Out	Default?
P_VALUE	NUMBER	IN	

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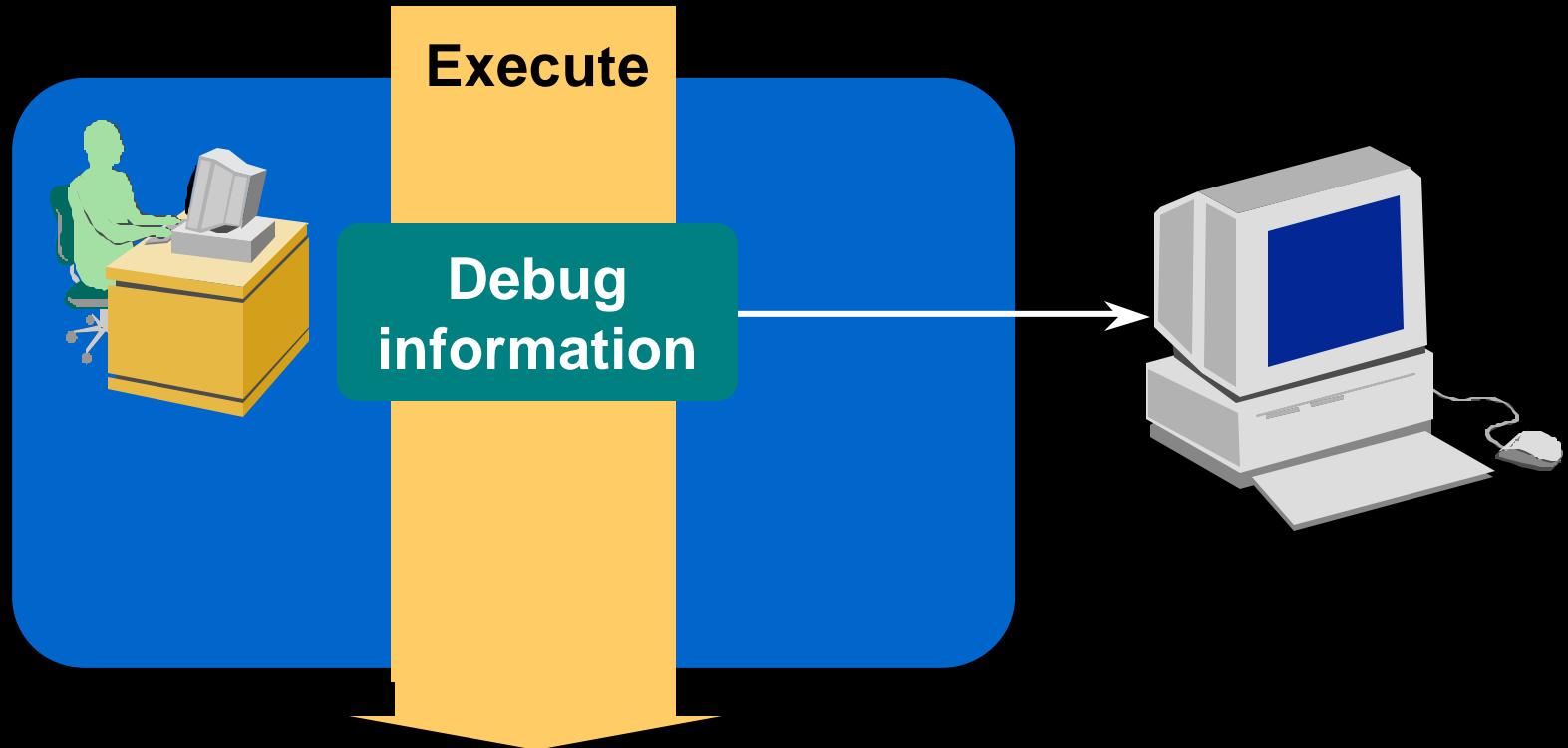
Debugging PL/SQL Program Units

- **The DBMS_OUTPUT package:**
 - Accumulates information into a buffer
 - Allows retrieval of the information from the buffer
- **Autonomous procedure calls (for example, writing the output to a log table)**
- **Software that uses DBMS_DEBUG**
 - Procedure Builder
 - Third-party debugging software

Summary



Summary



Practice 11 Overview

This practice covers the following topics:

- **Re-creating the source file for a procedure**
- **Re-creating the source file for a function**

12

Creating Packages

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Objectives

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

- **Describe packages and list their possible 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 a use for a bodiless package**

Overview of Packages

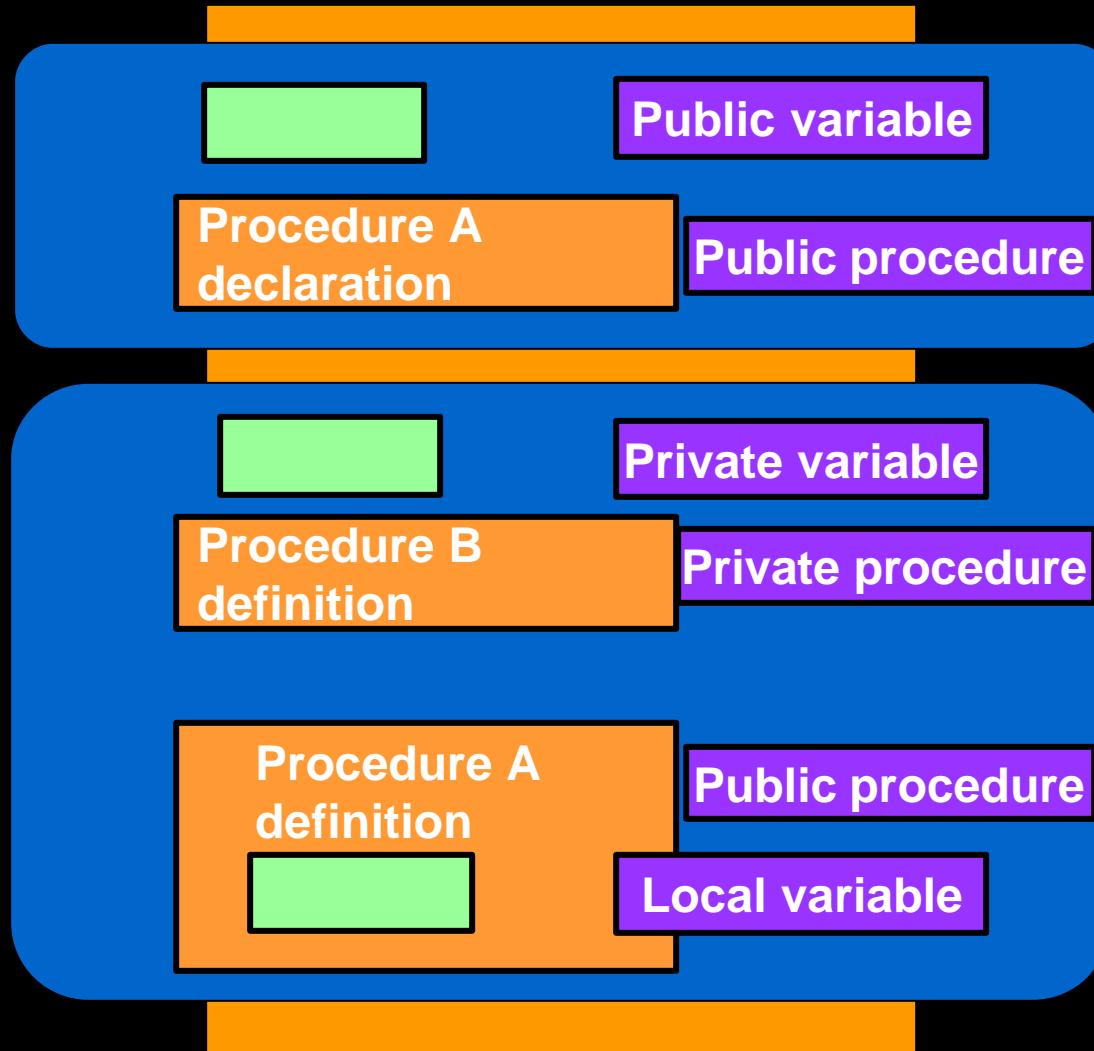
Packages:

- **Group logically related PL/SQL types, items, and subprograms**
- **Consist of two parts:**
 - **Specification**
 - **Body**
- **Cannot be invoked, parameterized, or nested**
- **Allow the Oracle server to read multiple objects into memory at once**

Components of a Package

Package specification

Package body

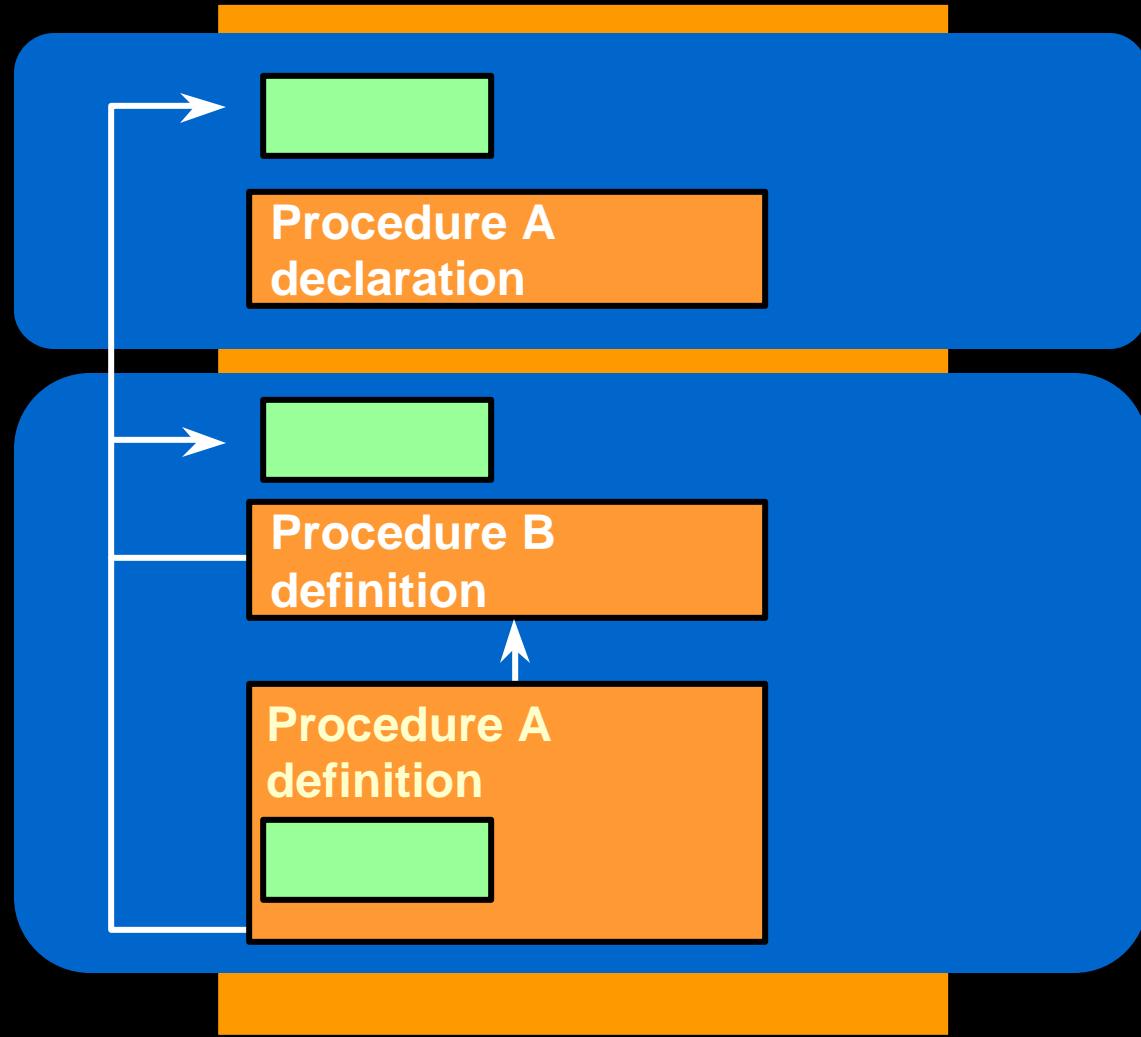


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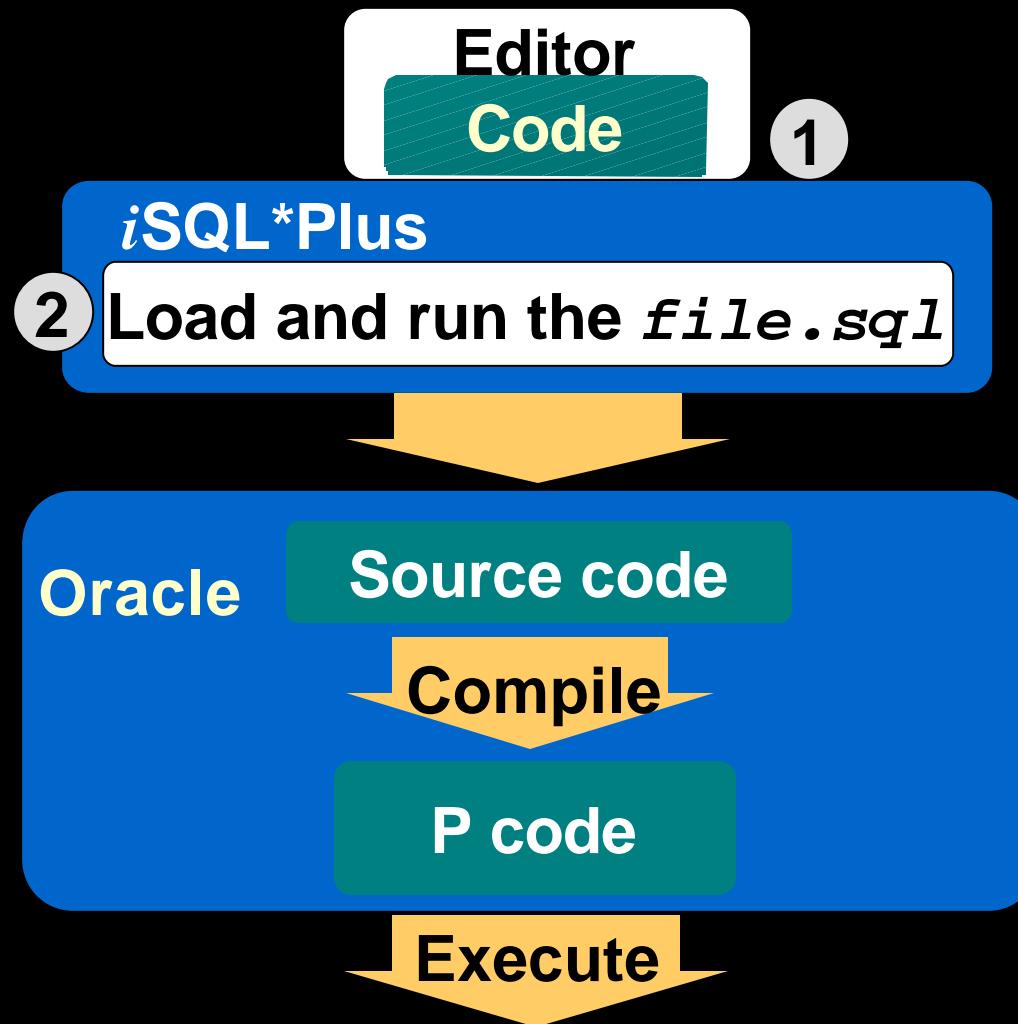
Referencing Package Objects

Package specification

Package body



Developing a Package



Developing a Package

- Saving the text of the CREATE PACKAGE statement in two different SQL files facilitates later modifications to the package.
- A package specification can exist without a package body, but a package body cannot exist without a package specification.

Creating the Package Specification

Syntax:

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

- The **REPLACE** option drops and recreates 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.**



Declaring Public Constructs

Package specification

COMM_PACKAGE package

G_COMM

1

RESET_COMM
procedure
declaration

2

Creating a Package Specification: Example

```
CREATE OR REPLACE PACKAGE comm_package IS
    g_comm NUMBER := 0.10; --initialized to 0.10
    PROCEDURE reset_comm
        (p_comm     IN NUMBER);
END comm_package;
/
```

Package created.

- **G_COMM is a global variable and is initialized to 0.10.**
- **RESET_COMM is a public procedure that is implemented in the package body.**



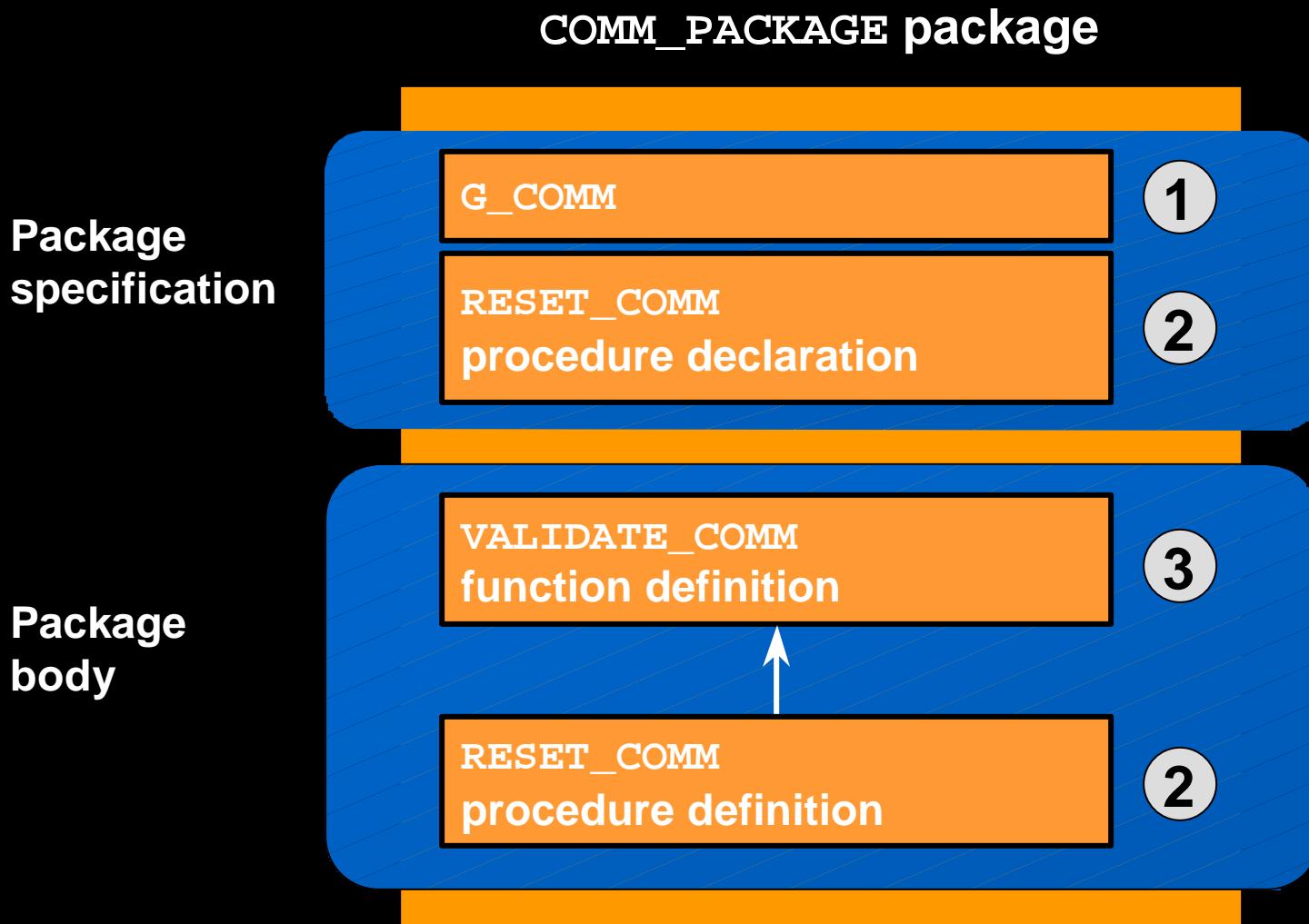
Creating the Package Body

Syntax:

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

- The REPLACE option drops and recreates the package body.
- Identifiers defined only in the package body are private constructs. These are not visible outside the package body.
- All private constructs must be declared before they are used in the public constructs.

Public and Private Constructs



Creating a Package Body: Example

comm_pack.sql

```
CREATE OR REPLACE PACKAGE BODY comm_package
IS
    FUNCTION validate_comm (p_comm IN NUMBER)
        RETURN BOOLEAN
    IS
        v_max_comm      NUMBER;
    BEGIN
        SELECT      MAX(commission_pct)
        INTO        v_max_comm
        FROM        employees;
        IF      p_comm > v_max_comm THEN RETURN(FALSE);
        ELSE      RETURN(TRUE);
        END IF;
    END validate_comm;
...

```



Creating a Package Body: Example

`comm_pack.sql`

```
PROCEDURE    reset_comm (p_comm      IN      NUMBER)
IS
BEGIN
  IF  validate_comm(p_comm)
    THEN    g_comm:=p_comm;    --reset global variable
  ELSE
    RAISE_APPLICATION_ERROR(-20210,'Invalid commission');
  END IF;
END reset_comm;
END comm_package;
/
```

Package body created.

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Invoking Package Constructs

Example 1: Invoke a function from a procedure within the same package.

```
CREATE OR REPLACE PACKAGE BODY comm_package IS
    . . .
    PROCEDURE reset_comm
        (p_comm IN NUMBER)
    IS
    BEGIN
        IF validate_comm(p_comm)
        THEN g_comm := p_comm;
        ELSE
            RAISE_APPLICATION_ERROR
                (-20210, 'Invalid commission');
        END IF;
    END reset_comm;
END comm_package;
```



Invoking Package Constructs

Example 2: Invoke a package procedure from *i*SQL*Plus.

```
EXECUTE comm_package.reset_comm(0.15)
```

Example 3: Invoke a package procedure in a different schema.

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

Example 4: Invoke a package procedure in a remote database.

```
EXECUTE comm_package.reset_comm@ny(0.15)
```

Declaring a Bodiless Package

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

```
Package created.
20 miles = 32.186 km
PL/SQL procedure successfully completed.
```



Referencing a Public Variable from a Stand-Alone Procedure

Example:

```
CREATE OR REPLACE PROCEDURE meter_to_yard
    (p_meter IN NUMBER, p_yard OUT NUMBER)
IS
BEGIN
    p_yard := p_meter * global_consts.meter_2_yard;
END meter_to_yard;
/
VARIABLE yard NUMBER
EXECUTE meter_to_yard (1, :yard)
PRINT yard
```

Procedure created.

PL/SQL procedure successfully completed.

YARD
1.0936

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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;
```

Guidelines for Developing 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.**

Advantages of Packages

- **Modularity:** Encapsulate related constructs.
- **Easier application design:** Code and compile specification and body separately.
- **Hiding information:**
 - Only the declarations in the package specification are visible and accessible to applications.
 - Private constructs in the package body are hidden and inaccessible.
 - All coding is hidden in the package body.

Advantages of Packages

- **Added functionality: Persistence 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**

Summary

In this lesson, you should have learned how to:

- **Improve organization, management, security, and performance by using packages**
- **Group related procedures and functions together in a package**
- **Change a package body without affecting a package specification**
- **Grant security access to the entire package**

Summary

In this lesson, you should have learned how to:

- **Hide the source code from users**
- **Load the entire package into memory on the first call**
- **Reduce disk access for subsequent calls**
- **Provide identifiers for the user session**

Summary

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

Practice 12 Overview

This practice covers the following topics:

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

13

More Package Concepts

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Objectives

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

- Write packages that use the overloading feature
- Describe errors with mutually referential subprograms
- Initialize variables with a one-time-only procedure
- Identify persistent states

Overloading

- Enables you to use the same name for different subprograms inside a PL/SQL block, a subprogram, or a package
- Requires the formal parameters of the subprograms to differ in number, order, or data type family
- Enables you to build more flexibility because a user or application is not restricted by the specific data type or number of formal parameters

Note: Only local or packaged subprograms can be overloaded. You cannot overload stand-alone subprograms.



Overloading: Example

over_pack.sql

```
CREATE OR REPLACE PACKAGE over_pack
IS
    PROCEDURE add_dept
        (p_deptno IN departments.department_id%TYPE,
         p_name IN departments.department_name%TYPE
                    DEFAULT 'unknown',
         p_loc IN departments.location_id%TYPE DEFAULT 0);
    PROCEDURE add_dept
        (p_name IN departments.department_name%TYPE
                    DEFAULT 'unknown',
         p_loc IN departments.location_id%TYPE DEFAULT 0);
END over_pack;
/
```

Package created.

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Overloading: Example

over_pack_body.sql

```
CREATE OR REPLACE PACKAGE BODY over_pack IS
  PROCEDURE add_dept
  (p_deptno IN departments.department_id%TYPE,
   p_name IN departments.department_name%TYPE DEFAULT 'unknown',
   p_loc  IN departments.location_id%TYPE DEFAULT 0)
  IS
  BEGIN
    INSERT INTO departments (department_id,
                            department_name, location_id)
    VALUES  (p_deptno, p_name, p_loc);
  END add_dept;
  PROCEDURE add_dept
  (p_name IN departments.department_name%TYPE DEFAULT 'unknown',
   p_loc  IN departments.location_id%TYPE DEFAULT 0)
  IS
  BEGIN
    INSERT INTO departments (department_id,
                            department_name, location_id)
    VALUES  (departments_seq.NEXTVAL, p_name, p_loc);
  END add_dept;
END over_pack;
/
```



Overloading: Example

- Most built-in functions are overloaded.
- For example, see the TO_CHAR function of the STANDARD package.

```
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;
```

- If you redeclare a built-in subprogram in a PL/SQL program, your local declaration overrides the global declaration.

Using Forward Declarations

You must declare identifiers before referencing them.

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

  PROCEDURE calc_rating(. . .)
  IS
  BEGIN
    ...
  END;

END forward_pack;
/
```



Using Forward Declarations

```
CREATE OR REPLACE PACKAGE BODY forward_pack
IS

PROCEDURE calc_rating(. . .);      -- forward declaration

PROCEDURE award_bonus(. . .)
IS
BEGIN
calc_rating(. . .);
. . .
END;

PROCEDURE calc_rating(. . .)
IS
BEGIN
. . .
END;

END forward_pack;
/
```



Creating a One-Time-Only Procedure

```
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;
/
```



Restrictions on Package Functions Used in SQL

A function called from:

- **A query or DML statement can not end the current transaction, create or roll back to a savepoint, or ALTER the system or session.**
- **A query statement or a parallelized DML statement can not execute a DML statement or modify the database.**
- **A DML statement can not read or modify the particular table being modified by that DML statement.**

Note: Calls to subprograms that break the above restrictions are not allowed.



User Defined Package: taxes_pack

```
CREATE OR REPLACE PACKAGE taxes_pack
IS
    FUNCTION tax (p_value IN NUMBER) RETURN NUMBER;
END taxes_pack;
/
```

Package created.

```
CREATE OR REPLACE PACKAGE BODY taxes_pack
IS
    FUNCTION tax (p_value IN NUMBER) RETURN NUMBER
    IS
        v_rate NUMBER := 0.08;
    BEGIN
        RETURN (p_value * v_rate);
    END tax;
END taxes_pack;
/
```

Package body created.



Invoking a User-Defined Package Function from a SQL Statement

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

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.

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Persistent State of Package Variables: Example

```
CREATE OR REPLACE PACKAGE comm_package IS
    g_comm NUMBER := 10;          --initialized to 10
    PROCEDURE reset_comm (p_comm IN NUMBER);
END comm_package;
/
```

```
CREATE OR REPLACE PACKAGE BODY comm_package IS
    FUNCTION validate_comm (p_comm IN NUMBER)
        RETURN BOOLEAN
    IS v_max_comm NUMBER;
    BEGIN
        ...
        -- validates commission to be less than maximum
        -- commission in the table
    END validate_comm;
    PROCEDURE reset_comm (p_comm IN NUMBER)
    IS BEGIN
        ...
        -- calls validate_comm with specified value
    END reset_comm;
END comm_package;
/
```



Persistent State of Package Variables

Time	Scott	Jones
9:00	<pre>EXECUTE comm_package.reset_comm (0.25) max_comm=0.4 > 0.25 g_comm = 0.25</pre>	
9:30		<pre>INSERT INTO employees (last_name, commission_pct) VALUES ('Madonna', 0.8); max_comm=0.8</pre>
9:35		<pre>EXECUTE comm_package.reset_comm(0.5) max_comm=0.8 > 0.5 g_comm = 0.5</pre>

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Persistent State of Package Variables

Time	Scott	Jones
9:00	<code>EXECUTE comm_package.reset_comm (0.25)</code> <code>max_comm=0.4 > 0.25</code> <code>g_comm = 0.25</code>	
9:30		<code>INSERT INTO employees (last_name, commission_pct) VALUES ('Madonna', 0.8);</code> <code>max_comm=0.8</code>
9:35		<code>EXECUTE comm_package.reset_comm(0.5)</code> <code>max_comm=0.8 > 0.5</code> <code>g_comm = 0.5</code>
10:00	<code>EXECUTE comm_package.reset_comm (0.6)</code> <code>max_comm=0.4 < 0.6 INVALID</code>	
11:00		<code>ROLLBACK;</code>
11:01		<code>EXIT</code>

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Persistent State of Package Variables

Time	Scott	Jones
9:00	<pre>EXECUTE comm_package.reset_comm (0.25) max_comm=0.4 > 0.25 g_comm = 0.25</pre>	
9:30		<pre>INSERT INTO employees (last_name, commission_pct) VALUES ('Madonna', 0.8); max_comm=0.8</pre>
9:35		<pre>EXECUTE comm_package.reset_comm(0.5) max_comm=0.8 > 0.5 g_comm = 0.5</pre>
10:00	<pre>EXECUTE comm_package.reset_comm (0.6) max_comm=0.4 < 0.6 INVALID</pre>	<pre>ROLLBACK; EXIT</pre>
11:00		<pre>Logged In again. g_comm = 10, max_comm=0.4</pre>
11:01		<pre>EXECUTE comm_package.reset_comm(0.25)</pre>
11:45		
12:00	<p>VALID →</p>	

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Controlling the Persistent State of a Package Cursor

Example:

```
CREATE OR REPLACE PACKAGE pack_cur
IS
    CURSOR c1 IS      SELECT employee_id
                      FROM     employees
                      ORDER BY employee_id DESC;
    PROCEDURE proc1_3rows;
    PROCEDURE proc4_6rows;
END pack_cur;
/
```

Package created.



Controlling the Persistent State of a Package Cursor

```
CREATE OR REPLACE PACKAGE BODY pack_cur IS
  v_empno NUMBER;
  PROCEDURE proc1_3rows IS
  BEGIN
    OPEN c1;
    LOOP
      FETCH c1 INTO v_empno;
      DBMS_OUTPUT.PUT_LINE('Id : ' || (v_empno));
      EXIT WHEN c1%ROWCOUNT >= 3;
    END LOOP;
  END proc1_3rows;
  PROCEDURE proc4_6rows IS
  BEGIN
    LOOP
      FETCH c1 INTO v_empno;
      DBMS_OUTPUT.PUT_LINE('Id : ' || (v_empno));
      EXIT WHEN c1%ROWCOUNT >= 6;
    END LOOP;
    CLOSE c1;
  END proc4_6rows;
END pack_cur;
/
```



Executing PACK_CUR

```
SET SERVEROUTPUT ON
EXECUTE pack_cur.proc1_3rows
EXECUTE pack_cur.proc4_6rows
```

```
Id :208
Id :207
Id :206
PL/SQL procedure successfully completed.
Id :205
Id :204
Id :203
PL/SQL procedure successfully completed.
```



PL/SQL Tables and Records in Packages

```
CREATE OR REPLACE PACKAGE emp_package IS
    TYPE emp_table_type IS TABLE OF employees%ROWTYPE
        INDEX BY BINARY_INTEGER;
    PROCEDURE read_emp_table
        (p_emp_table OUT emp_table_type);
END emp_package;
/
```

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



Summary

In this lesson, you should have learned how to:

- Overload subprograms
- Use forward referencing
- Use one-time-only procedures
- Describe the purity level of package functions
- Identify the persistent state of packaged objects

Practice 13 Overview

This practice covers the following topics:

- **Using overloaded subprograms**
- **Creating a one-time-only procedure**

14

Oracle Supplied Packages

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Objectives

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

- **Write dynamic SQL statements using DBMS_SQL and EXECUTE IMMEDIATE**
- **Describe the use and application of some Oracle server-supplied packages:**
 - DBMS_DDL
 - DBMS_JOB
 - DBMS_OUTPUT
 - UTL_FILE
 - UTL_HTTP and UTL_TCP

Using Supplied Packages

Oracle-supplied packages:

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

Using Native Dynamic SQL

Dynamic SQL:

- Is a **SQL statement that contains variables that can change during runtime**
- Is a **SQL statement with placeholders and is stored as a character string**
- Enables **general-purpose code to be written**
- Enables **data-definition, data-control, or session-control statements to be written and executed from PL/SQL**
- Is **written using either DBMS_SQL or native dynamic SQL**



Execution Flow

SQL statements go through various stages:

- Parse
- Bind
- Execute
- Fetch

Note: Some stages may be skipped.

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

Using DBMS_SQL

```
CREATE OR REPLACE PROCEDURE delete_all_rows
  (p_tab_name IN VARCHAR2, p_rows_del OUT NUMBER)
IS
  cursor_name    INTEGER;
BEGIN
  cursor_name := DBMS_SQL.OPEN_CURSOR;
  DBMS_SQLPARSE(cursor_name, 'DELETE FROM ' || p_tab_name,
                 DBMS_SQL.NATIVE );
  p_rows_del := DBMS_SQL.EXECUTE (cursor_name);
  DBMS_SQL CLOSE_CURSOR(cursor_name);
END;
/
```

Use dynamic SQL to delete rows

```
VARIABLE deleted NUMBER
EXECUTE delete_all_rows('employees', :deleted)
PRINT deleted
```

PL/SQL procedure successfully completed.

DELETED

109

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Using the EXECUTE IMMEDIATE Statement

Use the EXECUTE IMMEDIATE statement for native dynamic SQL with better performance.

```
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**.

Dynamic SQL Using EXECUTE IMMEDIATE

```
CREATE PROCEDURE del_rows
  (p_table_name  IN VARCHAR2,
   p_rows_deld    OUT NUMBER)
IS
BEGIN
  EXECUTE IMMEDIATE 'delete from ' || p_table_name;
  p_rows_deld := SQL%ROWCOUNT;
END;
/
```

Procedure created.

```
VARIABLE deleted NUMBER
EXECUTE del_rows('test_employees', :deleted)
PRINT deleted
```

PL/SQL procedure successfully completed.

DELETED

109

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Using the DBMS_DDL Package

The DBMS_DDL Package:

- Provides access to some SQL DDL statements from stored procedures
- Includes some procedures:
 - ALTER_COMPILE (object_type, owner, object_name)

```
DBMS_DDL.ALTER_COMPILE('PROCEDURE', 'A_USER', 'QUERY_EMP')
```

- ANALYZE_OBJECT (object_type, owner, name, method)

```
DBMS_DDL.ANALYZE_OBJECT('TABLE', 'A_USER', 'JOBS', 'COMPUTE')
```

Note: This package runs with the privileges of calling user, rather than the package owner SYS.



Using DBMS_JOB for Scheduling

DBMS_JOB Enables the scheduling and execution of PL/SQL programs:

- **Submitting jobs**
- **Executing jobs**
- **Changing execution parameters of jobs**
- **Removing jobs**
- **Suspending Jobs**

DBMS_JOB Subprograms

Available subprograms include:

- **SUBMIT**
- **REMOVE**
- **CHANGE**
- **WHAT**
- **NEXT_DATE**
- **INTERVAL**
- **BROKEN**
- **RUN**

Submitting Jobs

You can submit jobs by using DBMS_JOB.SUBMIT.

Available parameters include:

- JOB OUT BINARY_INTEGER
- WHAT IN VARCHAR2
- NEXT_DATE IN DATE DEFAULT SYSDATE
- INTERVAL IN VARCHAR2 DEFAULT 'NULL'
- NO_PARSE IN BOOLEAN DEFAULT FALSE

Submitting Jobs

Use DBMS_JOB.SUBMIT to place a job to be executed in the job queue.

```
VARIABLE jobno NUMBER
BEGIN
  DBMS_JOB.SUBMIT (
    job    => :jobno,
    what   => 'OVER_PACK.ADD_DEPT( ''EDUCATION'',2710);',
    next_date => TRUNC(SYSDATE + 1),
    interval  => 'TRUNC(SYSDATE + 1)'
  );
  COMMIT;
END;
/
PRINT jobno
```

PL/SQL procedure successfully completed.

JOBNO
1

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Changing Job Characteristics

- **DBMS_JOB.CHANGE:** Changes the WHAT, NEXT_DATE, and INTERVAL parameters
- **DBMS_JOB.INTERVAL:** Changes the INTERVAL parameter
- **DBMS_JOB.NEXT_DATE:** Changes the next execution date
- **DBMS_JOB.WHAT:** Changes the WHAT parameter

Running, Removing, and Breaking Jobs

- **DBMS_JOB.RUN:** Runs a submitted job immediately
- **DBMS_JOB.REMOVE:** Removes a submitted job from the job queue
- **DBMS_JOB.BROKEN:** Marks a submitted job as broken, and a broken job will not run

Viewing Information on Submitted Jobs

- Use the **DBA_JOBS** dictionary view to see the status of submitted jobs.

```
SELECT job, log_user, next_date, next_sec,  
       broken, what  
FROM DBA_JOBS;
```

JOB	LOG_USER	NEXT_DATE	NEXT_SEC	B	WHAT
1	PLSQL	28-SEP-01	06:00:00	N	OVER_PACK.ADD_DEPT('EDUCATION',2710);

- Use the **DBA_JOBS_RUNNING** dictionary view to display jobs that are currently running.

Using the DBMS_OUTPUT Package

The DBMS_OUTPUT package enables you to output messages from PL/SQL blocks. Available procedures include:

- PUT
- NEW_LINE
- PUT_LINE
- GET_LINE
- GET_LINES
- ENABLE/DISABLE

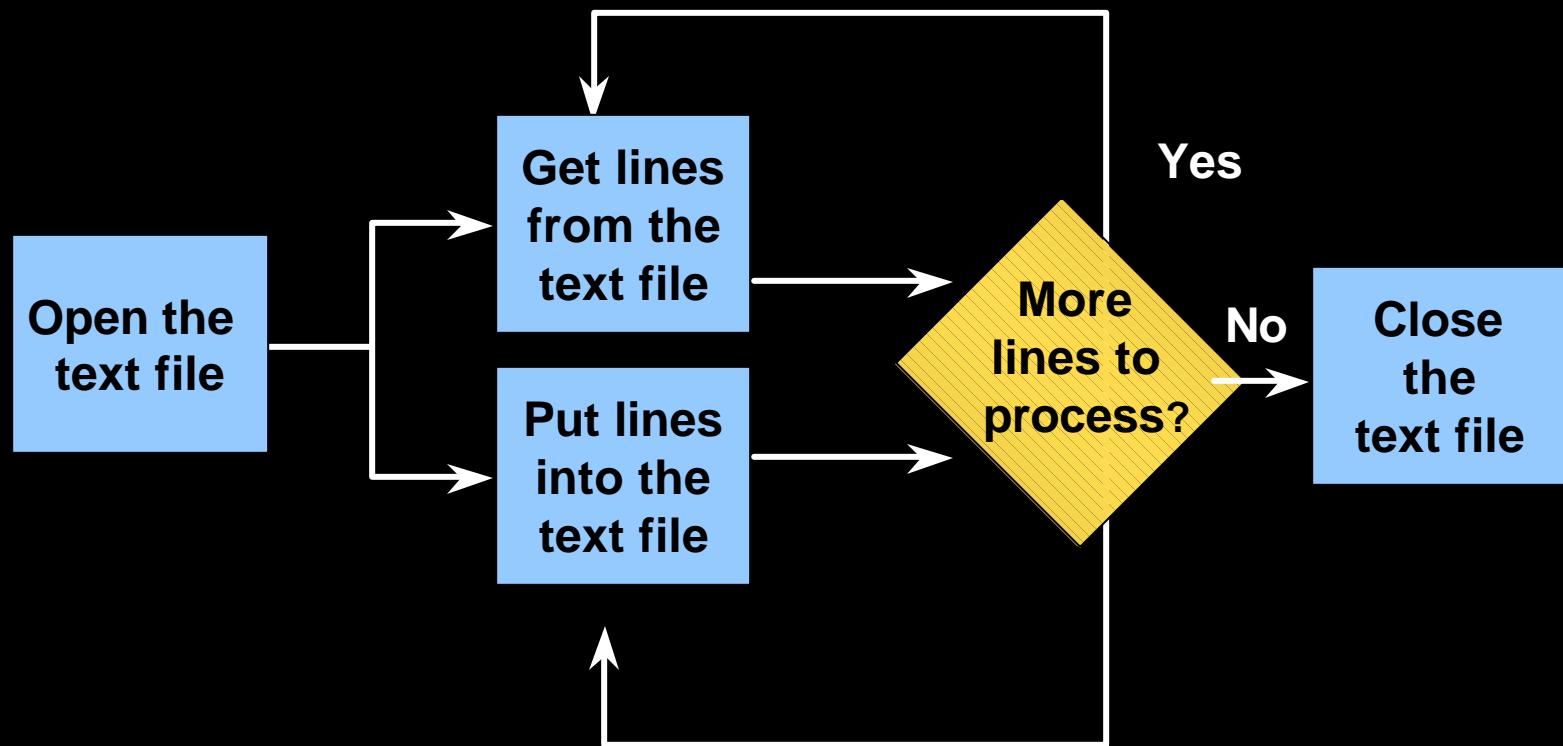
Interacting with Operating System Files

- **UTL_FILE Oracle-supplied package:**
 - Provides text file I/O capabilities
 - Is available with version 7.3 and later
- **The DBMS_LOB Oracle-supplied package:**
 - Provides read-only operations on external BFILES
 - Is available with version 8 and later
 - Enables read and write operations on internal LOBS

What Is the UTL_FILE Package?

- Extends I/O to text files within PL/SQL
- Provides security for directories on the server through the `init.ora` file
- Is similar to standard operating system I/O
 - Open files
 - Get text
 - Put text
 - Close files
 - Use the exceptions specific to the UTL_FILE package

File Processing Using the UTL_FILE Package



UTL_FILE Procedures and Functions

- **Function FOPEN**
- **Function IS_OPEN**
- **Procedure GET_LINE**
- **Procedure PUT, PUT_LINE, PUTF**
- **Procedure NEW_LINE**
- **Procedure FFLUSH**
- **Procedure FCLOSE, FCLOSE_ALL**

Exceptions Specific to the UTL_FILE Package

- **INVALID_PATH**
- **INVALID_MODE**
- **INVALID_FILEHANDLE**
- **INVALID_OPERATION**
- **READ_ERROR**
- **WRITE_ERROR**
- **INTERNAL_ERROR**

The FOPEN and IS_OPEN Functions

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

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

Using UTL_FILE

sal_status.sql

```
CREATE OR REPLACE PROCEDURE sal_status
(p_filedir IN VARCHAR2,  p_filename IN VARCHAR2)
IS
  v_filehandle UTL_FILE.FILE_TYPE;
  CURSOR emp_info IS
    SELECT last_name, salary, department_id
      FROM employees
     ORDER BY department_id;
  v_newdeptno employees.department_id%TYPE;
  v_olddeptno employees.department_id%TYPE := 0;
BEGIN
  v_filehandle := UTL_FILE.FOPEN (p_filedir, p_filename,'w');
  UTL_FILE.PUTF (v_filehandle,'SALARY REPORT: GENERATED ON
                           %s\n', SYSDATE);
  UTL_FILE.NEW_LINE (v_filehandle);
  FOR v_emp_rec IN emp_info LOOP
    v_newdeptno := v_emp_rec.department_id;
    ...
  END LOOP;
  UTL_FILE.CLOSE (v_filehandle);
END;
/
```



Using UTL_FILE

sal_status.sql

```
...
IF v_newdeptno <> v_olddeptno THEN
    UTL_FILE.PUTF (v_filehandle, 'DEPARTMENT: %s\n',
                    v_emp_rec.department_id);
END IF;
UTL_FILE.PUTF (v_filehandle, ' EMPLOYEE: %s earns: %s\n',
                v_emp_rec.last_name, v_emp_rec.salary);
v_olddeptno := v_newdeptno;
END LOOP;
UTL_FILE.PUT_LINE (v_filehandle, '*** END OF REPORT ***');
UTL_FILE.FCLOSE (v_filehandle);

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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The UTL_HTTP Package

The UTL_HTTP package:

- Enables HTTP callouts from PL/SQL and SQL to access data on the Internet
- Contains the functions REQUEST and REQUEST_PIECES which take the URL of a site as a parameter, contact that site, and return the data obtained from that site
- Requires a proxy parameter to be specified in the above functions, if the client is behind a firewall
- Raises INIT_FAILED or REQUEST_FAILED exceptions if HTTP call fails
- Reports an HTML error message if specified URL is not accessible

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Using the UTL_HTTP Package

```
SELECT UTL_HTTP.REQUEST( 'http://www.oracle.com' ,
                           'edu-proxy.us.oracle.com' )
FROM DUAL;
```

UTL_HTTP.REQUEST('HTTP://WWW.ORACLE.COM','EDU-PROXY.US.ORACLE.COM')

```
<html> <head> <title>Oracle Corporation</title> <meta name="description" content="Oracle Corporation provides the software that powers the Internet. For more information about Oracle, please call 650/506-7000."> <meta name="keywords" content="Oracle, Oracle Corporation, Oracle Corp, Oracle8i, Oracle 9i, 8i, 9i"> <script language="JavaScript" src="http://www.oracle.com/admin/jscripts/lib.js"> </script> </head> <body>
bgcolor="#FFFFFF" text="#000000" link="#000000" vlink="#FF0000"> <!--Start Header--> <center> <table border=0 cellspacing=0 cellpadding=3 width=850 align="center"> <tr> <td align= center valign="middle"> <div align="right"><a href="http://www.oracle.com/elog/trackurl?d=http://my.oracle.com&di=872609" target="_top"></a>&nbsp;<a href="/products/index.html?content.html" target="_top"></a>&nbsp; <a href="http://oraclestore.oracle.com/" target="_top"></a></div></td> <td align= center valign="middle" width="34%"> <div align="center"><a href="/" target="_top"></a></div></td> <td align= center valign="middle"> <div align="left"><a href="http://otn.oracle.com/software/"></a>&nbsp;<a href="/corporate/contact/index.html?content.html" target="_top"></a>&nbsp;<a href="/pls/use/use_query_html.show_query_form?p_person_id=100&p_location_array=&p_doc_location_array=&p_keyword_array=&p_value_array=></a></div> </td></tr></table> <!--End Header--> <table border=0 cellspacing=0 cellpadding=3 width=850> <tr><td align="center" width="100%"> <table border=1 width=850>
```

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Using the UTL_TCP Package

The UTL_TCP Package:

- **Enables PL/SQL applications to communicate with external TCP/IP-based servers using TCP/IP**
- **Contains functions to open and close connections, to read or write binary or text data to or from a service on an open connection**
- **Requires remote host and port as well as local host and port as arguments to its functions**
- **Raises exceptions if the buffer size is too small, when no more data is available to read from a connection, when a generic network error occurs, or when bad arguments are passed to a function call**

Oracle-Supplied Packages

Other Oracle-supplied packages include:

- DBMS_ALERT
- DBMS_APPLICATION_INFO
- DBMS_DESCRIBE
- DBMS_LOCK
- DBMS_SESSION
- DBMS_SHARED_POOL
- DBMS_TRANSACTION
- DBMS.Utility



Summary

In this lesson, you should have learned how to:

- **Take advantage of the preconfigured packages that are provided by Oracle**
- **Create packages by using the `catproc.sql` script**
- **Create packages individually.**

Practice 14 Overview

This practice covers using:

- **DBMS_SQL for dynamic SQL**
- **DBMS_DDL to analyze a table**
- **DBMS_JOB to schedule a task**
- **UTL_FILE to generate text reports**

15

Manipulating Large Objects

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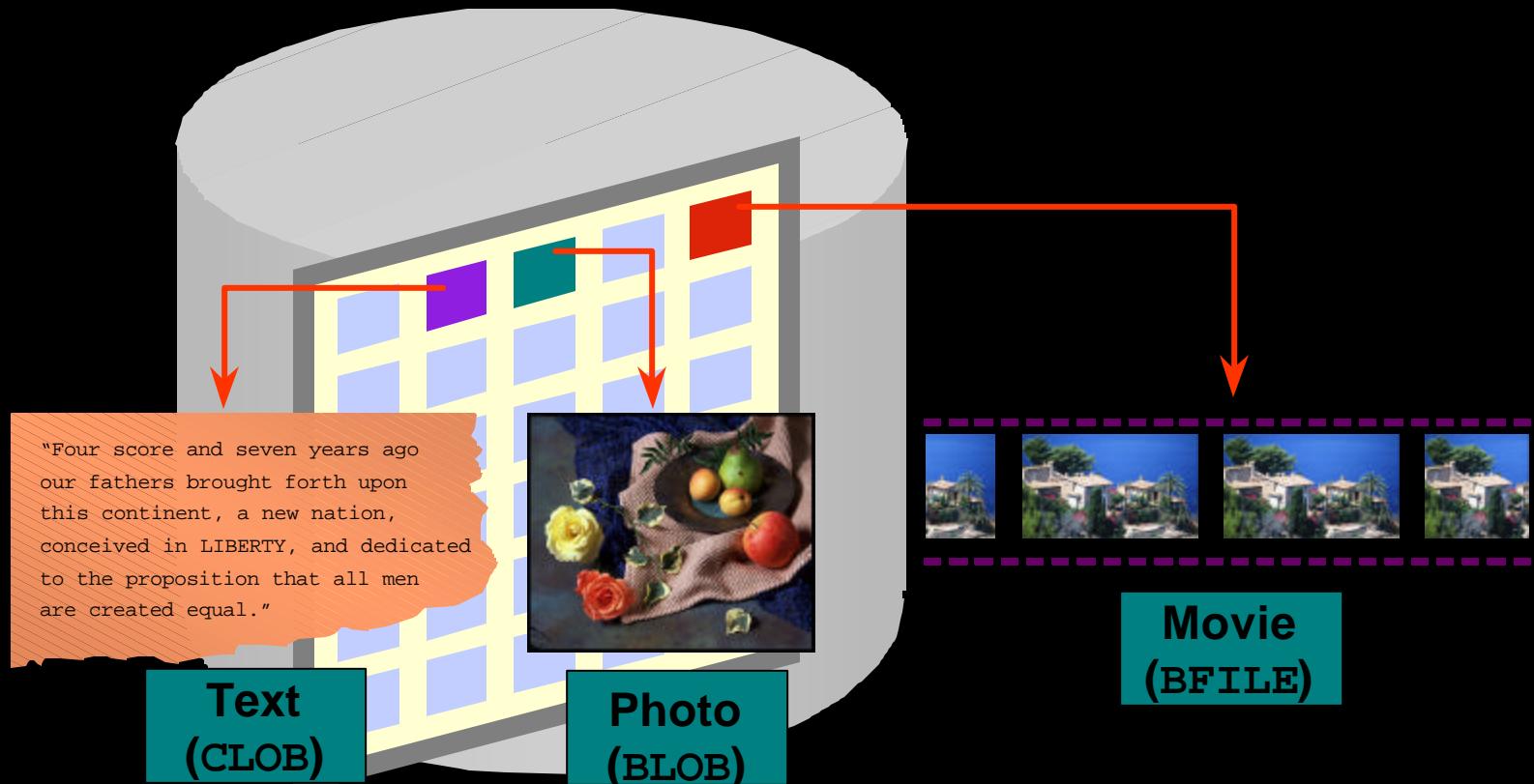
Objectives

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

- **Compare and contrast LONG and large object (LOB) 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**

What Is a LOB?

LOBs are used to store large unstructured data such as text, graphic images, films, and sound waveforms.

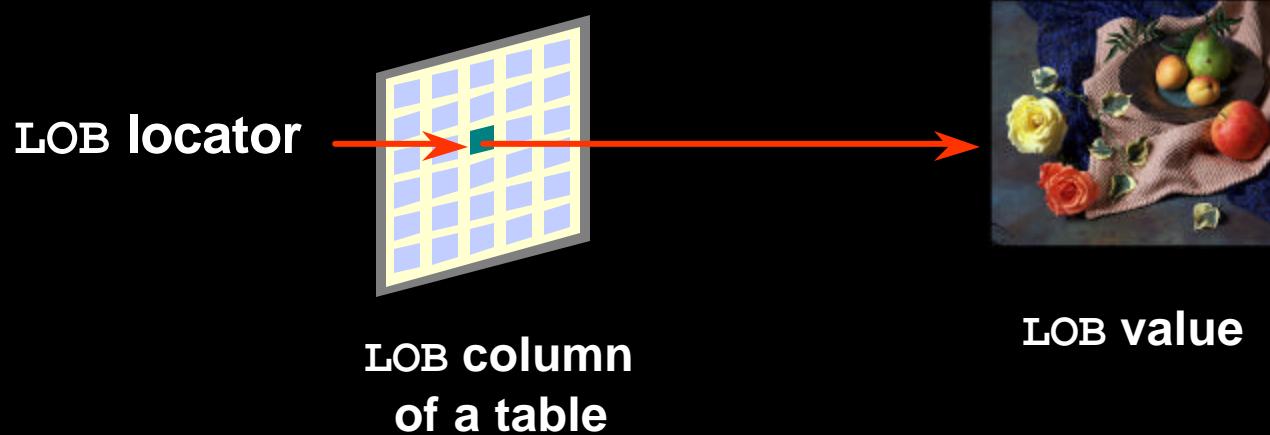


Contrasting LONG and LOB Data Types

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

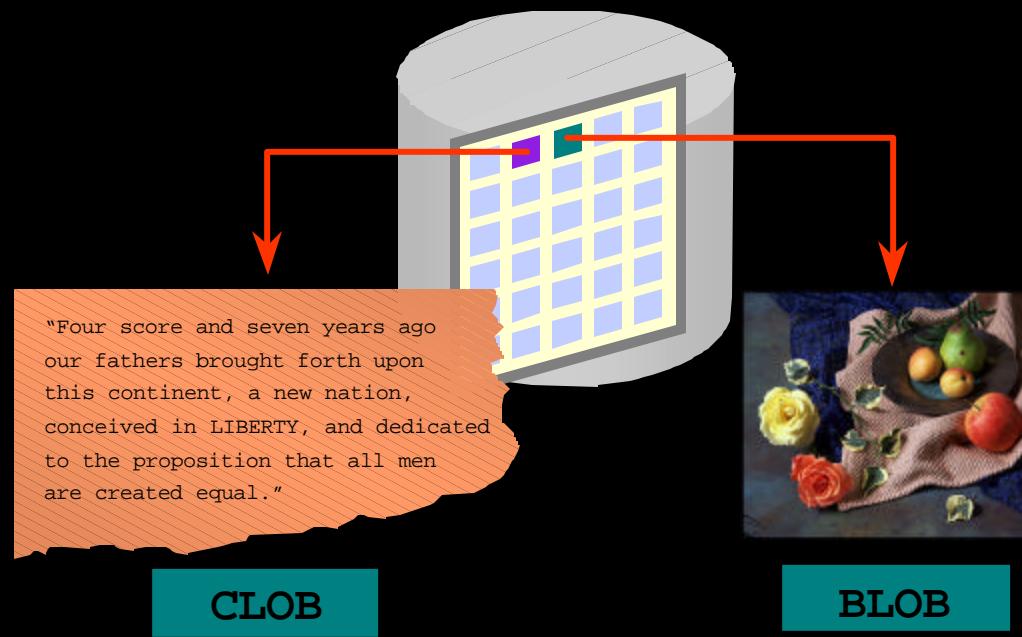
Anatomy of a LOB

The LOB column stores a locator to the LOB's value.



Internal LOBS

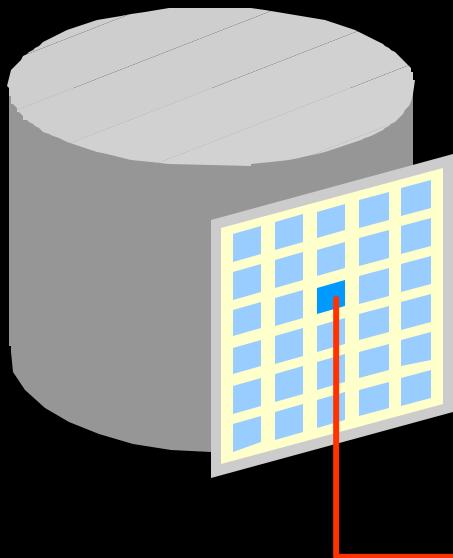
The LOB value is stored in the database.



Managing Internal LOBS

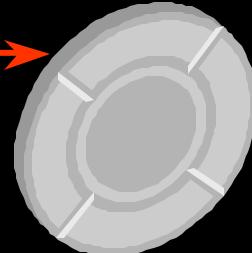
- To interact fully with LOB, file-like interfaces are provided in:
 - PL/SQL package `DBMS_LOB`
 - Oracle Call Interface (OCI)
 - Oracle Objects for object linking and embedding (OLE)
 - Pro*C/C++ and Pro*COBOL precompilers
 - JDBC
- The Oracle server provides some support for LOB management through SQL.

What Are BFILES?



The **BFILE** data type supports an external or file-based large object as:

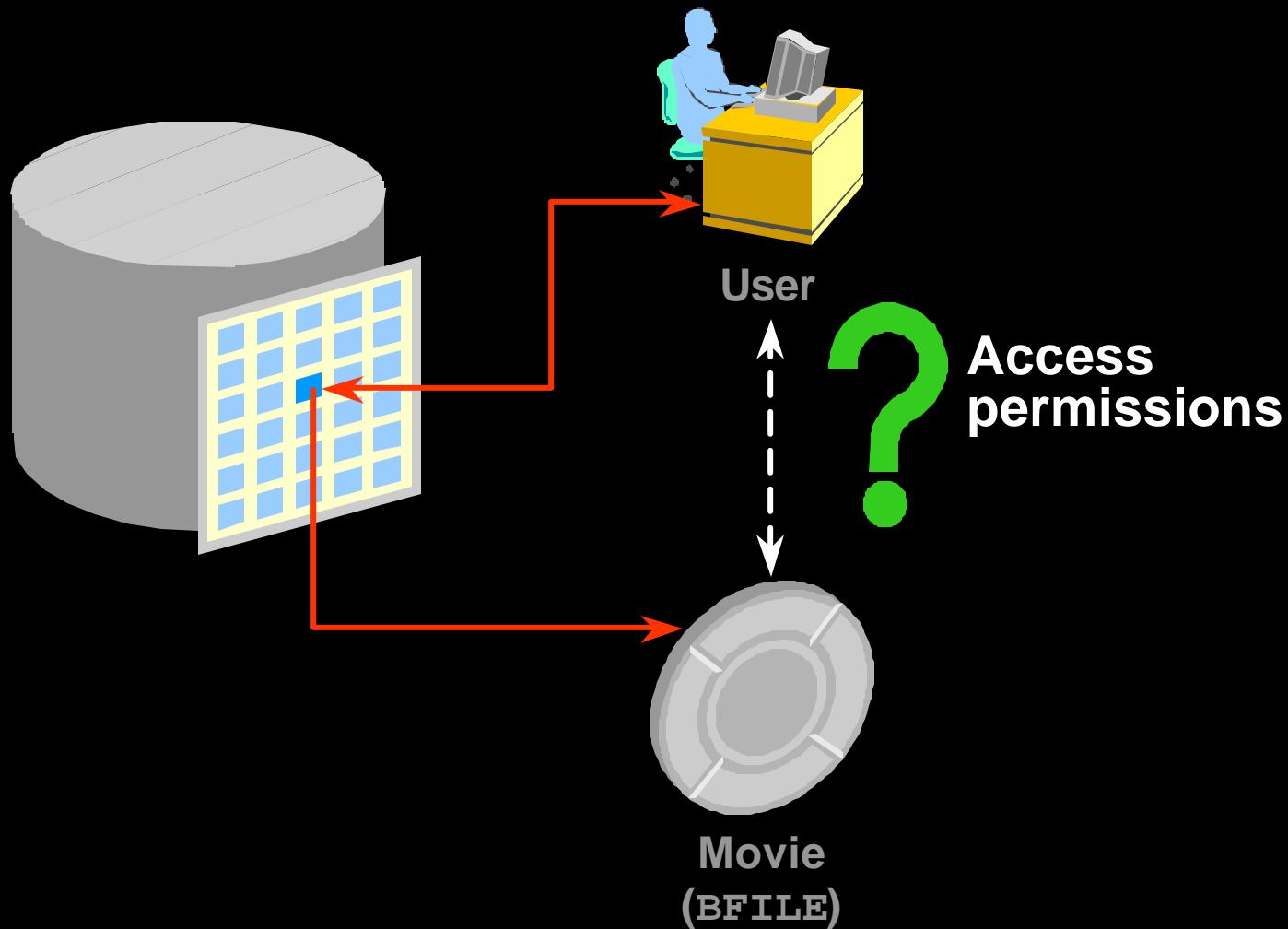
- Attributes in an object type
- Column values in a table



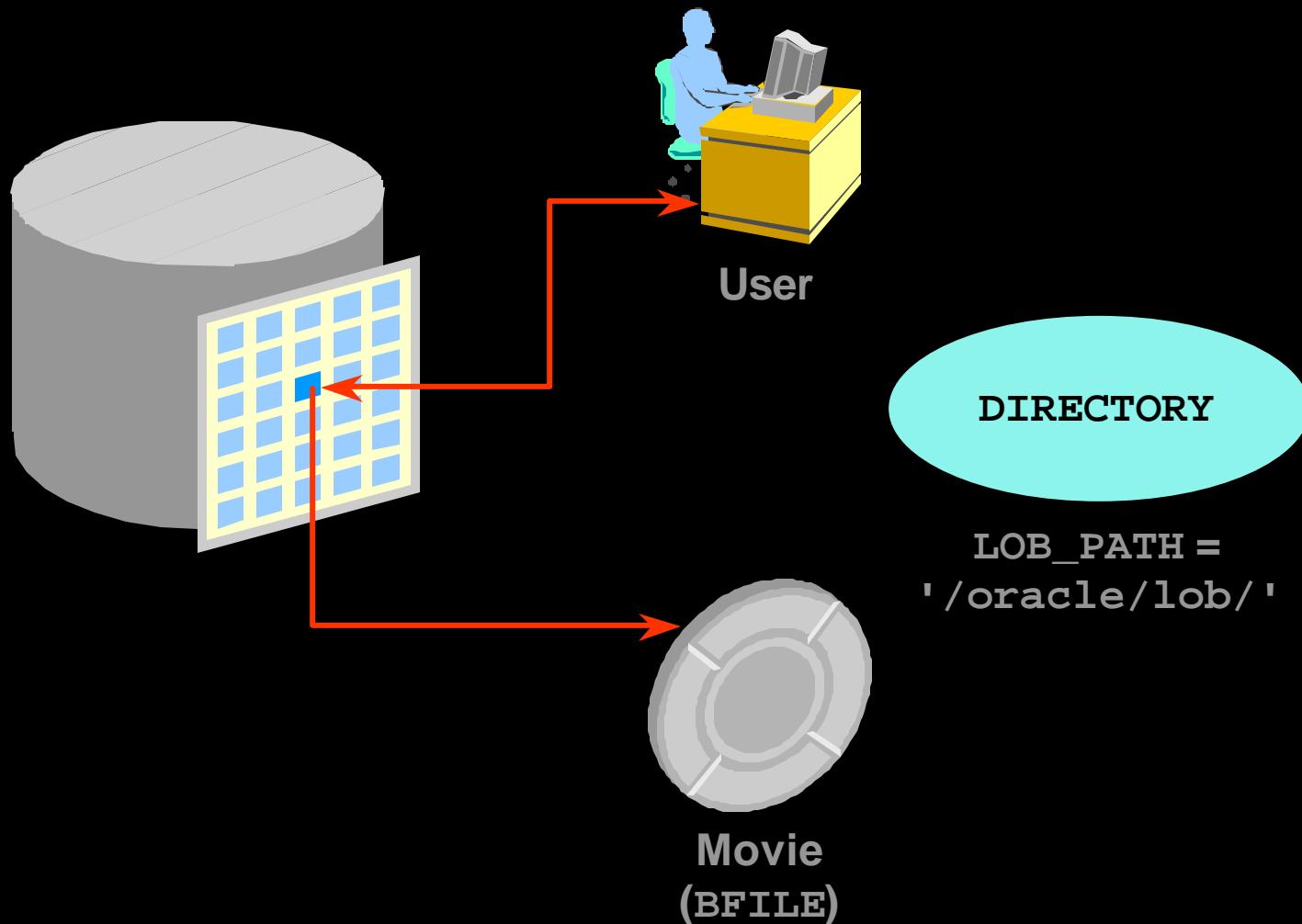
Movie
(**BFILE**)

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Securing BFILES



A New Database Object: DIRECTORY



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.**

Managing BFILES

- Create an OS directory and supply files.
- Create an Oracle table with a column that holds the BFILE data type.
- Create a DIRECTORY object.
- Grant privileges to read the DIRECTORY object to users.
- Insert rows into the table by using the BFILENAME function.
- Declare and initialize a LOB locator in a program.
- Read the BFILE.

Preparing to Use BFILES

- Create or modify an Oracle table with a column that holds the BFILE data type.

```
ALTER TABLE employees  
ADD emp_video BFILE;
```

- Create a DIRECTORY object by using the CREATE DIRECTORY command.

```
CREATE DIRECTORY dir_name  
AS os_path;
```

- Grant privileges to read the DIRECTORY object to users.

```
GRANT READ ON DIRECTORY dir_name TO  
user|role|PUBLIC;
```

The BFILENAME Function

Use the BFILENAME function to initialize a BFILE column.

```
FUNCTION BFILENAME (directory_alias IN VARCHAR2,  
                  filename IN VARCHAR2)  
RETURN BFILE;
```

Loading BFILES

```
CREATE OR REPLACE PROCEDURE load_emp_bfile
    (p_file_loc IN VARCHAR2) IS
    v_file        BFILE;
    v_filename    VARCHAR2(16);
    CURSOR emp_cursor IS
        SELECT first_name FROM employees
        WHERE department_id = 60 FOR UPDATE;
BEGIN
    FOR emp_record IN emp_cursor LOOP
        v_filename := emp_record.first_name || '.bmp';
        v_file := BFILENAME(p_file_loc, v_filename);
        DBMS_LOB.FILEOPEN(v_file);
        UPDATE employees SET emp_video = v_file
            WHERE CURRENT OF emp_cursor;
        DBMS_OUTPUT.PUT_LINE('LOADED FILE: ' || v_filename
            || ' SIZE: ' || DBMS_LOB.GETLENGTH(v_file));
        DBMS_LOB.FILECLOSE(v_file);
    END LOOP;
END load_emp_bfile;
/
```

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Loading BFILES

Use the DBMS_LOB.FILEEXISTS function to verify that the file exists in the operating system. The function returns 0 if the file does not exist, and returns 1 if the file does exist.

```
CREATE OR REPLACE PROCEDURE load_emp_bfile
(p_file_loc IN VARCHAR2)
IS
    v_file          BFILE;      v_filename        VARCHAR2(16);
    v_file_exists  BOOLEAN;
    CURSOR emp_cursor IS ...
BEGIN
    FOR emp_record IN emp_cursor LOOP
        v_filename := emp_record.first_name || '.bmp';
        v_file := BFILENAME (p_file_loc, v_filename);
        v_file_exists := (DBMS_LOB.FILEEXISTS(v_file) = 1);
        IF v_file_exists THEN
            DBMS_LOB.FILEOPEN (v_file); ...
    END LOOP;
END;
```

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Migrating from LONG to LOB

The Oracle9*i* server allows 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.

Migrating From LONG to LOB

- **Implicit conversion:** 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 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**

The DBMS_LOB Package

- Working with LOB often requires the use of the Oracle-supplied package DBMS_LOB.
- DBMS_LOB provides routines to access and manipulate internal and external LOBS.
- Oracle9i enables retrieving LOB data directly using SQL, without using any special LOB API.
- In PL/SQL you can define a VARCHAR2 for a CLOB and a RAW for BLOB.

The 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**



The 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.**

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
```

Adding LOB Columns to a Table

```
ALTER TABLE employees ADD
(resume          CLOB,
 picture        BLOB);
```

```
Table altered.
```



Populating LOB Columns

Insert a row into a table with LOB columns:

```
INSERT INTO employees (employee_id, first_name,
    last_name, email, hire_date, job_id,
    salary, resume, picture)
VALUES (405, 'Marvin', 'Ellis', 'MELLIS', SYSDATE,
    'AD_ASST', 4000, EMPTY_CLOB(),NULL);
```

1 row created.

Initialize a LOB column using the EMPTY_BLOB() function:

```
UPDATE employees
SET resume = 'Date of Birth: 8 February 1951',
    picture = EMPTY_BLOB()
WHERE employee_id = 405;
```

1 row updated.



Updating LOB by Using SQL

UPDATE CLOB column

```
UPDATE employees  
SET resume = 'Date of Birth: 1 June 1956'  
WHERE employee_id = 170;
```

```
1 row updated.
```



Updating LOB by Using DBMS_LOB in PL/SQL

```
DECLARE
    lobloc CLOB;          -- serves as the LOB locator
    text    VARCHAR2(32767):='Resigned: 5 August 2000';
    amount  NUMBER ;      -- amount to be written
    offset  INTEGER;      -- where to start writing
BEGIN
    SELECT resume INTO lobloc
    FROM employees
    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 employees
    WHERE employee_id = 170 FOR UPDATE;
    amount := length(text);
    DBMS_LOB.WRITEAPPEND(lobloc, amount, text);
    COMMIT;
END;
```



Selecting CLOB Values by Using SQL

```
SELECT employee_id, last_name , resume -- CLOB  
FROM employees  
WHERE employee_id IN (405, 170);
```

EMPLOYEE_ID	LAST_NAME	RESUME
170	Fox	Date of Birth: 1 June 1956 Resigned = 30 September 2000
405	Ellis	Date of Birth: 8 February 1951 Resigned = 5 August 2000

Selecting CLOB Values by Using DBMS_LOB

- **DBMS_LOB.SUBSTR(lob_column, no_of_chars, starting)**
- **DBMS_LOB.INSTR (lob_column, pattern)**

```
SELECT DBMS_LOB.SUBSTR (resume, 5, 18),  
       DBMS_LOB.INSTR (resume, ' = ')  
FROM   employees  
WHERE  employee_id IN (170, 405);
```

DBMS_LOB.SUBSTR(RESUME,5,18)	DBMS_LOB.INSTR(RESUME,'=')
June	36
Febru	40

Selecting CLOB Values in PL/SQL

```
DECLARE
    text VARCHAR2(4001);
BEGIN
    SELECT resume INTO text
    FROM employees
    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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Removing LOBS

Delete a row containing LOBS:

```
DELETE
FROM employees
WHERE employee_id = 405;
```

1 row deleted.

Disassociate a LOB value from a row:

```
UPDATE employees
SET resume = EMPTY_CLOB()
WHERE employee_id = 170;
```

1 row updated.



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 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.

Creating a Temporary LOB

PL/SQL procedure to create and test a temporary LOB:

```
CREATE OR REPLACE PROCEDURE IsTempLOBOpen
    (p_lob_loc IN OUT BLOB, p_retval OUT INTEGER)
IS
BEGIN
    -- create a temporary LOB
    DBMS_LOB.CREATETEMPORARY (p_lob_loc, TRUE);
    -- see if the LOB is open: returns 1 if open
    p_retval := DBMS_LOB.ISOPEN (p_lob_loc);
    DBMS_OUTPUT.PUT_LINE ('The file returned a value
                           ....' || p_retval);
    -- free the temporary LOB
    DBMS_LOB.FREETEMPORARY (p_lob_loc);
END;
/
```

Procedure created.



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:**
 - **The 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**

Practice 15 Overview

This practice covers the following topics:

- **Creating object types, using the new data types CLOB and BLOB**
- **Creating a table with LOB data types as columns**
- **Using the DBMS_LOB package to populate and interact with the LOB data**

16

Creating Database Triggers

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Objectives

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

- **Describe different types of triggers**
- **Describe database triggers and their use**
- **Create database triggers**
- **Describe database trigger firing rules**
- **Remove database triggers**

Types of Triggers

A trigger:

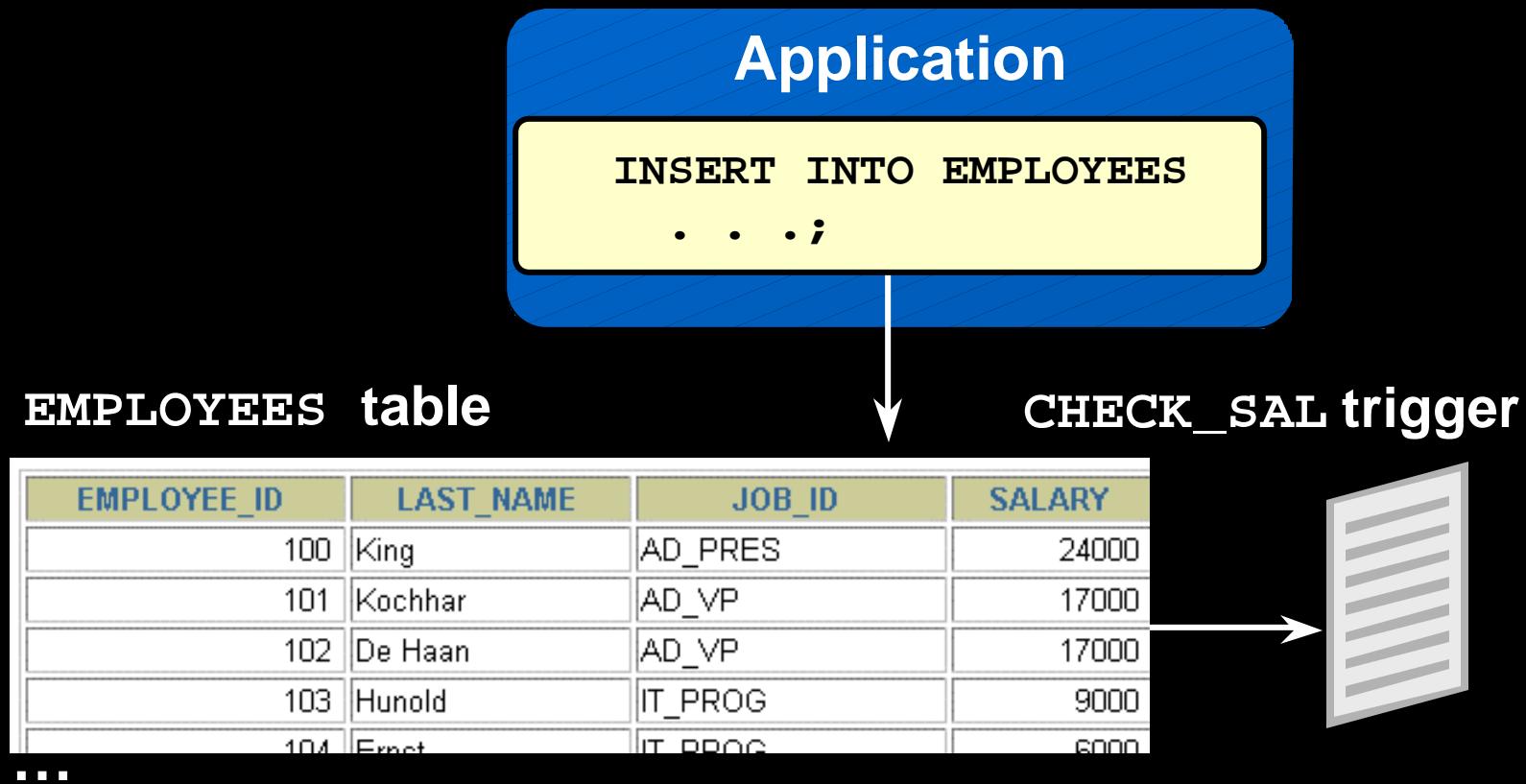
- Is a PL/SQL block or a PL/SQL procedure associated with a table, view, schema, or the database
- Executes implicitly whenever a particular event takes place
- Can be either:
 - Application trigger: Fires whenever an event occurs with a particular application
 - Database trigger: Fires whenever a data event (such as DML) or system event (such as logon or shutdown) occurs on a schema or database

Guidelines for Designing Triggers

- **Design triggers to:**
 - Perform related actions
 - Centralize global operations
- **Do not design triggers:**
 - Where functionality is already built into the Oracle server
 - That duplicate other triggers
- **Create stored procedures and invoke them in a trigger, if the PL/SQL code is very lengthy.**
- **The excessive use of triggers can result in complex interdependencies, which may be difficult to maintain in large applications.**



Database Trigger: Example



Creating DML Triggers

A triggering statement contains:

- **Trigger timing**
 - For table: BEFORE, AFTER
 - For view: INSTEAD OF
- **Triggering event: INSERT, UPDATE, or DELETE**
- **Table name: On table, view**
- **Trigger type: Row or statement**
- **WHEN clause: Restricting condition**
- **Trigger body: PL/SQL block**

DML Trigger Components

Trigger timing: When should the trigger fire?

- **BEFORE:** Execute the trigger body before the triggering DML event on a table.
- **AFTER:** Execute the trigger body after the triggering DML event on a table.
- **INSTEAD OF:** Execute the trigger body instead of the triggering statement. This is used for views that are not otherwise modifiable.

DML Trigger Components

Triggering user event: Which DML statement causes the trigger to execute? You can use any of the following:

- **INSERT**
- **UPDATE**
- **DELETE**

DML Trigger Components

Trigger type: Should the trigger body execute for each row the statement affects or only once?

- **Statement:** The trigger body executes once for the triggering event. This is the default. A statement trigger fires once, even if no rows are affected at all.
- **Row:** The trigger body executes once for each row affected by the triggering event. A row trigger is not executed if the triggering event affects no rows.

DML Trigger Components

**Trigger body: What action should the trigger perform?
The trigger body is a PL/SQL block or a call to a procedure.**

Firing Sequence

Use the following firing sequence for a trigger on a table, when a single row is manipulated:

DML statement

```
INSERT INTO departments (department_id,  
                         department_name, location_id)  
VALUES (400, 'CONSULTING', 2400);
```

1 row created.

Triggering action

DEPARTMENT_ID	DEPARTMENT_NAME	LOCATION_ID
10	Administration	1700
20	Marketing	1800
30	Purchasing	1700
...		

→ BEFORE statement
trigger

400	CONSULTING	2400
-----	------------	------

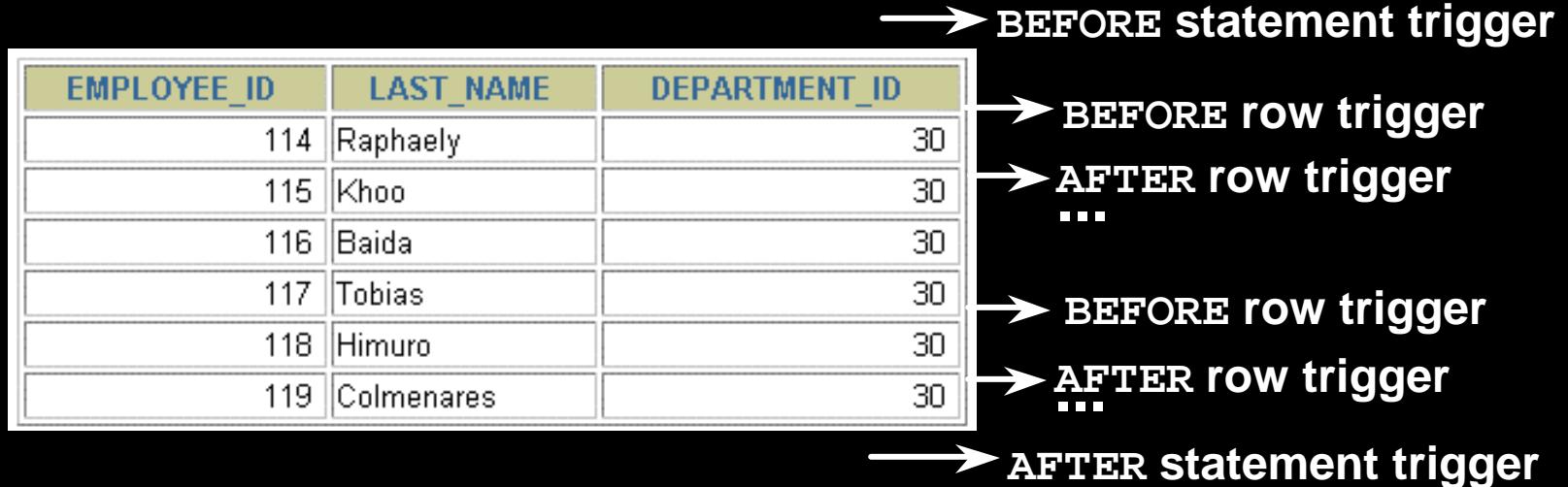
→ BEFORE row trigger
→ AFTER row trigger
→ AFTER statement trigger

Firing Sequence

Use the following firing sequence for a trigger on a table, when many rows are manipulated:

```
UPDATE employees  
    SET salary = salary * 1.1  
 WHERE department_id = 30;
```

6 rows updated.



Syntax for Creating DML Statement Triggers

Syntax:

```
CREATE [OR REPLACE] TRIGGER trigger_name
  timing
    event1 [OR event2 OR event3]
    ON table_name
trigger_body
```

Note: Trigger names must be unique with respect to other triggers in the same schema.

Creating DML Statement Triggers

Example:

```
CREATE OR REPLACE TRIGGER secure_emp
BEFORE INSERT ON employees
BEGIN
  IF (TO_CHAR(SYSDATE,'DY') IN ('SAT','SUN')) OR
    (TO_CHAR(SYSDATE,'HH24:MI')
      NOT BETWEEN '08:00' AND '18:00')
    THEN RAISE_APPLICATION_ERROR (-20500,'You may
          insert into EMPLOYEES table only
          during business hours.');
  END IF;
END;
/
```

Trigger created.



Testing SECURE_EMP

```
INSERT INTO employees (employee_id, last_name,  
                      first_name, email, hire_date,  
                      job_id, salary, department_id)  
VALUES (300, 'Smith', 'Rob', 'RSMITH', SYSDATE,  
        'IT_PROG', 4500, 60);
```

```
INSERT INTO employees (employee_id, last_name, first_name, email,  
                      *)
```

ERROR at line 1:

ORA-20500: You may insert into EMPLOYEES table only during business hours.

ORA-06512: at "PLSQL.SECURE_EMP", line 4

ORA-04088: error during execution of trigger 'PLSQL.SECURE_EMP'



Using Conditional Predicates

```
CREATE OR REPLACE TRIGGER secure_emp
BEFORE INSERT OR UPDATE OR DELETE ON employees
BEGIN
  IF (TO_CHAR (SYSDATE,'DY') IN ('SAT','SUN')) OR
    (TO_CHAR (SYSDATE, 'HH24') NOT BETWEEN '08' AND '18')
  THEN
    IF DELETING THEN
      RAISE_APPLICATION_ERROR (-20502,'You may delete from
                                EMPLOYEES table only during business hours.');
    ELSIF INSERTING THEN
      RAISE_APPLICATION_ERROR (-20500,'You may insert into
                                EMPLOYEES table only during business hours.');
    ELSIF UPDATING ('SALARY') THEN
      RAISE_APPLICATION_ERROR (-20503,'You may update
                                SALARY only during business hours.');
    ELSE
      RAISE_APPLICATION_ERROR (-20504,'You may update
                                EMPLOYEES table only during normal hours.');
    END IF;
  END IF;
END;
```



Creating a DML Row Trigger

Syntax:

```
CREATE [OR REPLACE] TRIGGER trigger_name
  timing
    event1 [OR event2 OR event3]
    ON table_name
    [REFERENCING OLD AS old / NEW AS new]
FOR EACH ROW
  [WHEN (condition) ]
trigger_body
```

Creating DML Row Triggers

```
CREATE OR REPLACE TRIGGER restrict_salary
BEFORE INSERT OR UPDATE OF salary ON employees
FOR EACH ROW
BEGIN
    IF NOT (:NEW.job_id IN ('AD_PRES', 'AD_VP'))
        AND :NEW.salary > 15000
    THEN
        RAISE_APPLICATION_ERROR (-20202,'Employee
                                cannot earn this amount');
    END IF;
END;
/
```

Trigger created.



Using OLD and NEW Qualifiers

```
CREATE OR REPLACE TRIGGER audit_emp_values
AFTER DELETE OR INSERT OR UPDATE ON employees
FOR EACH ROW
BEGIN
  INSERT INTO audit_emp_table (user_name, timestamp,
    id, old_last_name, new_last_name, old_title,
    new_title, old_salary, new_salary)
  VALUES (USER, SYSDATE, :OLD.employee_id,
    :OLD.last_name, :NEW.last_name, :OLD.job_id,
    :NEW.job_id, :OLD.salary, :NEW.salary );
END;
/
```

Trigger created.



Using OLD and NEW Qualifiers: Example Using Audit_Emp_Table

```
INSERT INTO employees
    (employee_id, last_name, job_id, salary, ...)
VALUES (999, 'Temp emp', 'SA_REP', 1000, ...);
```

```
UPDATE employees
SET salary = 2000, last_name = 'Smith'
WHERE employee_id = 999;
```

```
1 row created.
1 row updated.
```

```
SELECT user_name, timestamp, ... FROM audit_emp_table
```

USER_NAME	TIMESTAMP	ID	OLD_LAST_N	NEW_LAST_N	OLD_TITLE	NEW_TITLE	OLD_SALARY	NEW_SALARY
PLSQL	28-SEP-01			Temp emp		SA_REP		1000
PLSQL	28-SEP-01	999	Temp emp	Smith	SA_REP	SA_REP	1000	2000

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Restricting a Row Trigger

```
CREATE OR REPLACE TRIGGER derive_commission_pct
  BEFORE INSERT OR UPDATE OF salary ON employees
  FOR EACH ROW
  WHEN (NEW.job_id = 'SA_REP')
BEGIN
  IF INSERTING
    THEN :NEW.commission_pct := 0;
  ELSIF :OLD.commission_pct IS NULL
    THEN :NEW.commission_pct := 0;
  ELSE
    :NEW.commission_pct := :OLD.commission_pct + 0.05;
  END IF;
END;
/
```

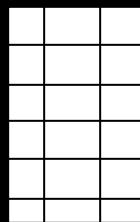
Trigger created.

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INSTEAD OF Triggers

Application

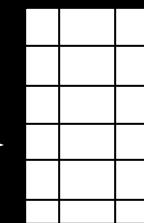
```
INSERT INTO my_view  
. . . ;
```



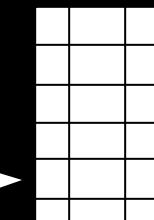
MY_VIEW

INSTEAD OF
Trigger

INSERT
TABLE1



UPDATE
TABLE2



Creating an INSTEAD OF Trigger

Syntax:

```
CREATE [OR REPLACE] TRIGGER trigger_name
  INSTEAD OF
    event1 [OR event2 OR event3]
    ON view_name
    [REFERENCING OLD AS old / NEW AS new]
    [FOR EACH ROW]
trigger_body
```

Creating an INSTEAD OF Trigger

INSERT into EMP_DETAILS that is based on EMPLOYEES and DEPARTMENTS tables

1 `INSERT INTO emp_details(employee_id, ...)
VALUES(9001,'ABBOTT',3000,10,'abbott.mail.com','HR_MAN');`

**INSTEAD OF INSERT
into EMP_DETAILS →**

EMPLOYEE_ID	LAST_NAME	DEPARTMENT_ID	EMAIL	JOB_ID
100	King	90	SKING	AD_PRES
101	Kochhar	90	NKOCHHAR	AD_VP
102	De Haan	90	LDEHAAN	AD_VP
...				

Creating an INSTEAD OF Trigger

INSERT into EMP_DETAILS that is based on EMPLOYEES and DEPARTMENTS tables

1
INSERT INTO emp_details(employee_id, ...) VALUES(9001,'ABBOTT',3000,10,'abbott.mail.com','HR_MAN');

INSTEAD OF INSERT
into EMP_DETAILS →

EMPLOYEE_ID	LAST_NAME	DEPARTMENT_ID	EMAIL	JOB_ID
100	King	90	SKING	AD_PRES
101	Kochhar	90	NKOCHHAR	AD_VP
102	De Haan	90	LDEHAAN	AD_VP
...				

2
INSERT into
NEW_EMPS

EMPLOYEE_ID	LAST_NAME	SALARY	DEPARTMENT_ID	EMAIL
100	King	24000	90	SKING
101	Kochhar	17000	90	NKOCHHAR
102	De Haan	17000	90	LDEHAAN
...				
9001	ABBOTT	3000	10	abbott.m...

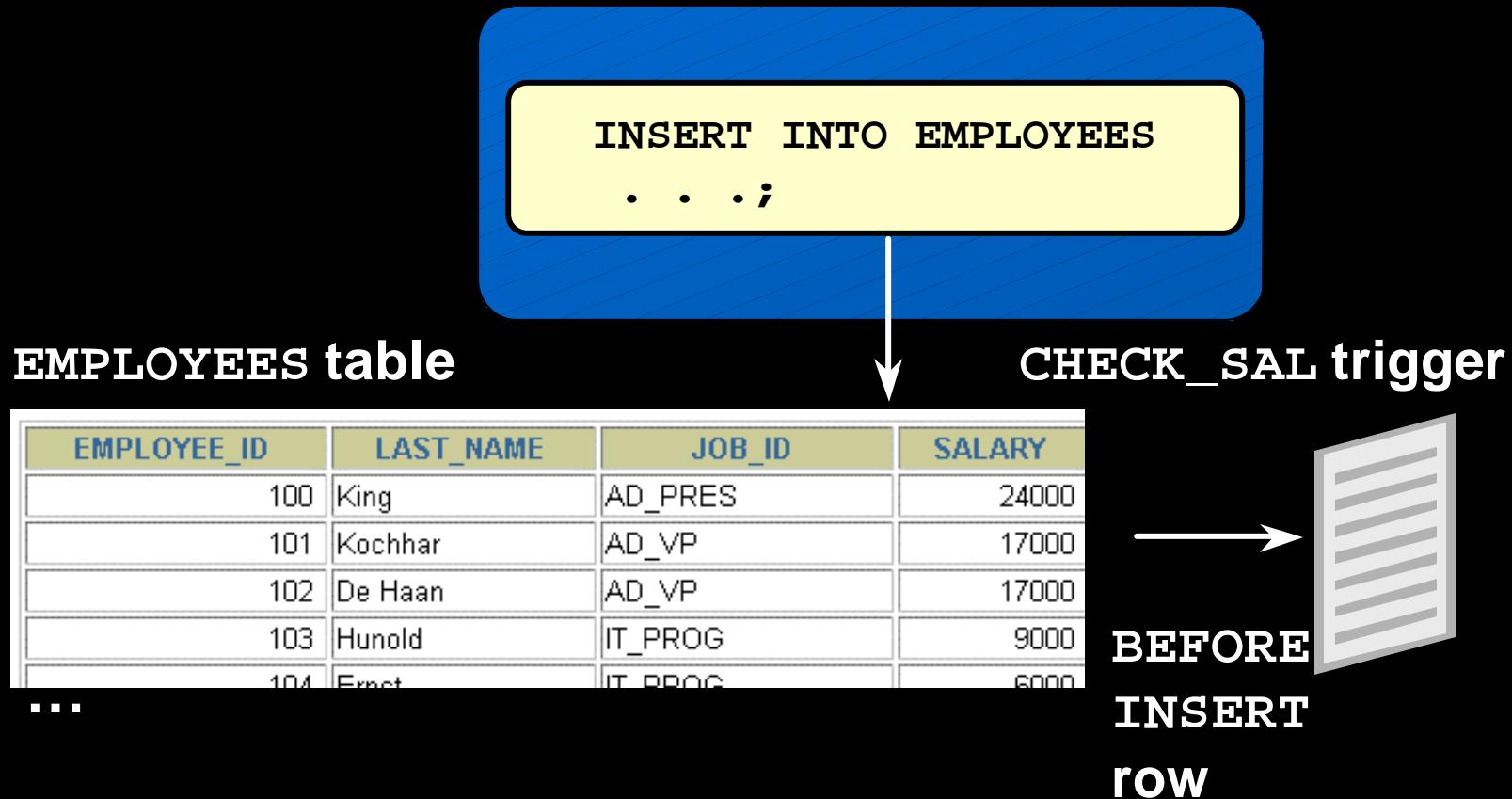
3
UPDATE
NEW_DEPTS

DEPARTMENT_ID	DEPARTMENT_NAME	TOT_DEPT_SAL
10	Administration	940
20	Marketing	19000
30	Purchasing	30129
40	Human Resources	6500
...		

Differentiating Between Database Triggers and Stored Procedures

Triggers	Procedures
Defined with CREATE TRIGGER	Defined with CREATE PROCEDURE
Data dictionary contains source code in <code>USER_TRIGGERS</code>	Data dictionary contains source code in <code>USER_SOURCE</code>
Implicitly invoked	Explicitly invoked
COMMIT, SAVEPOINT, and ROLLBACK are not allowed	COMMIT, SAVEPOINT, and ROLLBACK are allowed

Differentiating Between Database Triggers and Form Builder Triggers



Managing Triggers

Disable or reenable a database trigger:

```
ALTER TRIGGER trigger_name DISABLE | ENABLE
```

Disable or reenable all triggers for a table:

```
ALTER TABLE table_name DISABLE | ENABLE ALL TRIGGERS
```

Recompile a trigger for a table:

```
ALTER TRIGGER trigger_name COMPILE
```

DROP TRIGGER Syntax

To remove a trigger from the database, use the DROP TRIGGER syntax:

```
DROP TRIGGER trigger_name;
```

Example:

```
DROP TRIGGER secure_emp;
```

```
Trigger dropped.
```

Note: All triggers on a table are dropped when the table is dropped.

Trigger Test Cases

- **Test each triggering data operation, as well as nontriggering data operations.**
- **Test each case of the WHEN clause.**
- **Cause the trigger to fire directly from a basic data operation, as well as indirectly from a procedure.**
- **Test the effect of the trigger upon other triggers.**
- **Test the effect of other triggers upon the trigger.**

Trigger Execution Model and Constraint Checking

- 1. Execute all BEFORE STATEMENT triggers.**
- 2. Loop for each row affected:**
 - a. Execute all BEFORE ROW triggers.**
 - b. Execute all AFTER ROW triggers.**
- 3. Execute the DML statement and perform integrity constraint checking.**
- 4. Execute all AFTER STATEMENT triggers.**

Trigger Execution Model and Constraint Checking: Example

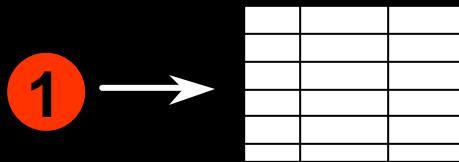
```
UPDATE employees SET department_id = 999  
WHERE employee_id = 170;  
-- Integrity constraint violation error
```

```
CREATE OR REPLACE TRIGGER constr_emp_trig  
AFTER UPDATE ON employees  
FOR EACH ROW  
BEGIN  
    INSERT INTO departments  
        VALUES (999, 'dept999', 140, 2400);  
END;  
/
```

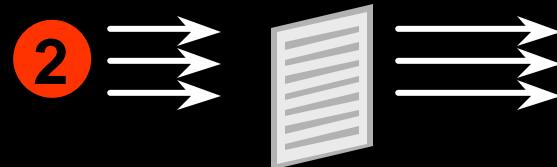
```
UPDATE employees SET department_id = 999  
WHERE employee_id = 170;  
-- Successful after trigger is fired
```

A Sample Demonstration for Triggers Using Package Constructs

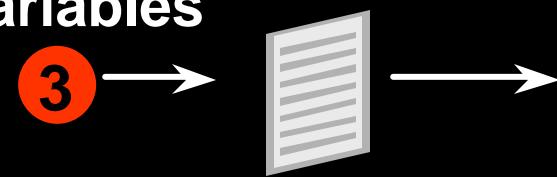
DML into
EMPLOYEES table



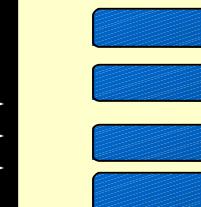
AUDIT_EMP_TRIG
FOR EACH ROW
Increment variables



AUDIT_EMP_TAB
AFTER STATEMENT
Copy and then reset
variables



VAR_PACK
package



AUDIT_TABLE

After Row and After Statement Triggers

```
CREATE OR REPLACE TRIGGER audit_emp_trig
AFTER UPDATE or INSERT or DELETE on EMPLOYEES
FOR EACH ROW
BEGIN
  IF      DELETING      THEN  var_pack.set_g_del(1);
  ELSIF   INSERTING     THEN  var_pack.set_g_ins(1);
  ELSIF   UPDATING ('SALARY')
                  THEN  var_pack.set_g_up_sal(1);
  ELSE    var_pack.set_g_upd(1);
  END IF;
END audit_emp_trig;
/
```

```
CREATE OR REPLACE TRIGGER audit_emp_tab
AFTER UPDATE or INSERT or DELETE on employees
BEGIN
  audit_emp;
END audit_emp_tab;
/
```



Demonstration: VAR_PACK Package Specification

var_pack.sql

```
CREATE OR REPLACE PACKAGE var_pack
IS
-- these functions are used to return the
-- values of package variables
  FUNCTION g_del RETURN NUMBER;
  FUNCTION g_ins RETURN NUMBER;
  FUNCTION g_upd RETURN NUMBER;
  FUNCTION g_up_sal RETURN NUMBER;
-- these procedures are used to modify the
-- values of the package variables
  PROCEDURE set_g_del      (p_val   IN  NUMBER);
  PROCEDURE set_g_ins      (p_val   IN  NUMBER);
  PROCEDURE set_g_upd      (p_val   IN  NUMBER);
  PROCEDURE set_g_up_sal  (p_val   IN  NUMBER);
END var_pack;
/
```



Demonstration: Using the AUDIT_EMP Procedure

```
CREATE OR REPLACE PROCEDURE audit_emp IS
  v_del      NUMBER      := var_pack.g_del;
  v_ins      NUMBER      := var_pack.g_ins;
  v_upd      NUMBER      := var_pack.g_upd;
  v_up_sal   NUMBER      := var_pack.g_up_sal;
BEGIN
  IF  v_del + v_ins + v_upd != 0  THEN
    UPDATE audit_table SET
      del = del + v_del, ins = ins + v_ins,
      upd = upd + v_upd
    WHERE user_name=USER AND tablename='EMPLOYEES'
      AND column_name IS NULL;
  END IF;
  IF v_up_sal != 0  THEN
    UPDATE audit_table SET upd = upd + v_up_sal
    WHERE user_name=USER AND tablename='EMPLOYEES'
      AND column_name = 'SALARY';
  END IF;
-- resetting global variables in package VAR_PACK
  var_pack.set_g_del (0); var_pack.set_g_ins (0);
  var_pack.set_g_upd (0); var_pack.set_g_up_sal (0);
END audit_emp;
```

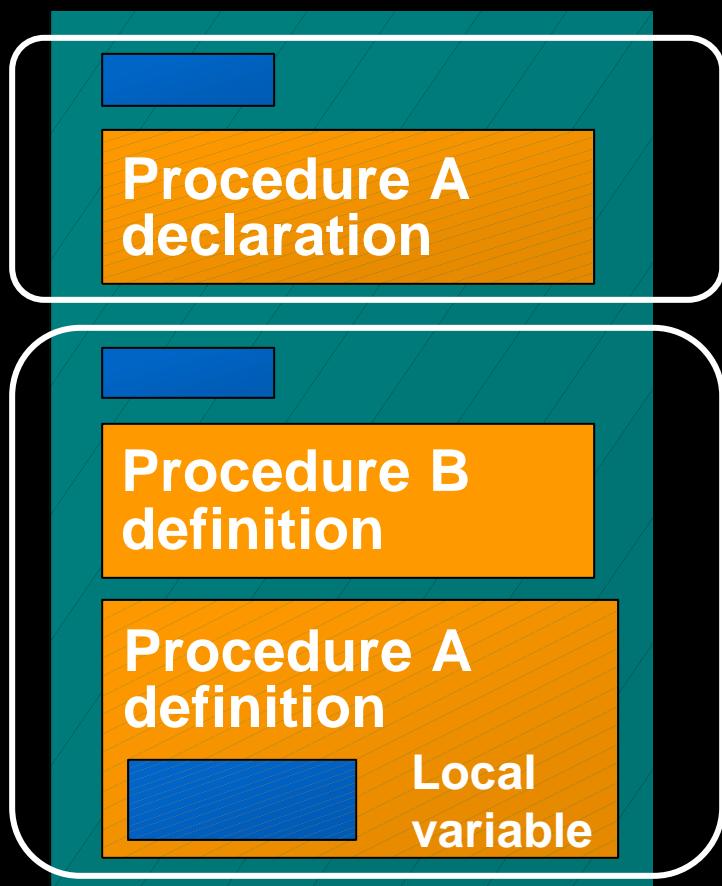


Summary

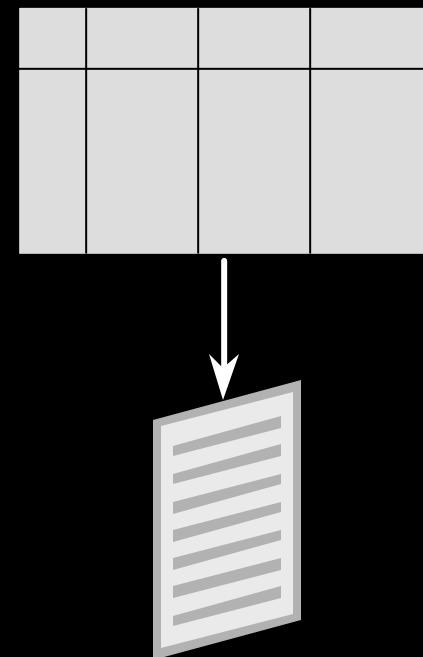
Procedure

```
xxxxxxxxxxxxxxxxxxxx  
vvvvvvvvvvvvvvvvv  
xxxxxxxxxxxxxxxxxxxx  
vvvvvvvvvvvvvvvvv  
xxxxxxxxxxxxxxxxxxxx  
vvvvvvvvvvvvvvvvv  
xxxxxxxxxxxxxxxxxxxx  
xxxxxxxxxxxxxxxxxxxx  
vvvvvvvvvvvvvvvvv  
xxxxxxxxxxxxxxxxxxxx  
vvvvvvvvvvvvvvvvv  
xxxxxxxxxxxxxxxxxxxx  
vvvvvvvvvvvvvvvvv  
xxxxxxxxxxxxxxxxxxxx  
vvvvvvvvvvvvvvvvv  
xxxxxxxxxxxxxxxxxxxx
```

Package



Trigger



Practice 16 Overview

This practice covers the following topics:

- **Creating statement and row triggers**
- **Creating advanced triggers to add to the capabilities of the Oracle database**

17

More Trigger Concepts

Objectives

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

- Create additional database triggers
- Explain the rules governing triggers
- Implement triggers

Creating Database Triggers

- **Triggering user event:**
 - **CREATE, ALTER, or DROP**
 - **Logging on or off**
- **Triggering database or system event:**
 - **Shutting down or starting up the database**
 - **A specific error (or any error) being raised**

Creating Triggers on DDL Statements

Syntax:

```
CREATE [OR REPLACE] TRIGGER trigger_name
  timing
  [ddl_event1 [OR ddl_event2 OR ...]]
  ON {DATABASE|SCHEMA}
trigger_body
```

Creating Triggers on System Events

```
CREATE [OR REPLACE] TRIGGER trigger_name
  timing
  [database_event1 [OR database_event2 OR ...]]
  ON {DATABASE|SCHEMA}
trigger_body
```

LOGON and LOGOFF Trigger Example

```
CREATE OR REPLACE TRIGGER logon_trig
AFTER LOGON    ON    SCHEMA
BEGIN
  INSERT INTO log_trig_table(user_id, log_date, action)
  VALUES (USER, SYSDATE, 'Logging on');
END;
/
```

```
CREATE OR REPLACE TRIGGER logoff_trig
BEFORE LOGOFF   ON    SCHEMA
BEGIN
  INSERT INTO log_trig_table(user_id, log_date, action)
  VALUES (USER, SYSDATE, 'Logging off');
END;
/
```



CALL Statements

```
CREATE [OR REPLACE] TRIGGER trigger_name
timing
    event1 [OR event2 OR event3]
    ON table_name
    [REFERENCING OLD AS old | NEW AS new]
    [FOR EACH ROW]
    [WHEN condition]
    CALL procedure_name
```

```
CREATE OR REPLACE TRIGGER log_employee
BEFORE INSERT ON EMPLOYEES
    CALL log_execution
/
```

Reading Data from a Mutating Table

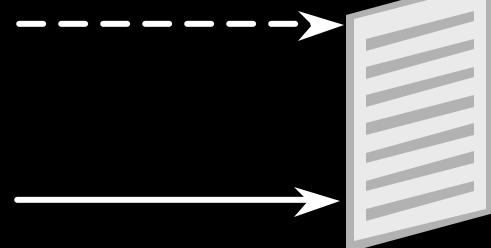
```
UPDATE employees  
SET salary = 3400  
WHERE last_name = 'Stiles';
```

EMPLOYEES table

EMPLOYEE_ID	LAST_NAME	JOB_ID	SALARY
125	Nayer	ST_CLERK	3200
126	Mikkilineni	ST_CLERK	2700
127	Landry	ST_CLERK	2400
...			
138	Stiles	ST_CLERK	3400
...			

Failure

CHECK_SALARY
trigger



Triggered table/
mutating table

Trigger event

Mutating Table: Example

```
CREATE OR REPLACE TRIGGER check_salary
    BEFORE INSERT OR UPDATE OF salary, job_id
    ON employees
    FOR EACH ROW
    WHEN (NEW.job_id <> 'AD_PRES')
DECLARE
    v_minsalary employees.salary%TYPE;
    v_maxsalary employees.salary%TYPE;
BEGIN
    SELECT MIN(salary), MAX(salary)
        INTO v_minsalary, v_maxsalary
        FROM employees
        WHERE job_id = :NEW.job_id;
    IF :NEW.salary < v_minsalary OR
        :NEW.salary > v_maxsalary THEN
        RAISE_APPLICATION_ERROR(-20505,'Out of range');
    END IF;
END;
/
```



Mutating Table: Example

```
UPDATE employees  
    SET salary = 3400  
 WHERE last_name = 'Stiles';
```

```
UPDATE employees  
    *  
ERROR at line 1:  
ORA-04091: table PLSQL.EMPLOYEES is mutating, trigger/function may not see it  
ORA-06512: at "PLSQL.CHECK_SALARY", line 5  
ORA-04088: error during execution of trigger 'PLSQL.CHECK_SALARY'
```



Implementing Triggers

You can use trigger for:

- Security
- Auditing
- Data integrity
- Referential integrity
- Table replication
- Computing derived data automatically
- Event logging

Controlling Security Within the Server

```
GRANT SELECT, INSERT, UPDATE, DELETE
    ON     employees
    TO     clerk;                      -- database role
GRANT clerk TO scott;
```



Controlling Security with a Database Trigger

```
CREATE OR REPLACE TRIGGER secure_emp
  BEFORE INSERT OR UPDATE OR DELETE ON employees
DECLARE
  v_dummy VARCHAR2(1);
BEGIN
  IF (TO_CHAR (SYSDATE, 'DY') IN ('SAT','SUN'))
    THEN RAISE_APPLICATION_ERROR (-20506,'You may only
                                   change data during normal business hours.');
  END IF;
  SELECT COUNT(*) INTO v_dummy FROM holiday
  WHERE holiday_date = TRUNC (SYSDATE);
  IF v_dummy > 0 THEN RAISE_APPLICATION_ERROR(-20507,
                                                'You may not change data on a holiday.');
  END IF;
END;
/
```



Using the Server Facility to Audit Data Operations

```
AUDIT INSERT, UPDATE, DELETE  
  ON departments  
  BY ACCESS  
WHENEVER SUCCESSFUL;
```

Audit succeeded.

The Oracle server stores the audit information in a data dictionary table or operating system file.

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Auditing by Using a Trigger

```
CREATE OR REPLACE TRIGGER audit_emp_values
AFTER DELETE OR INSERT OR UPDATE ON employees
FOR EACH ROW
BEGIN
  IF (audit_emp_package.g_reason IS NULL) THEN
    RAISE_APPLICATION_ERROR (-20059, 'Specify a reason
      for the data operation through the procedure SET_REASON
      of the AUDIT_EMP_PACKAGE before proceeding.');
  ELSE
    INSERT INTO audit_emp_table (user_name, timestamp, id,
      old_last_name, new_last_name, old_title, new_title,
      old_salary, new_salary, comments)
    VALUES (USER, SYSDATE, :OLD.employee_id, :OLD.last_name,
      :NEW.last_name, :OLD.job_id, :NEW.job_id, :OLD.salary,
      :NEW.salary, audit_emp_package.g_reason);
  END IF;
END;
```

```
CREATE OR REPLACE TRIGGER cleanup_audit_emp
AFTER INSERT OR UPDATE OR DELETE ON employees
BEGIN
  audit_emp_package.g_reason := NULL;
END;
```



Enforcing Data Integrity Within the Server

```
ALTER TABLE employees ADD  
CONSTRAINT ck_salary CHECK (salary >= 500);
```

Table altered.



Protecting Data Integrity with a Trigger

```
CREATE OR REPLACE TRIGGER check_salary
  BEFORE UPDATE OF salary ON employees
  FOR EACH ROW
  WHEN (NEW.salary < OLD.salary)
BEGIN
  RAISE_APPLICATION_ERROR (-20508,
    'Do not decrease salary.');
END;
/
```



Enforcing Referential Integrity Within the Server

```
ALTER TABLE employees
  ADD CONSTRAINT emp_deptno_fk
    FOREIGN KEY (department_id)
      REFERENCES departments(department_id)
ON DELETE CASCADE;
```



Protecting Referential Integrity with a Trigger

```
CREATE OR REPLACE TRIGGER cascade_updates
AFTER UPDATE OF department_id ON departments
FOR EACH ROW
BEGIN
  UPDATE employees
    SET employees.department_id=:NEW.department_id
    WHERE employees.department_id=:OLD.department_id;
  UPDATE job_history
    SET department_id=:NEW.department_id
    WHERE department_id=:OLD.department_id;
END;
/
```



Replicating a Table Within the Server

```
CREATE SNAPSHOT emp_copy AS
SELECT * FROM employees@ny;
```

Replicating a Table with a Trigger

```
CREATE OR REPLACE TRIGGER emp_replica
  BEFORE INSERT OR UPDATE ON employees
  FOR EACH ROW
BEGIN /*Only proceed if user initiates a data operation,
        NOT through the cascading trigger.*/
  IF INSERTING THEN
    IF :NEW.flag IS NULL THEN
      INSERT INTO employees@sf
      VALUES(:new.employee_id, :new.last_name, . . . , 'B');
      :NEW.flag := 'A';
    END IF;
    ELSE /* Updating. */
      IF :NEW.flag = :OLD.flag THEN
        UPDATE employees@sf
        SET ename = :NEW.last_name, . . . ,
            flag = :NEW.flag
        WHERE employee_id = :NEW.employee_id;
      END IF;
      IF :OLD.flag = 'A' THEN :NEW.flag := 'B';
      ELSE :NEW.flag := 'A';
      END IF;
    END IF;
  END IF;
END;
```



Computing Derived Data Within the Server

```
UPDATE departments
   SET total_sal=(SELECT SUM(salary)
                  FROM employees
                 WHERE employees.department_id =
                      departments.department_id);
```

Computing Derived Values with a Trigger

```
CREATE OR REPLACE PROCEDURE increment_salary
  (p_id      IN departments.department_id%TYPE,
   p_salary  IN departments.total_sal%TYPE)
IS
BEGIN
  UPDATE departments
    SET total_sal = NVL (total_sal, 0)+ p_salary
      WHERE department_id = p_id;
END increment_salary;
```

```
CREATE OR REPLACE TRIGGER compute_salary
AFTER INSERT OR UPDATE OF salary OR DELETE ON employees
FOR EACH ROW
BEGIN
  IF DELETING THEN
    increment_salary(:OLD.department_id, (-1*:OLD.salary));
  ELSIF UPDATING THEN
    increment_salary(:NEW.department_id, (:NEW.salary-:OLD.salary))
  ELSE increment_salary(:NEW.department_id,:NEW.salary);--INSERT
  END IF;
END;
```



Logging Events with a Trigger

```
CREATE OR REPLACE TRIGGER notify_reorder_rep
BEFORE UPDATE OF quantity_on_hand, reorder_point
ON inventories FOR EACH ROW
DECLARE
v_descrip product_descriptions.product_description%TYPE;
v_msg_text VARCHAR2(2000);
stat_send number(1);
BEGIN
IF :NEW.quantity_on_hand <= :NEW.reorder_point THEN
  SELECT product_description INTO v_descrip
  FROM product_descriptions
  WHERE product_id = :NEW.product_id;
  v_msg_text := 'ALERT: INVENTORY LOW ORDER:' || CHR(10) ||
... 'Yours,' || CHR(10) || user || '.' || CHR(10) || CHR(10);
ELSIF
  :OLD.quantity_on_hand < :NEW.quantity_on_hand THEN NULL;
ELSE
  v_msg_text := 'Product #' || ... CHR(10);
END IF;
DBMS_PIPE.PACK_MESSAGE(v_msg_text);
stat_send := DBMS_PIPE.SEND_MESSAGE('INV_PIPE');
END;
```



Benefits of Database Triggers

- **Improved data security:**
 - Provide enhanced and complex security checks
 - Provide enhanced and complex auditing
- **Improved data integrity:**
 - Enforce dynamic data integrity constraints
 - Enforce complex referential integrity constraints
 - Ensure that related operations are performed together implicitly

Managing Triggers

The following system privileges are required to manage triggers:

- The **CREATE/ALTER/DROP (ANY) TRIGGER** privilege enables you to create a trigger in any schema
- The **ADMINISTER DATABASE TRIGGER** privilege enables you to create a trigger on DATABASE
- The **EXECUTE** privilege (if your trigger refers to any objects that are not in your schema)

Note: Statements in the trigger body operate under the privilege of the trigger owner, not the trigger user.

Viewing Trigger Information

You can view the following trigger information:

- **USER_OBJECTS** data dictionary view: object information
- **USER_TRIGGERS** data dictionary view: the text of the trigger
- **USER_ERRORS** data dictionary view: PL/SQL syntax errors (compilation errors) of the trigger

Using USER_TRIGGERS *

Column	Column Description
TRIGGER_NAME	Name of the trigger
TRIGGER_TYPE	The type is BEFORE, AFTER, INSTEAD OF
TRIGGERING_EVENT	The DML operation firing the trigger
TABLE_NAME	Name of the database table
REFERENCING_NAMES	Name used for :OLD and :NEW
WHEN_CLAUSE	The when_clause used
STATUS	The status of the trigger
TRIGGER_BODY	The action to take

* Abridged column list



Listing the Code of Triggers

```
SELECT trigger_name, trigger_type, triggering_event,
       table_name, referencing_names,
       status, trigger_body
  FROM user_triggers
 WHERE trigger_name = 'RESTRICT_SALARY';
```

trigger_name	trigger_type	triggering_event	table_name	referencing_names	when_clause	status	trigger_body
RESTRICT_SALARY	BEFORE EACH ROW	INSERT OR UPDATE	EMPLOYEES	REFERENCING NEW AS NEW OLD AS OLD		ENABLED	BEGIN IF NOT (:NEW.JOB_ID IN ('AD_PRES', 'AD_VP')) AND :NEW.SAL

Summary

In this lesson, you should have learned how to:

- **Use advanced database triggers**
- **List mutating and constraining rules for triggers**
- **Describe the real-world application of triggers**
- **Manage triggers**
- **View trigger information**

Practice 17 Overview

This practice covers creating advanced triggers to add to the capabilities of the Oracle database.

18

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 upon stored procedures and functions**
- **Manage procedural dependencies**

Understanding Dependencies

Dependent Objects

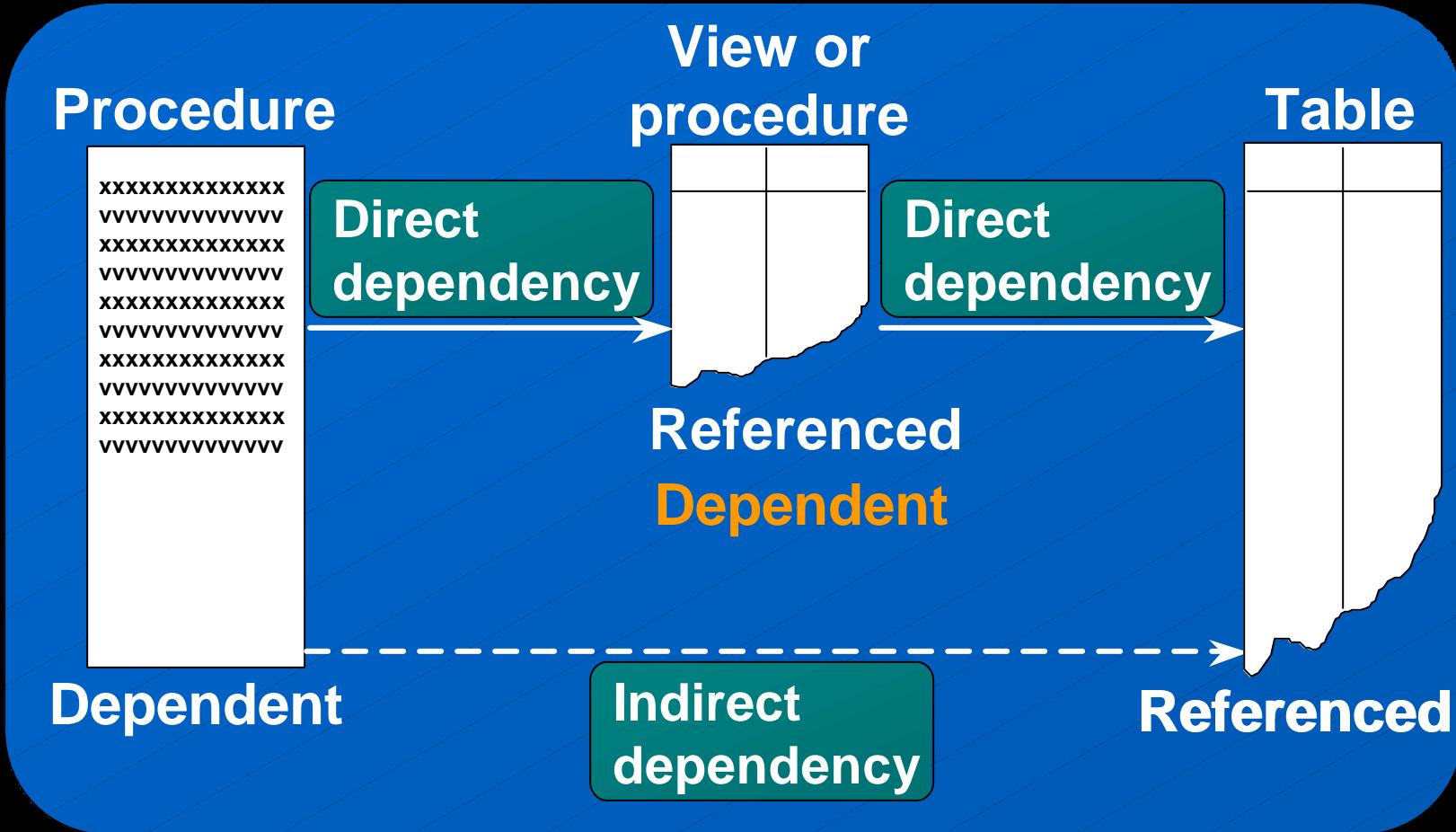
Table
View
Database Trigger
Procedure
Function
Package Body
Package Specification
User-Defined Object
and Collection Types

Referenced Objects

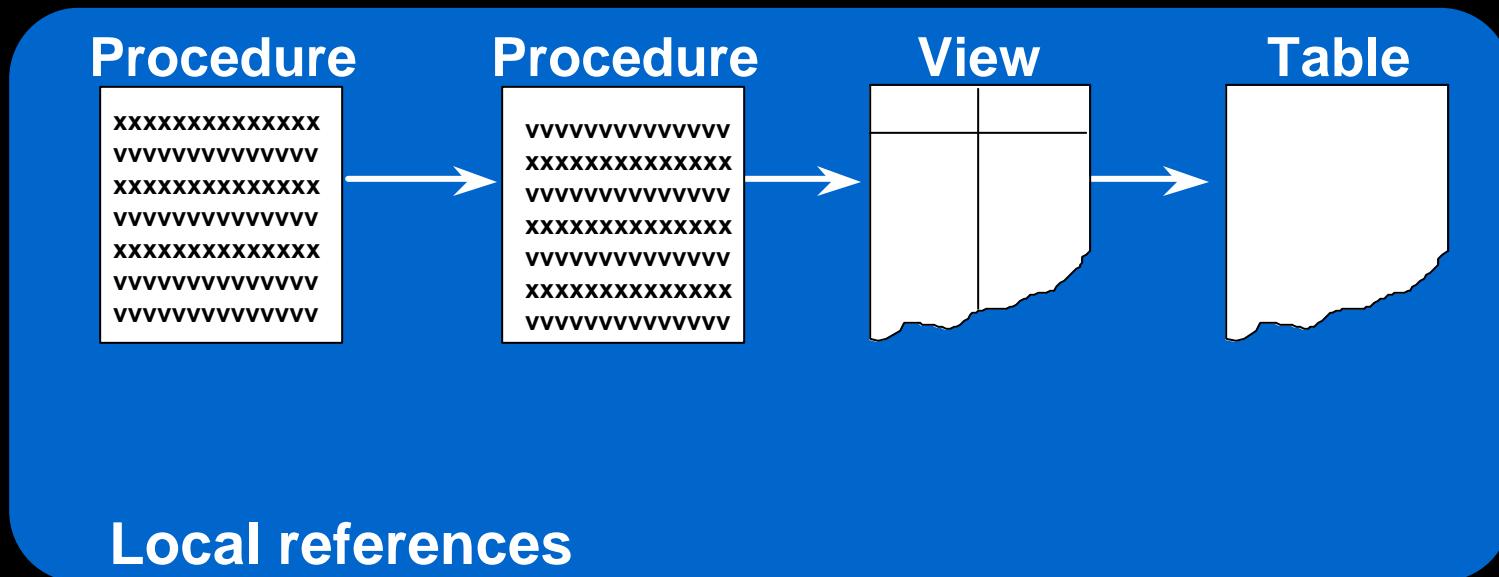
Function
Package Specification
Procedure
Sequence
Synonym
Table
View
User-Defined Object
and Collection Types



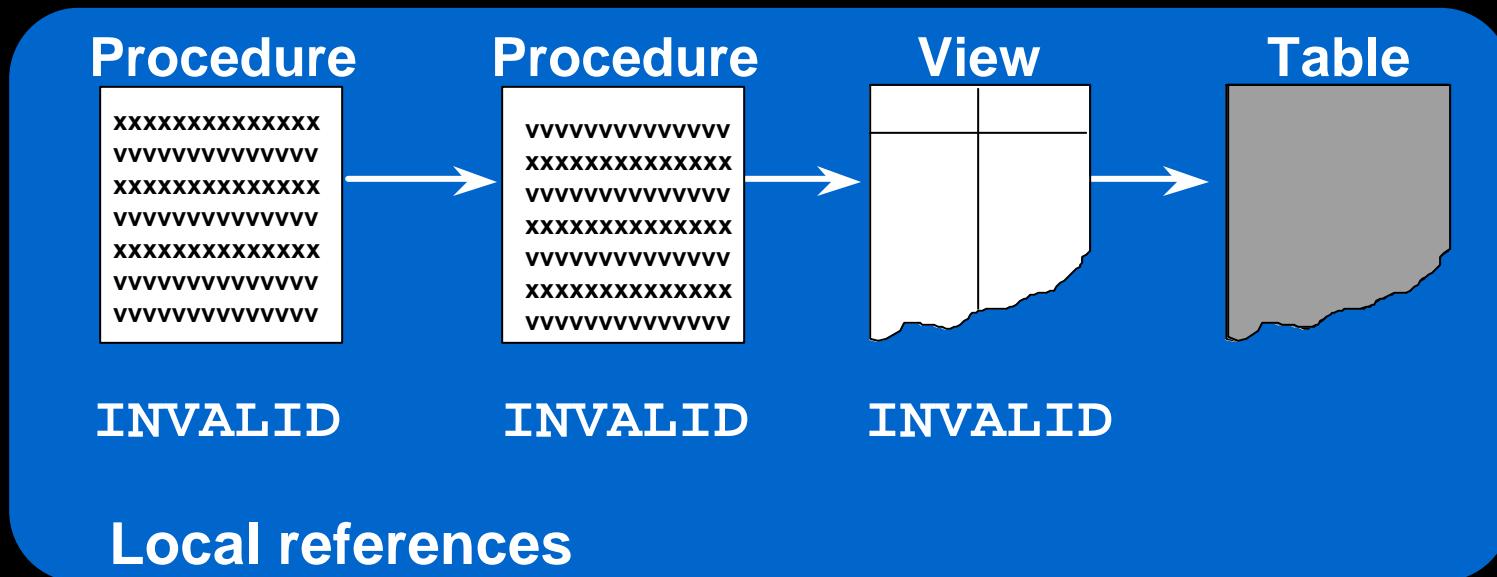
Dependencies



Local Dependencies



Local Dependencies



→
Direct local dependency

→
Definition change

The Oracle server implicitly recompiles any INVALID object when the object is next called.

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A Scenario of Local Dependencies

**ADD_EMP
procedure**

```
xxxxxxxxxxxxxxxxxxxxxx  
vvvvvvvvvvvvvvvvvvv  
vvvvvvvvvvvvvvv  
vvvvvvvvvvvvvvvvv  
vvvvvvvvvvvvvvv  
vvvvvvxxxxxxxxxxxxx  
xxxxxxxxxxxxxxxxxxx  
vvvvvvvvvvvvvvvvv
```

EMP_VW view

EMPLOYEE_ID	LAST_NAME	FIRST_NAME	EMAIL	DEPARTMENT_ID
100	King	Steven	SKING	
101	Kochhar	Neena	NKOCHHAR	
102	De Haan	Lex	LDEHAAN	
105	Austin	David	DAUSTIN	
108	Greenberg	Nancy	NGREENBRE	
...				

**QUERY_EMP
procedure**

```
xxxxxxxxxxxxxxxxxxxxxx  
vvvvvvvvvvvvvvvvv  
vvvvvvvvvvvvv  
vvvvvvvvvvvvvvv  
vvvvvvvvvvvvvvv  
vvvvvvxxxxxxxxxxxxx  
xxxxxxxxxxxxxxxxxxx  
vvvvvvvvvvvvvvvvv
```

EMPLOYEES table

EMPLOYEE_ID	FIRST_NAME	LAST_NAME	EMAIL	PHONE_NUMBER
100	Steven	King	SKING	515.123.4567
101	Neena	Kochhar	NKOCHHAR	515.123.4568
102	Lex	De Haan	LDEHAAN	515.123.4569
105	David	Austin	DAUSTIN	590.423.4568
108	Nancy	Greenberg	NGREENBRE	515.124.4568
...				

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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

Displaying Direct and Indirect Dependencies

1. Run the script `utldtree.sql` 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')
```

```
PL/SQL procedure successfully completed.
```

Displaying Dependencies

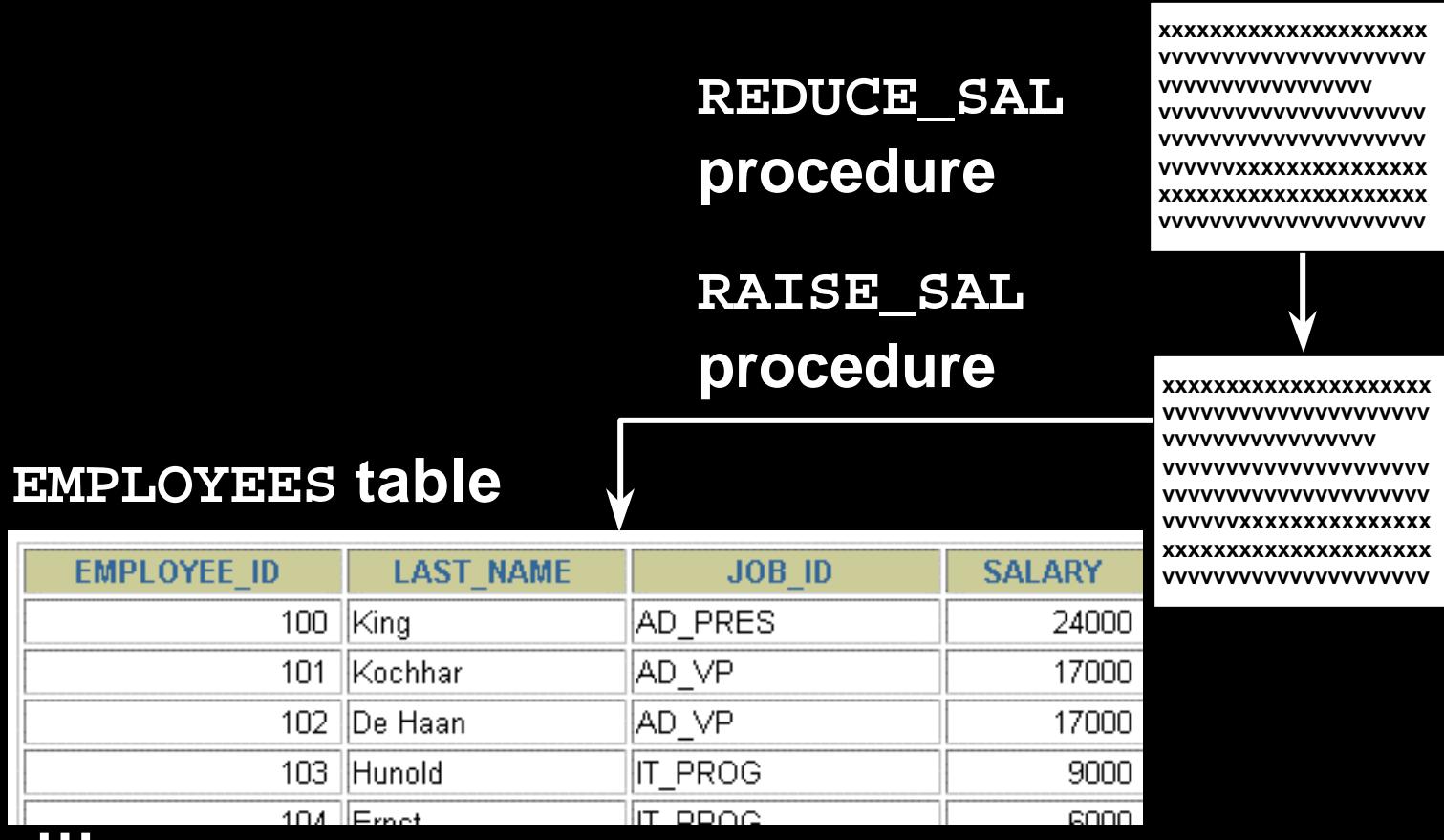
DEPTREE View

```
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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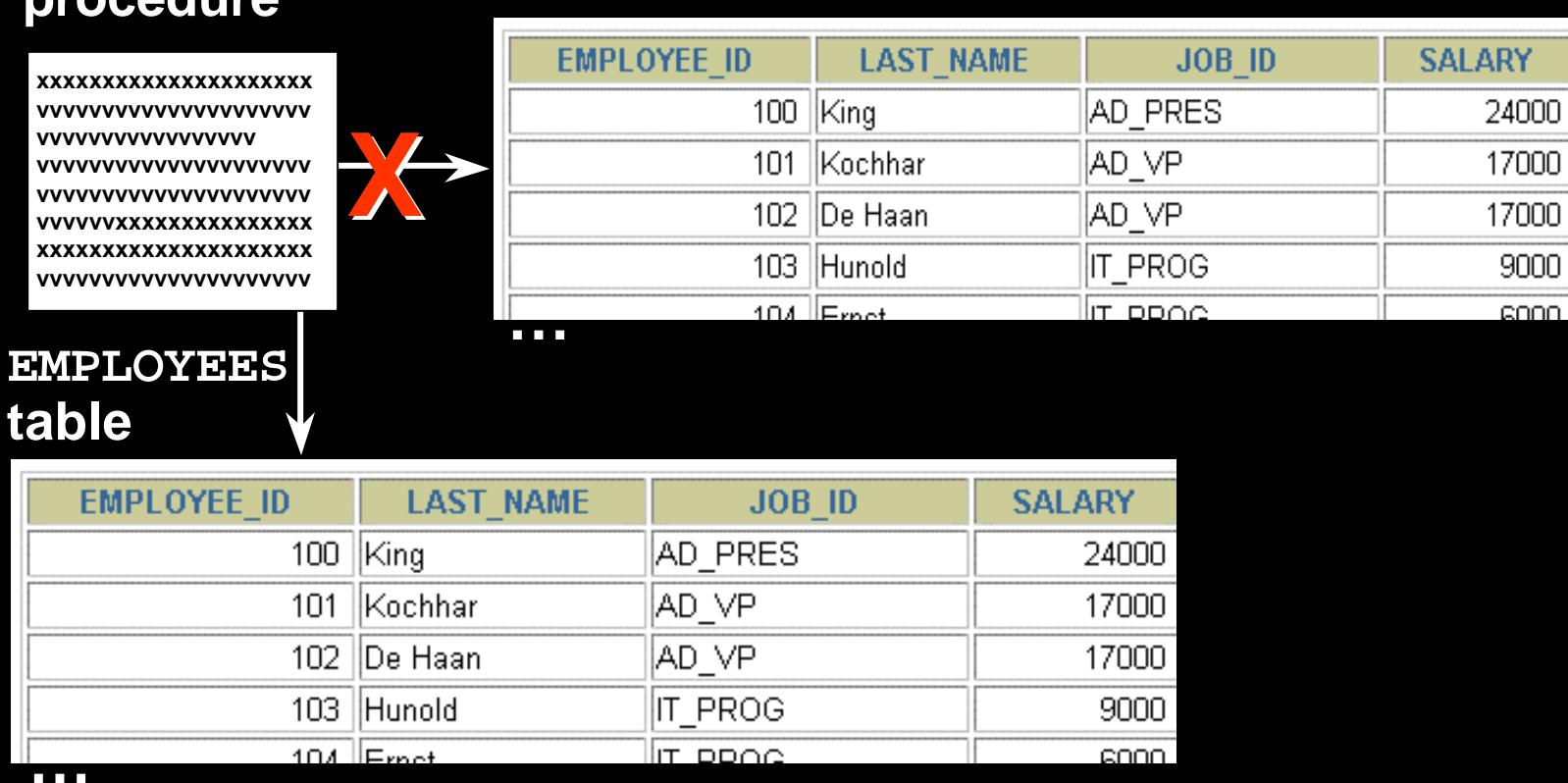
Another Scenario of Local Dependencies



A Scenario of Local Naming Dependencies

QUERY_EMP
procedure

EMPLOYEES public synonym



Understanding Remote Dependencies

Procedure

```
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv
```

Network

Procedure

```
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv
```

View

Table

Local and remote references



Direct local dependency

Direct remote dependency

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Understanding Remote Dependencies

Procedure

```
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv
```

Network

Procedure

```
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv  
xxxxxxxxxxxxxx  
vvvvvvvvvvvvv
```

INVALID

View



Table

A large gray rectangle with irregular edges, representing a table that is currently invalid or unavailable.

VALID

INVALID

Local and remote references



Direct local dependency

Direct remote dependency

Definition change

Concepts of Remote Dependencies

Remote dependencies are governed by the mode chosen by the user:

- **TIMESTAMP checking**
- **SIGNATURE checking**

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`

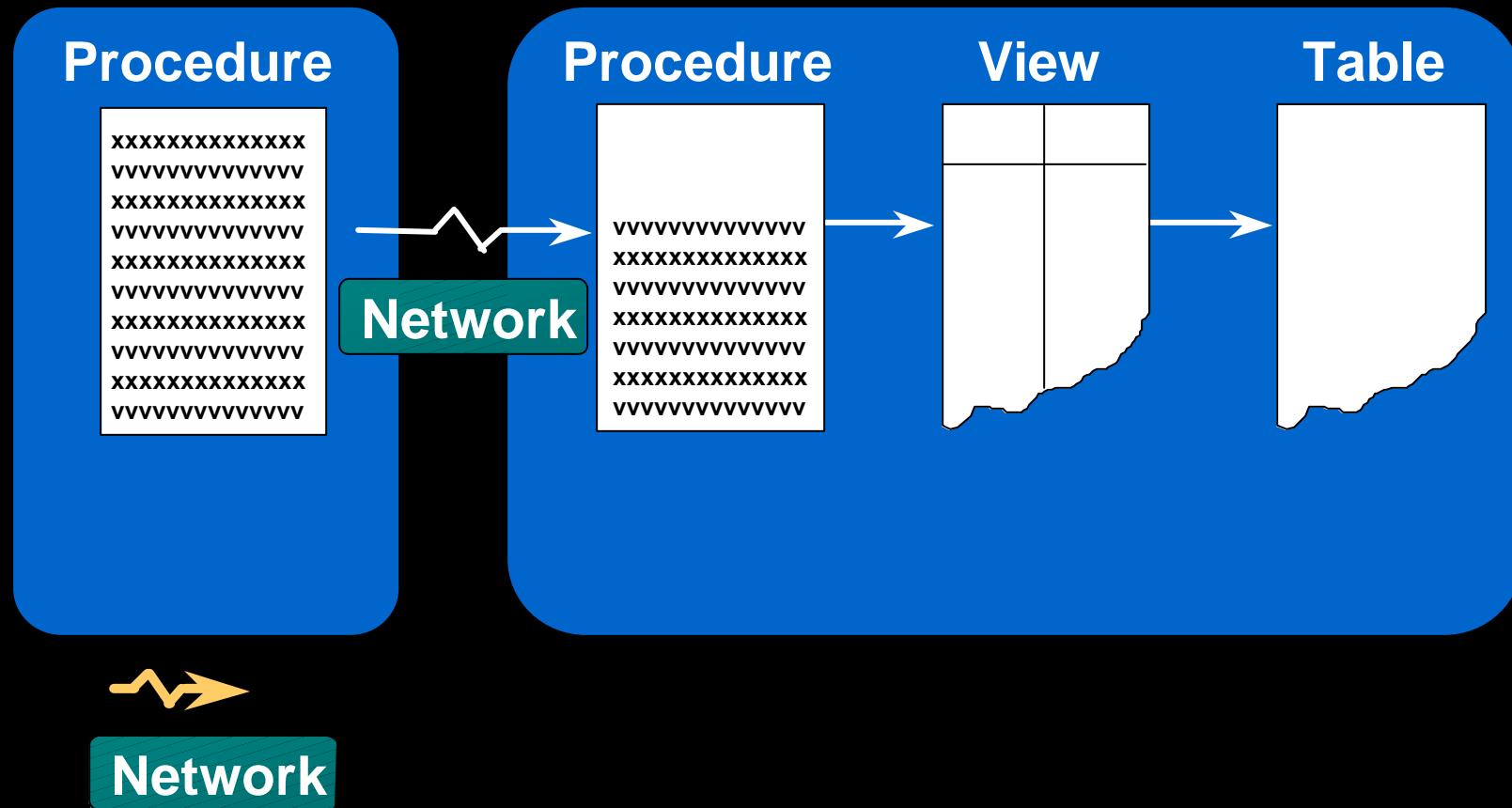
- At the session level

`ALTER SESSION SET`

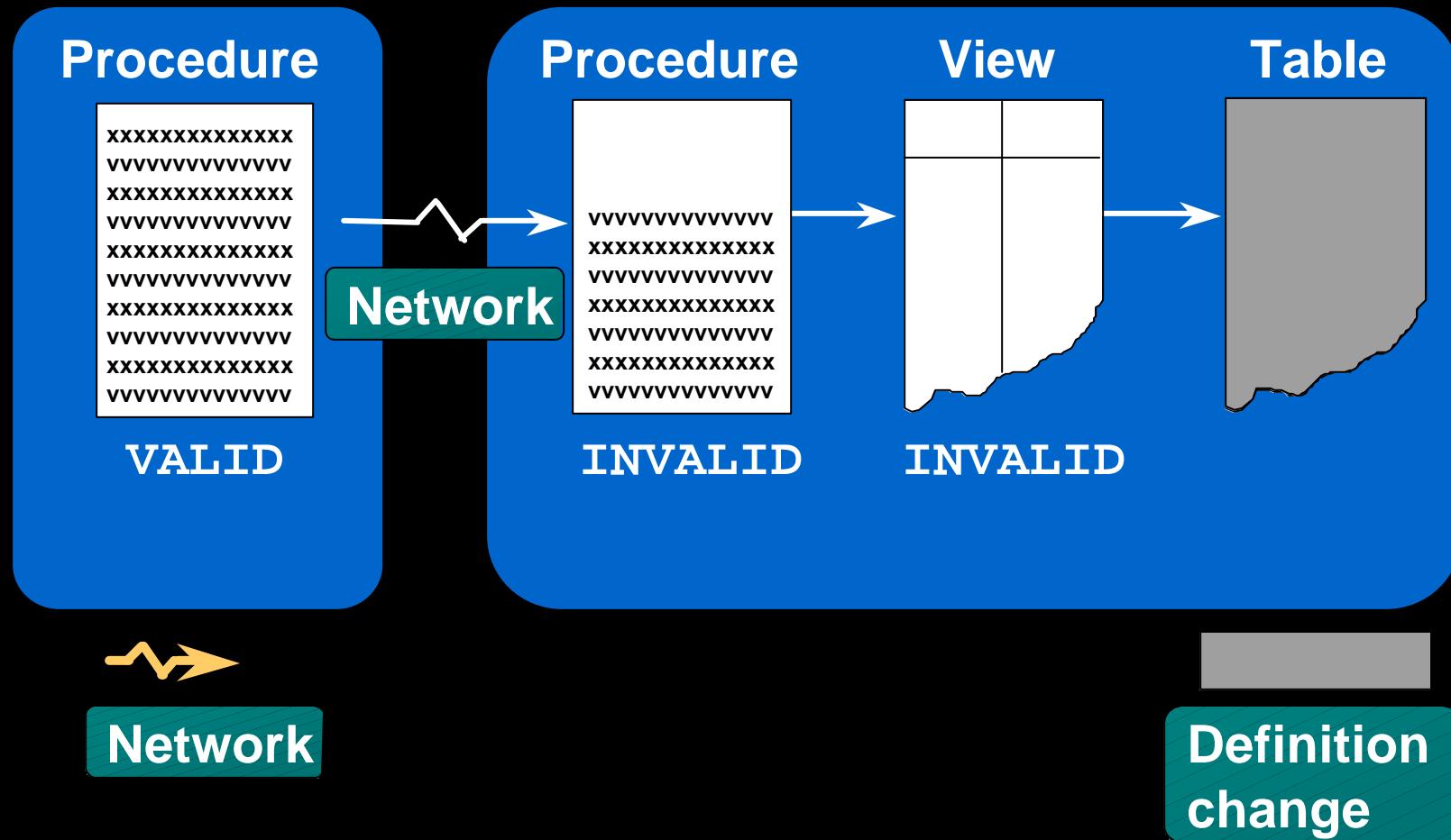
`REMOTE_DEPENDENCIES_MODE = value`



Remote Dependencies and Time Stamp Mode

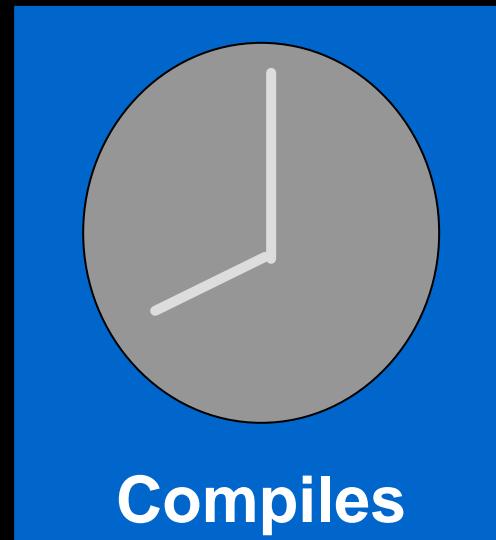


Remote Dependencies and Time Stamp Mode



Remote Procedure B Compiles at 8:00 a.m.

Remote procedure B

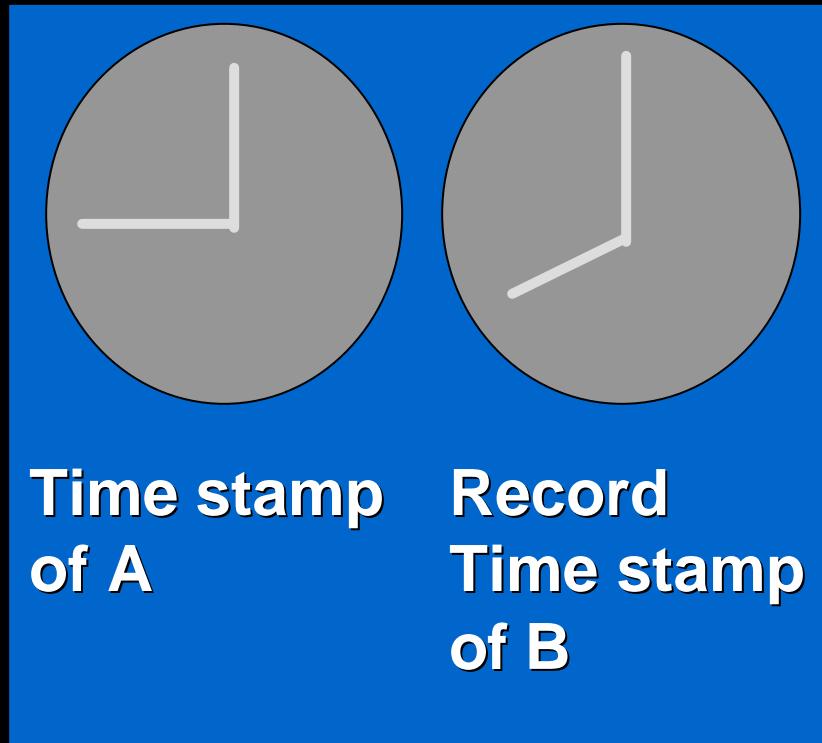


Valid

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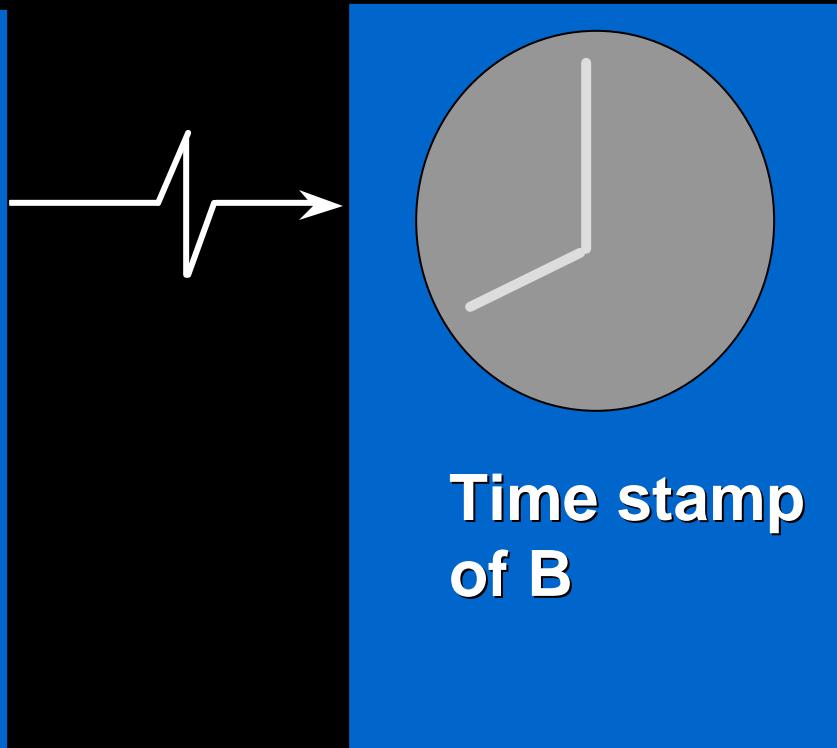
Local Procedure A Compiles at 9:00 a.m.

Local procedure A



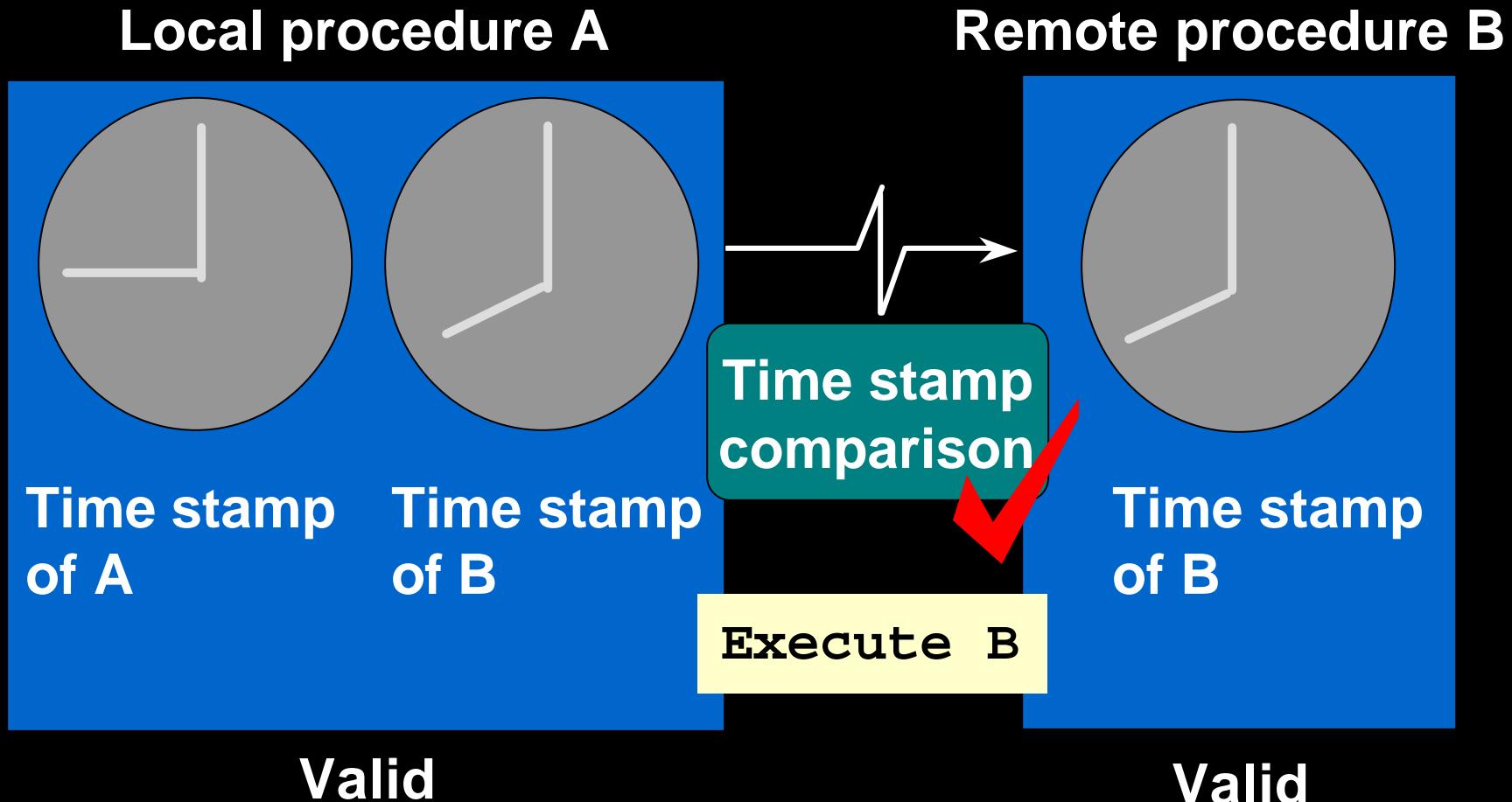
Valid

Remote procedure B



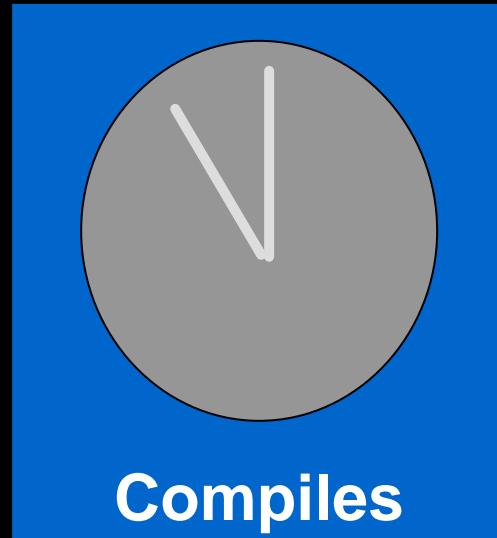
Valid

Execute Procedure A



Remote Procedure B Recompiled at 11:00 a.m.

Remote procedure B



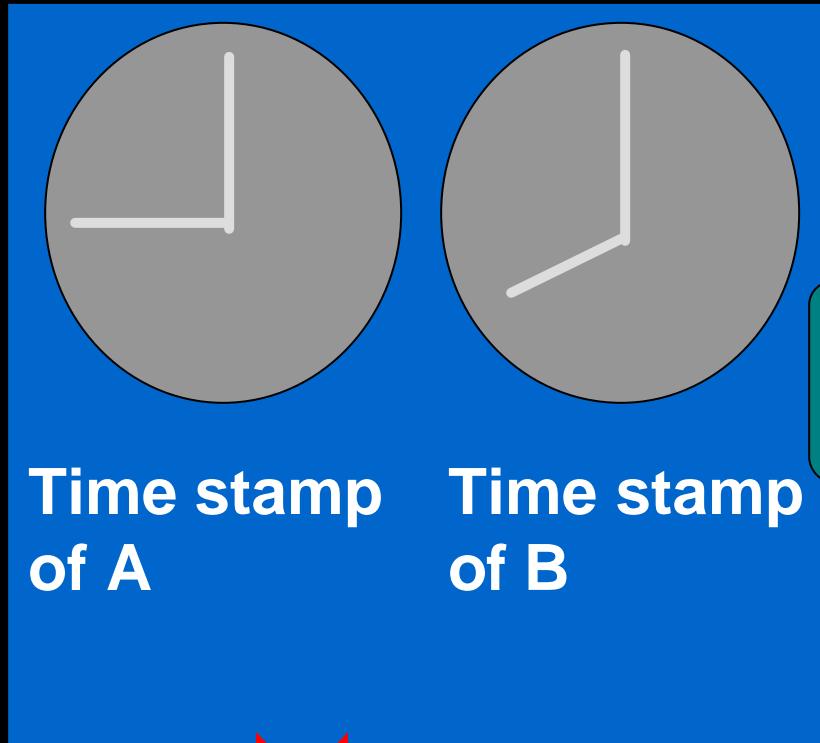
Compiles

Valid

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Execute Procedure A

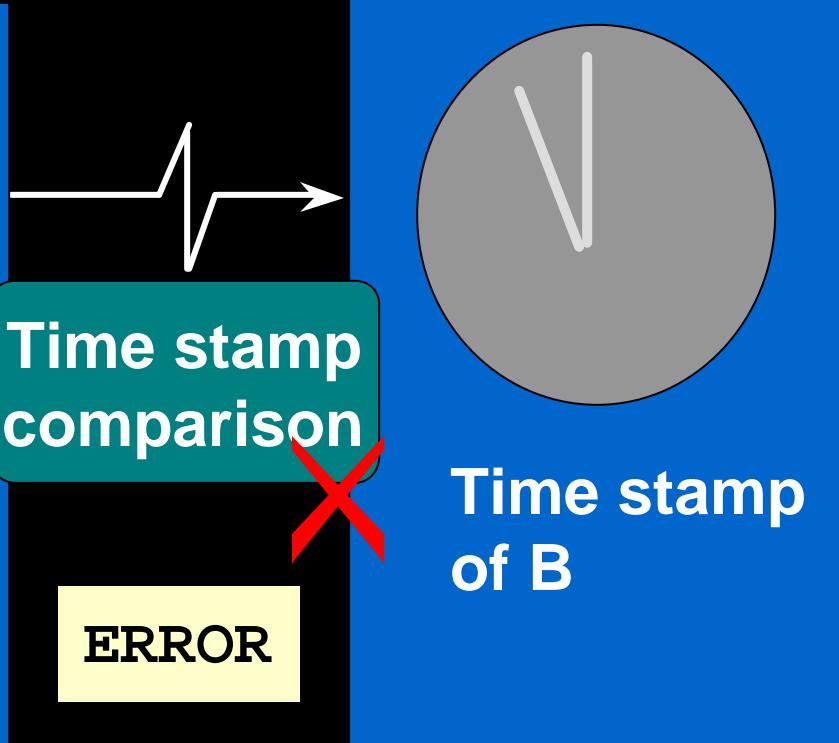
Local procedure A



Valid

Invalid

Remote procedure B



Valid

Signature Mode

- The signature of a procedure is:
 - The name of the procedure
 - The datatypes 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.

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];  
ALTER PACKAGE [SCHEMA.]package_name COMPILE BODY;
```

```
ALTER TRIGGER trigger_name [COMPILE[DEBUG]];
```



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

Successful Recompilation

Recompiling dependent procedures and functions is successful if:

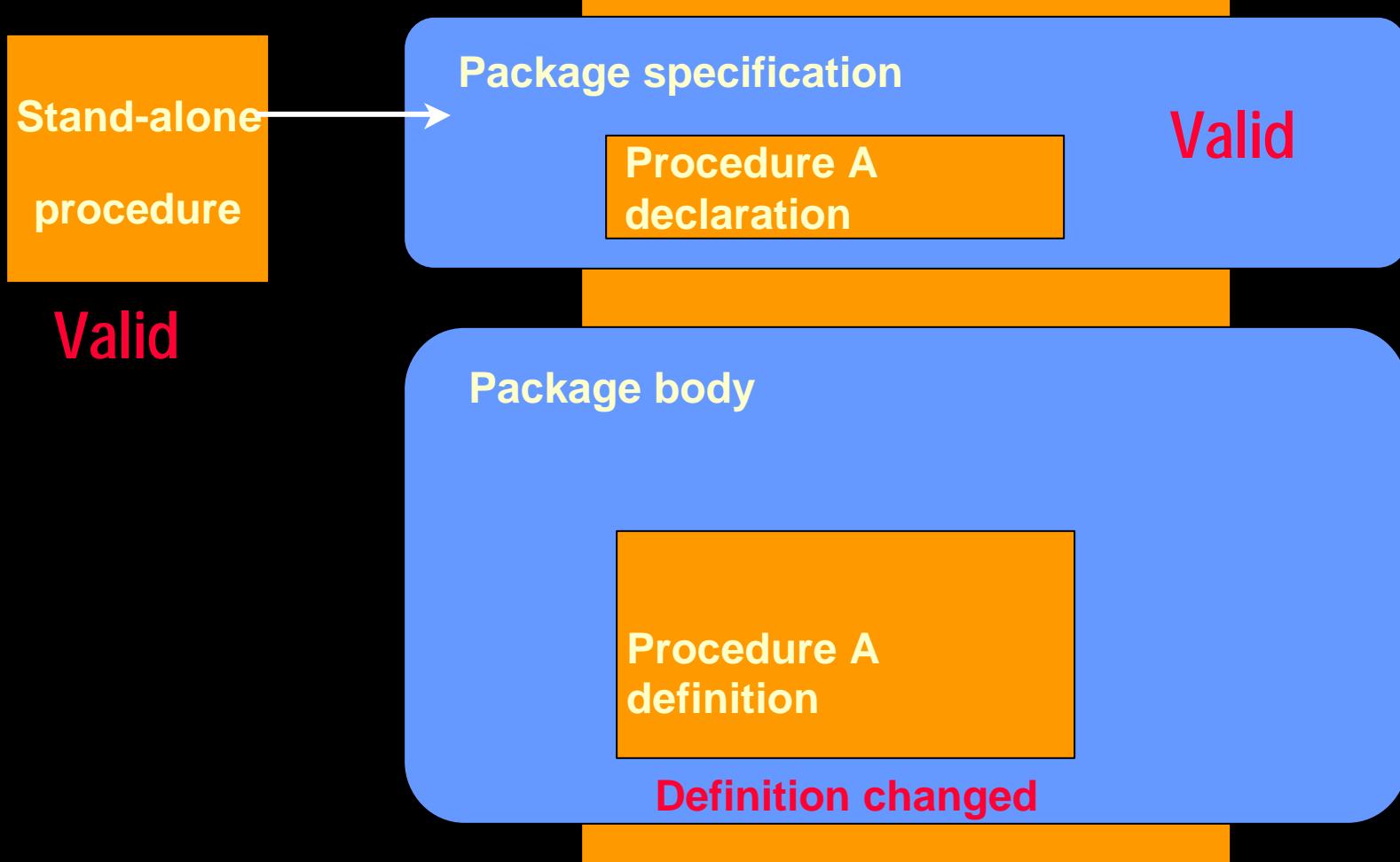
- **The referenced table has new columns**
- **The data type of referenced columns has not changed**
- **A private table is dropped, but a public table, having the same name and structure, exists**
- **The PL/SQL body of a referenced procedure has been modified and recompiled successfully**

Recompilation of Procedures

Minimize dependency failures by:

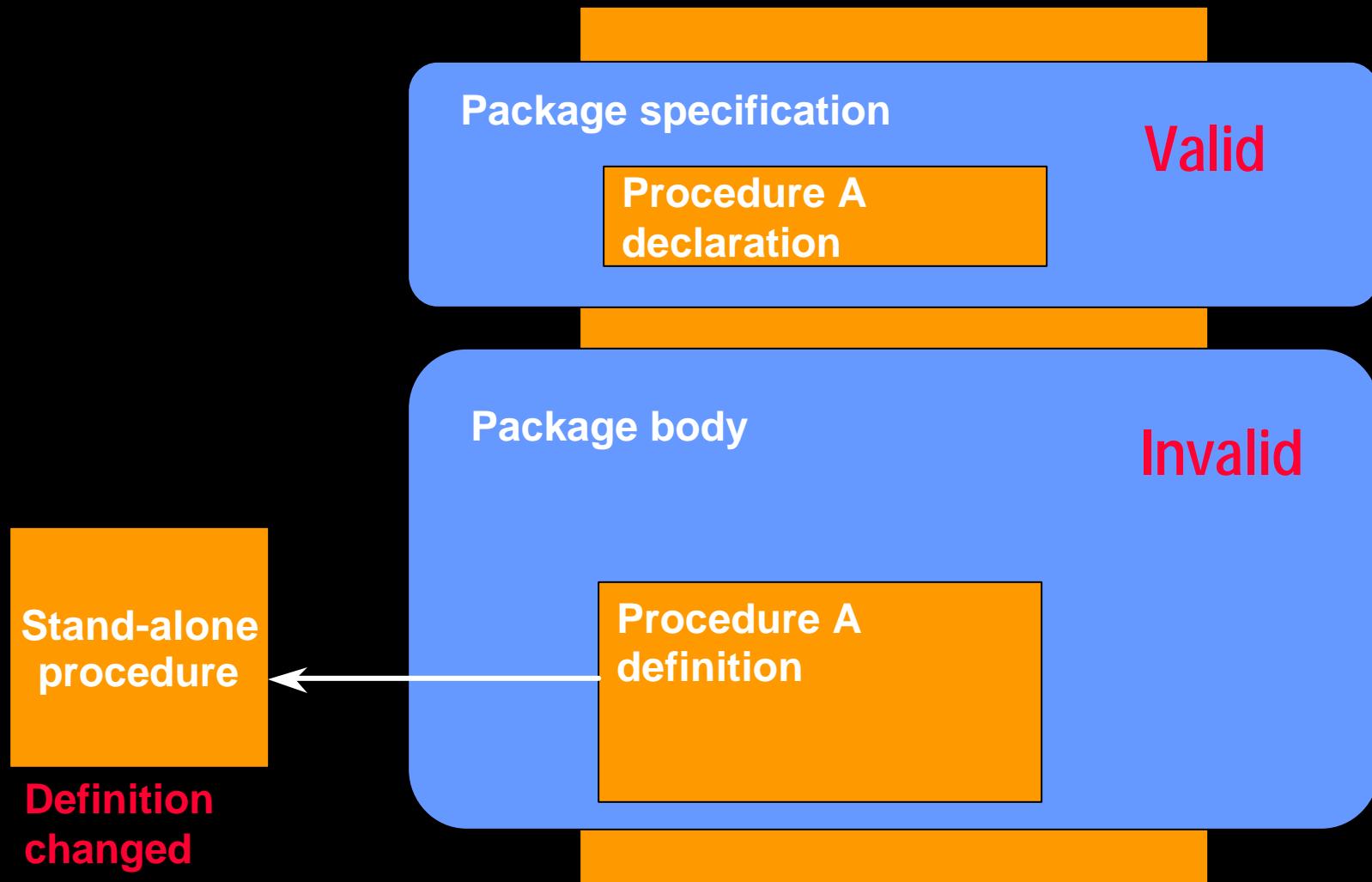
- Declaring records by using the `%ROWTYPE` attribute
- Declaring variables with the `%TYPE` attribute
- Querying with the `SELECT *` notation
- Including a column list with `INSERT` statements

Packages and Dependencies



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Packages and Dependencies



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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**

Practice 18 Overview

This practice covers the following topics:

- **Using DEPTREE_FILL and IDEPTREE to view dependencies**
- **Recompiling procedures, functions, and packages**



Creating Program Units by Using Procedure Builder

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Objectives

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

- **Describe the features of Oracle Procedure Builder**
- **Manage program units using the Object Navigator**
- **Create and compile program units using the Program Unit Editor**
- **Invoke program units using the PL/SQL Interpreter**
- **Debug subprograms using the debugger**
- **Control execution of an interrupted PL/SQL program unit**
- **Test possible solutions at run time**

PL/SQL Program Constructs

Tools Constructs
Anonymous blocks
Application procedures or functions
Application packages
Application triggers
Object types

```
<header> IS | AS  
or  DECLARE  
    • • •  
BEGIN  
    • • •  
EXCEPTION  
    • • •  
END;
```

Database Server Constructs

Anonymous blocks
Stored procedures or functions
Stored packages
Database triggers
Object types

Development Environments

- **iSQL*Plus uses the PL/SQL engine in the Oracle Server**
- **Oracle Procedure Builder uses the PL/SQL engine in the client tool or in the Oracle Server. It includes:**
 - A GUI development environment for PL/SQL code
 - Built-in editors
 - The ability to compile, test, and debug code
 - Application partitioning that allows drag-and-drop of program units between client and server

Developing Procedures and Functions Using *i*SQL*Plus

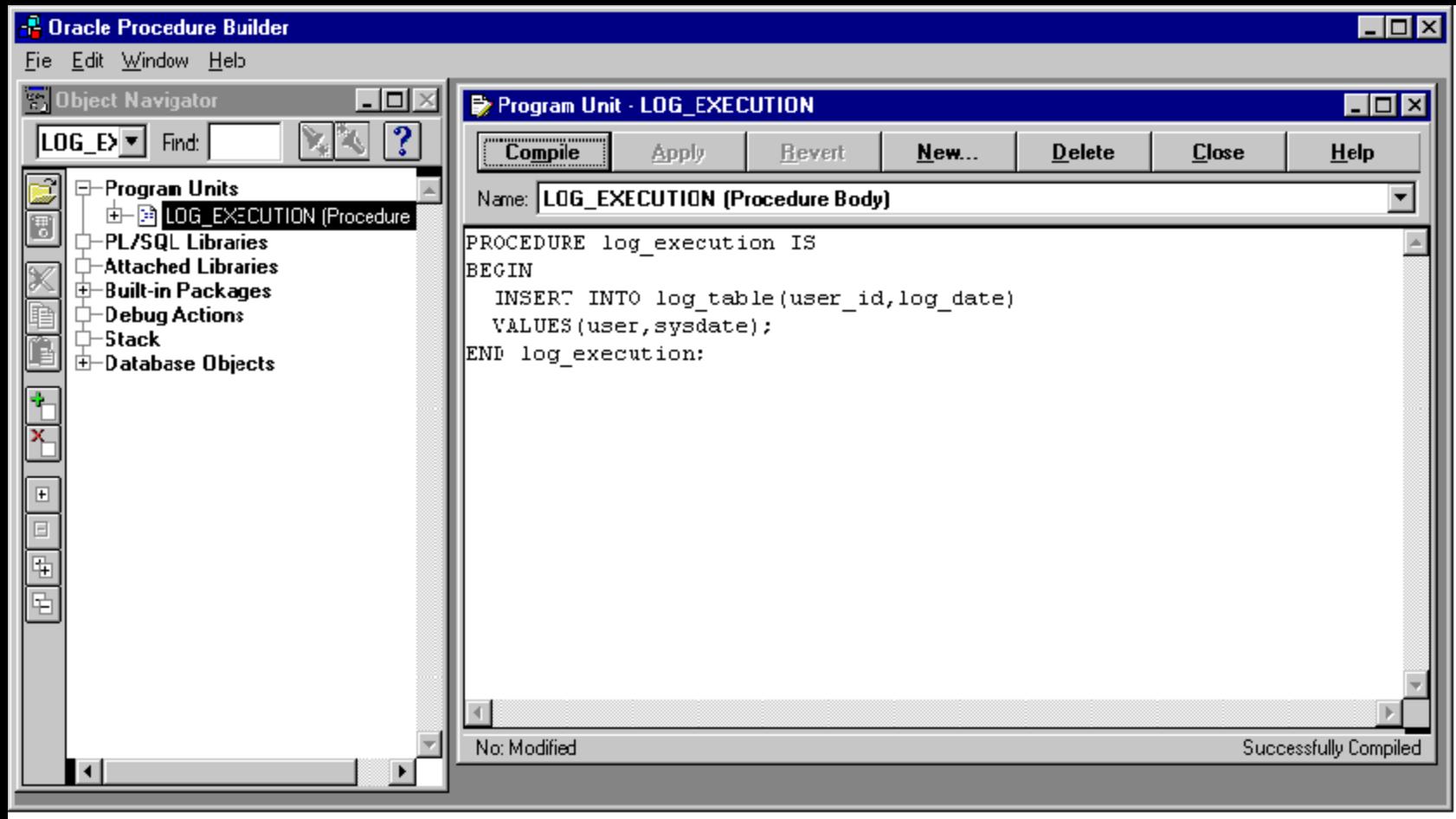
Script Location:

Enter statements:

```
REM Run the 01_addtabs.sql script before running this script
REM to ensure that the log_table is created.

CREATE OR REPLACE PROCEDURE log_execution
IS
BEGIN
  INSERT INTO log_table (user_id, log_date)
  VALUES      (user,    sysdate);
END log_execution;
```

Developing Procedures and Functions Using Oracle Procedure Builder

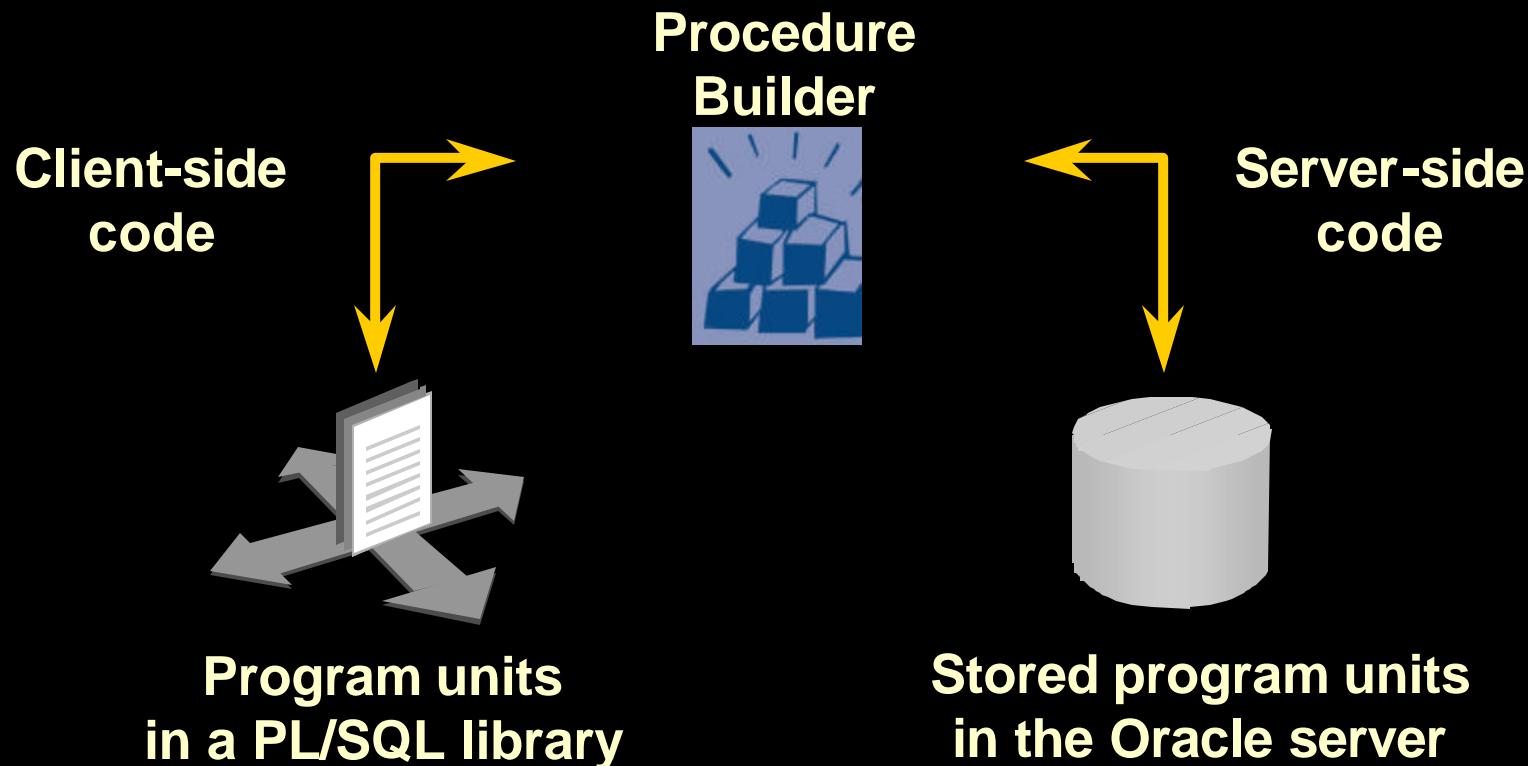


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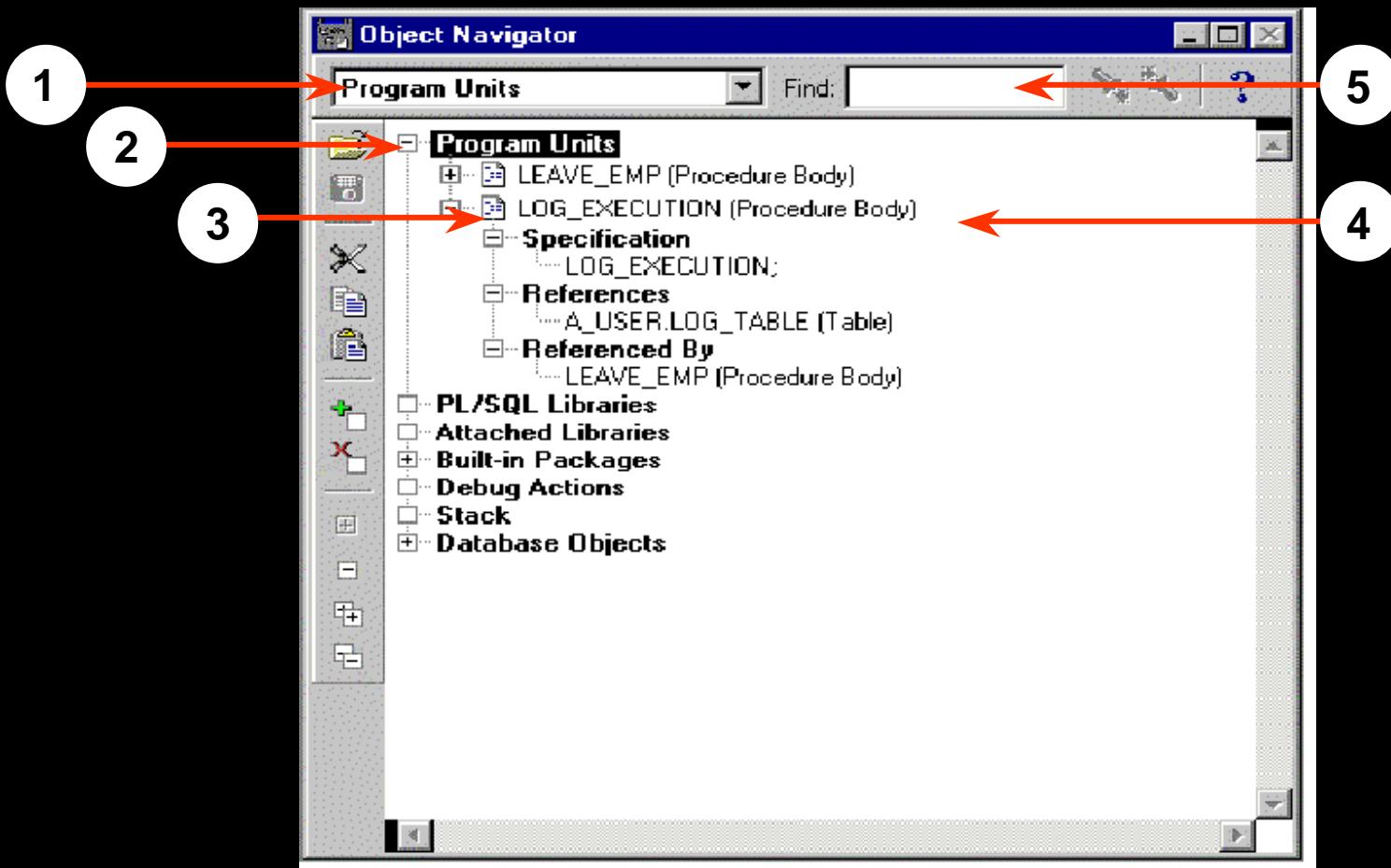
Components of Procedure Builder

Component	Function
Object Navigator	Manages PL/SQL constructs; performs debug actions
PL/SQL Interpreter	Debugs PL/SQL code; evaluates PL/SQL code in real time
Program Unit Editor	Creates and edits PL/SQL source code
Stored Program Unit Editor	Creates and edits server-side PL/SQL source code
Database Trigger Editor	Creates and edits database triggers

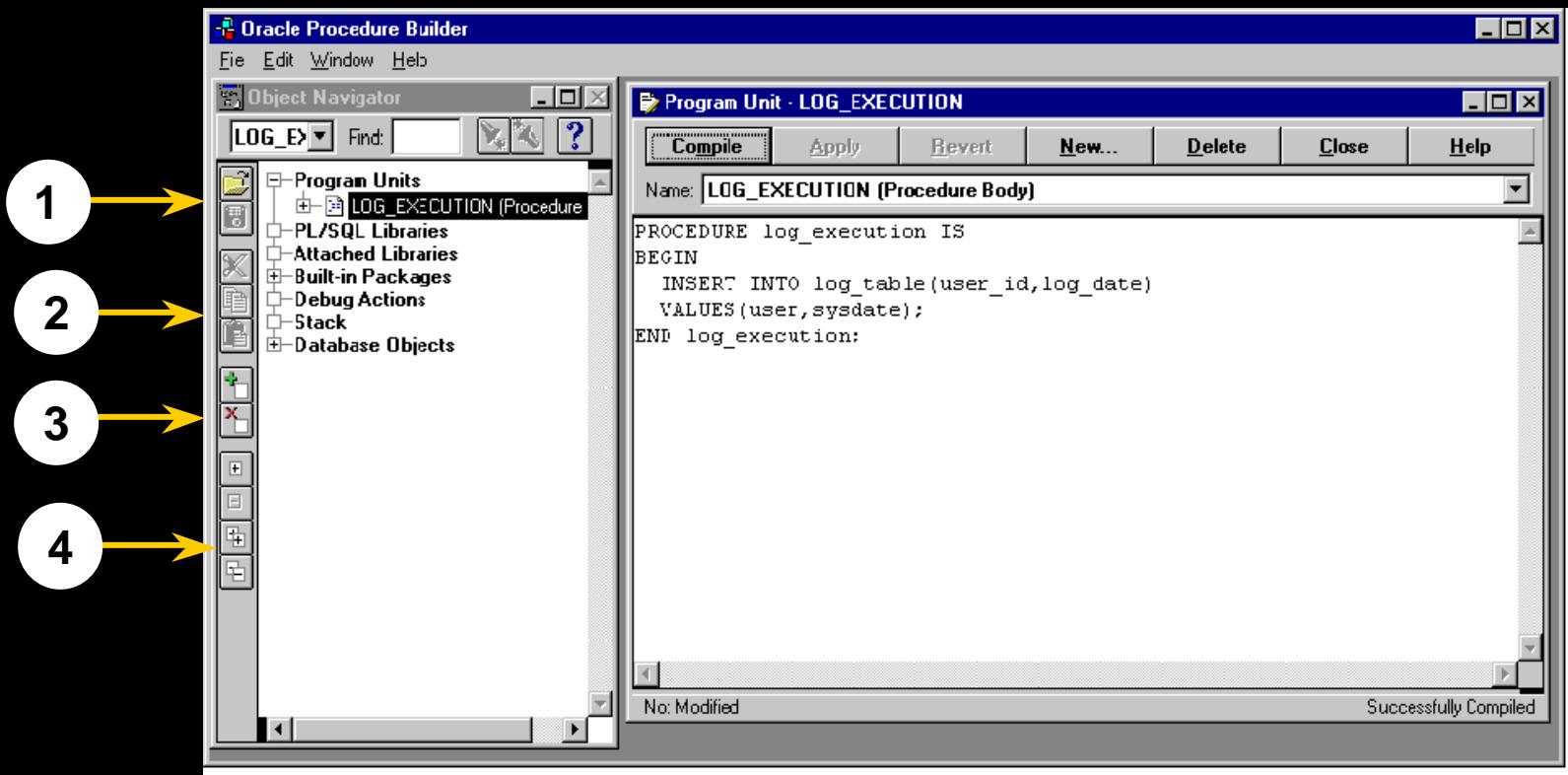
Developing Program Units and Stored Programs Units



Procedure Builder Components: The Object Navigator



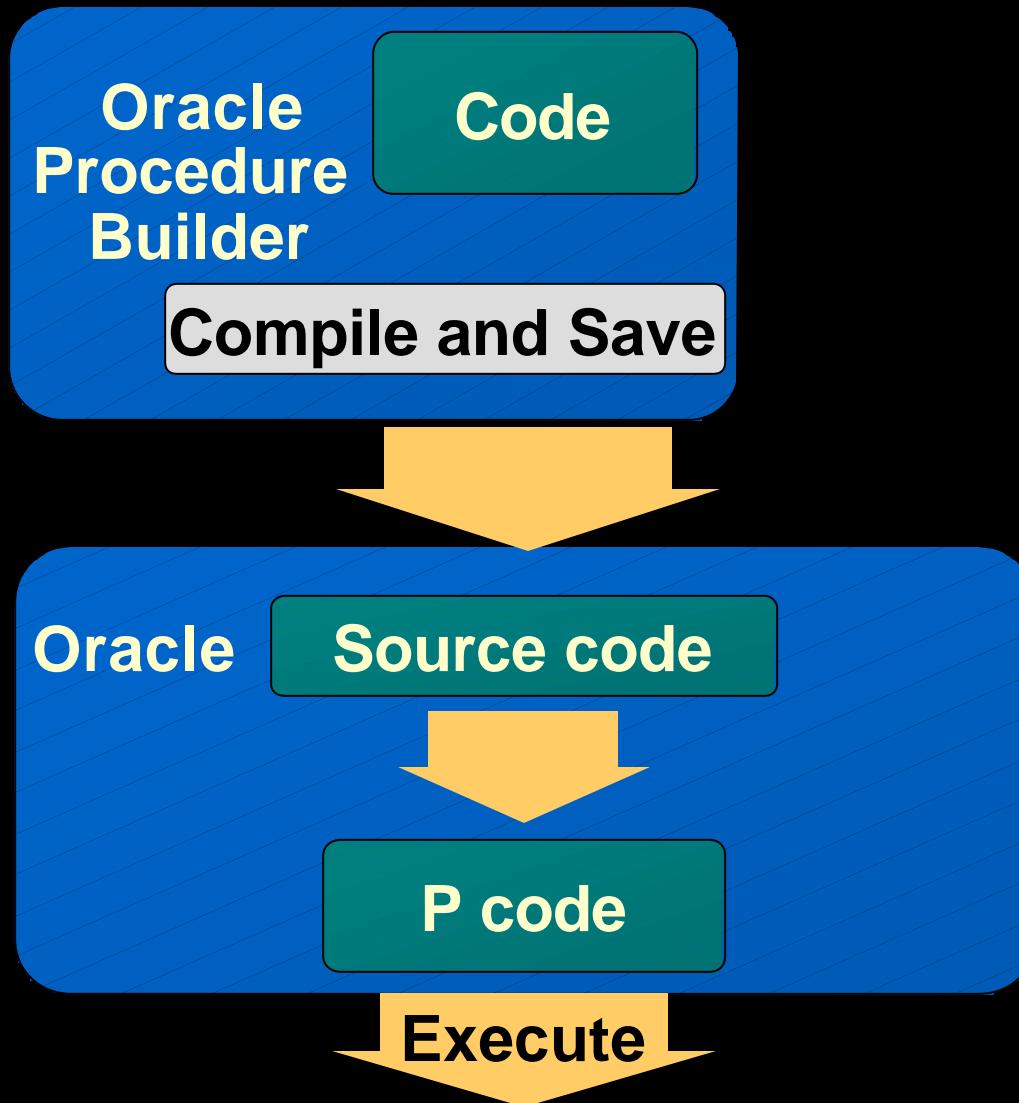
Procedure Builder Components: The Object Navigator



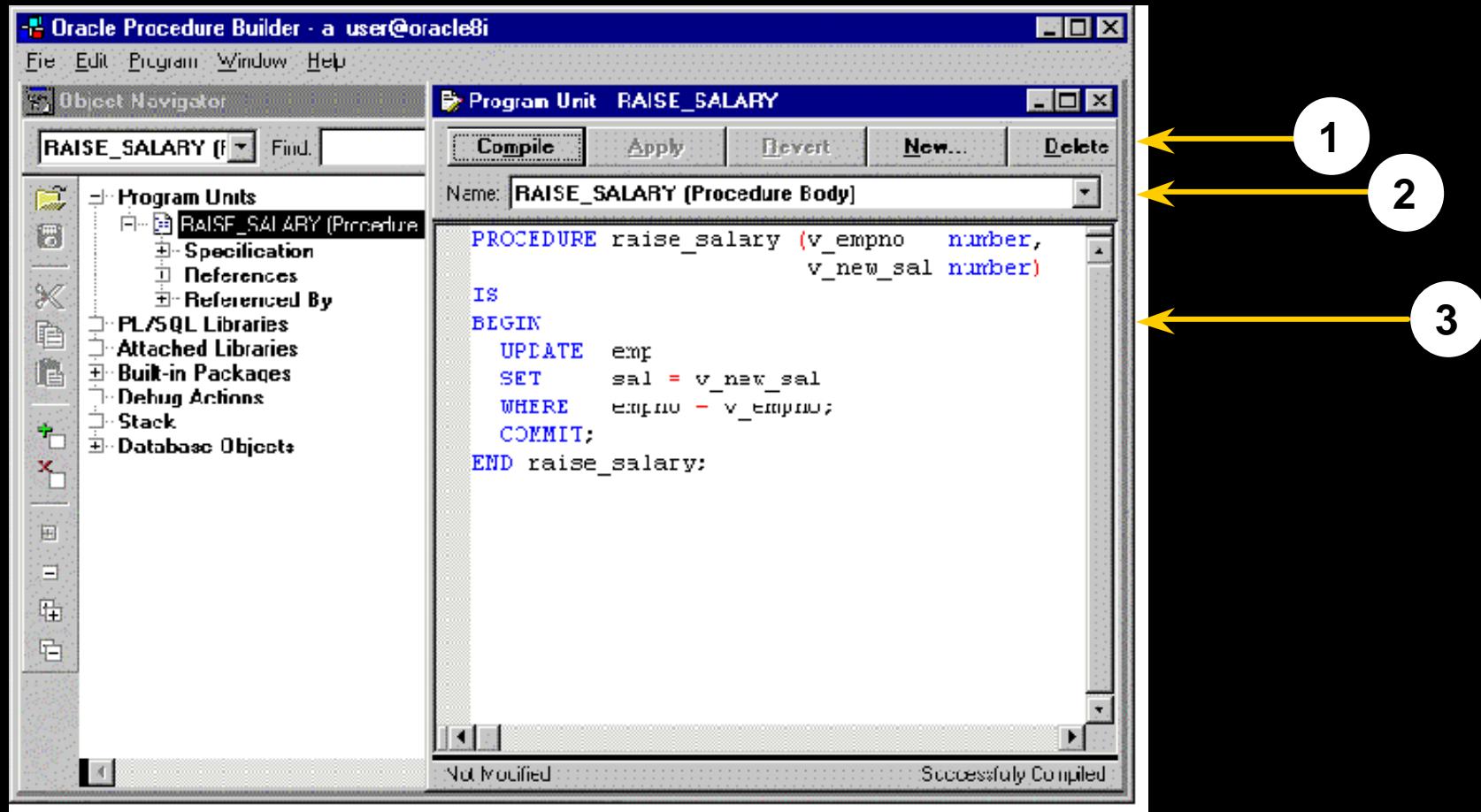
Procedure Builder Components: Objects of the Navigator

- **Program Units**
 - Specification
 - References
 - Referenced By
- **Libraries**
- **Attached Libraries**
- **Built-in Packages**
- **Debug Actions**
- **Stack**
- **Database Objects**

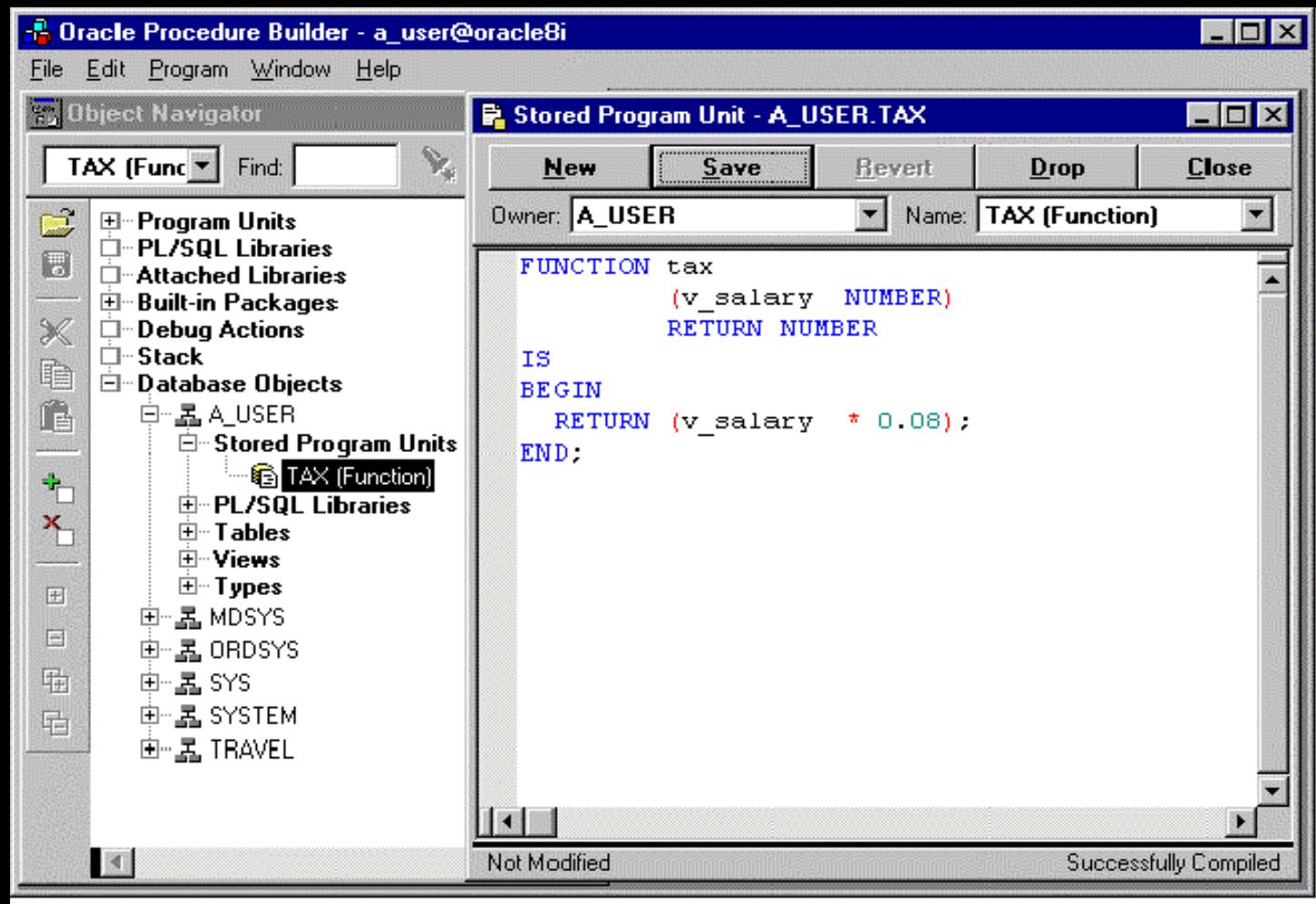
Developing Stored Procedures



Procedure Builder Components: The Program Unit Editor

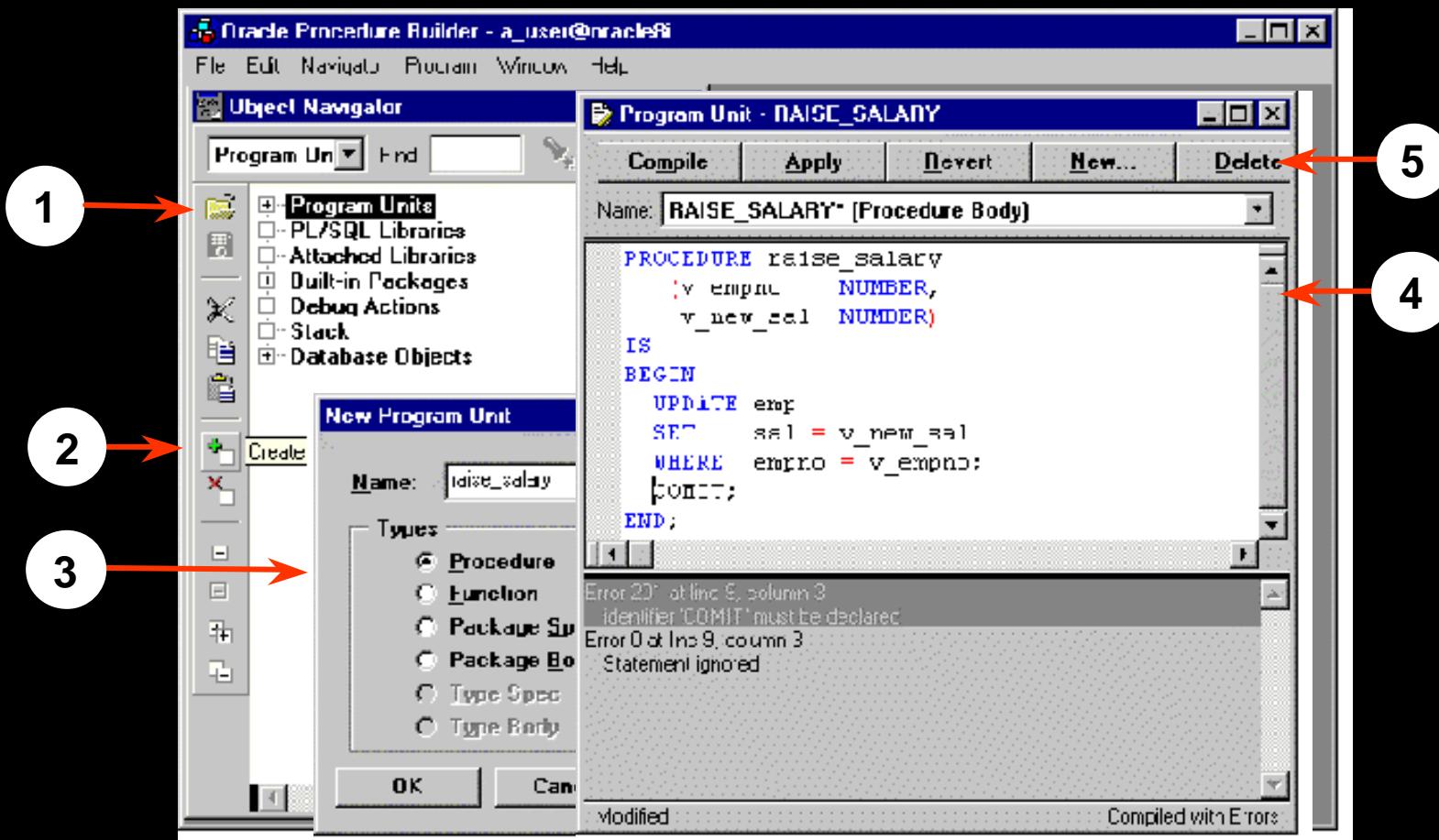


Procedure Builder Components: The Stored Program Unit Editor

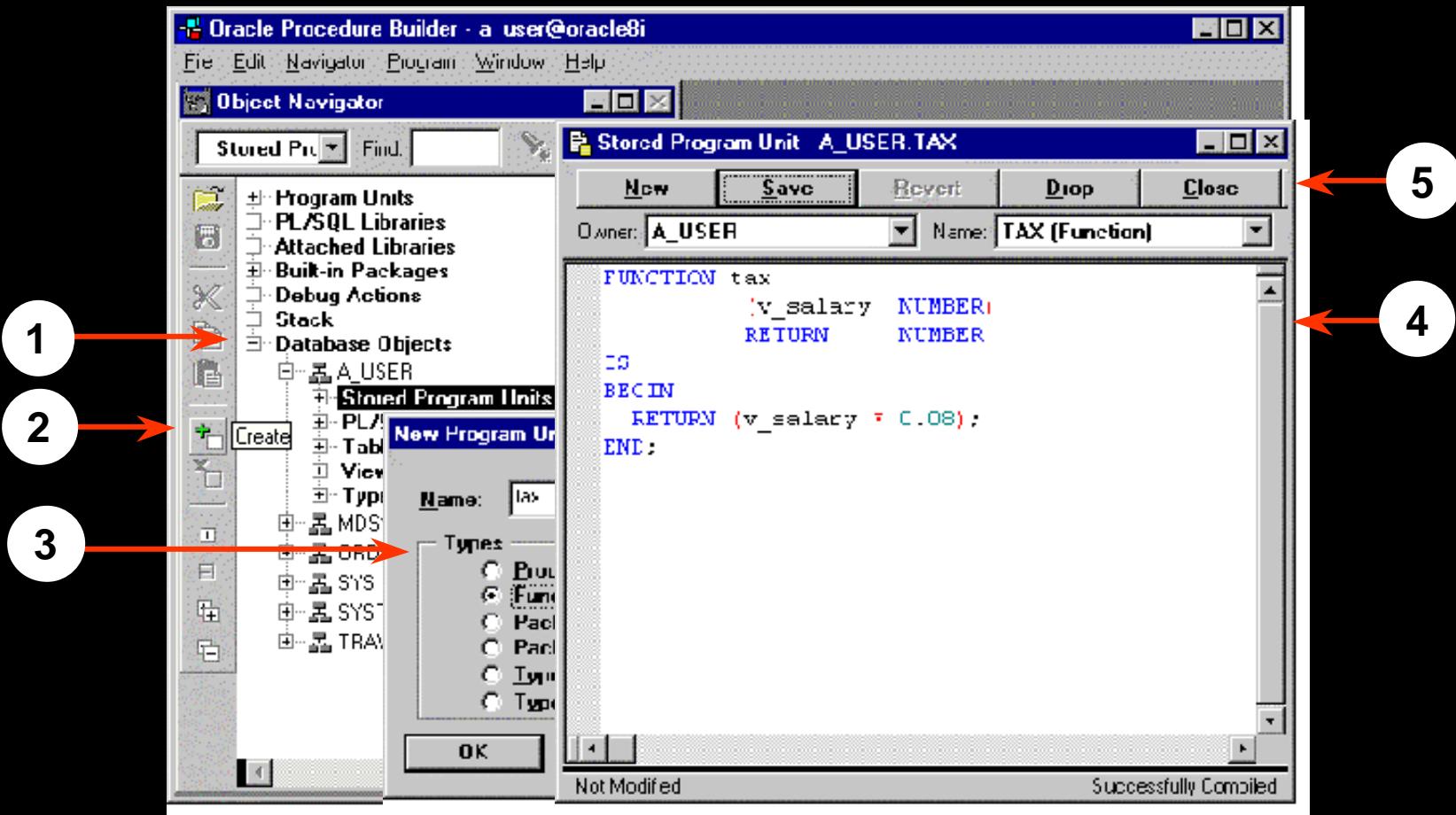


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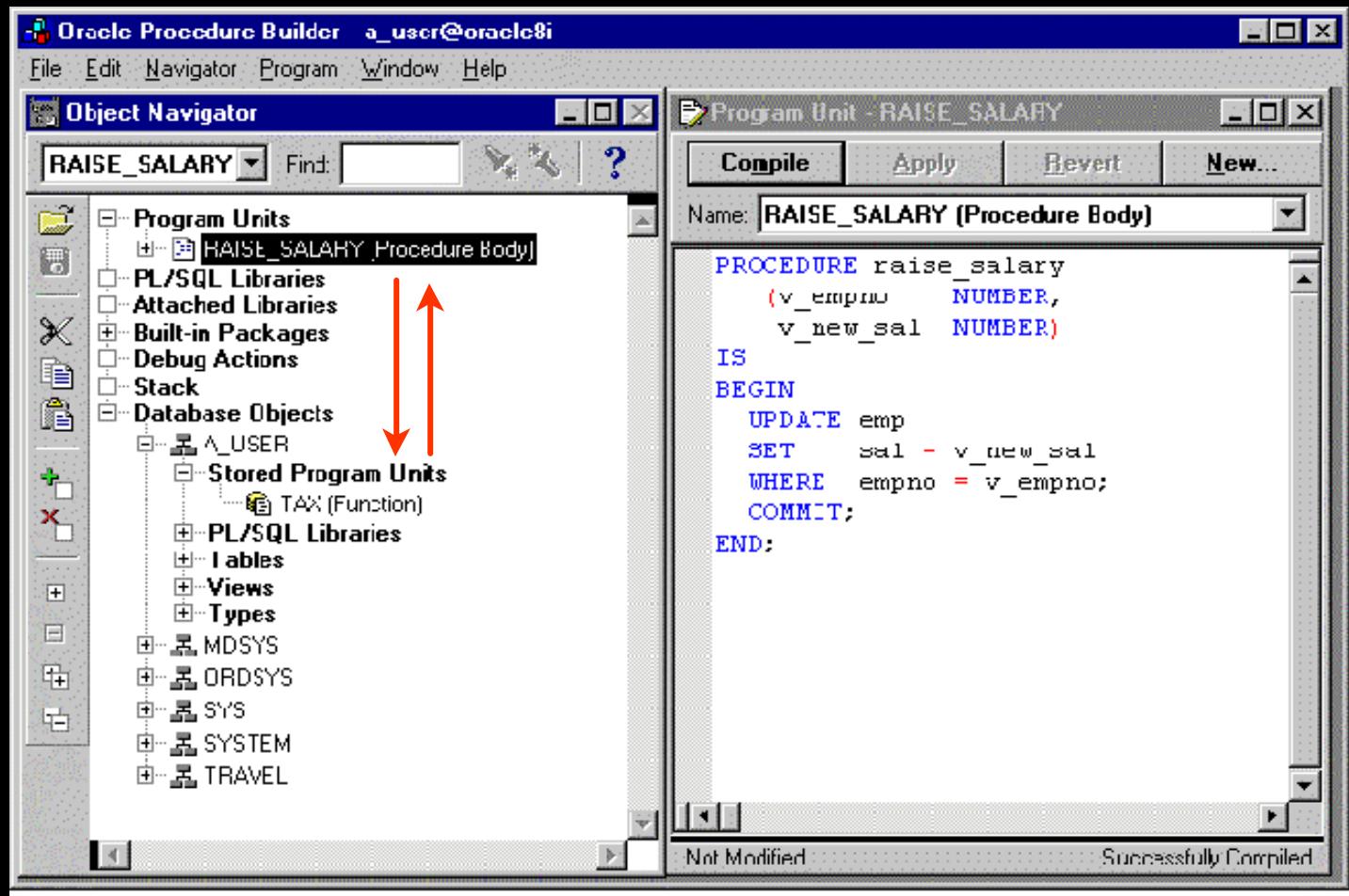
Creating a Client-Side Program Unit



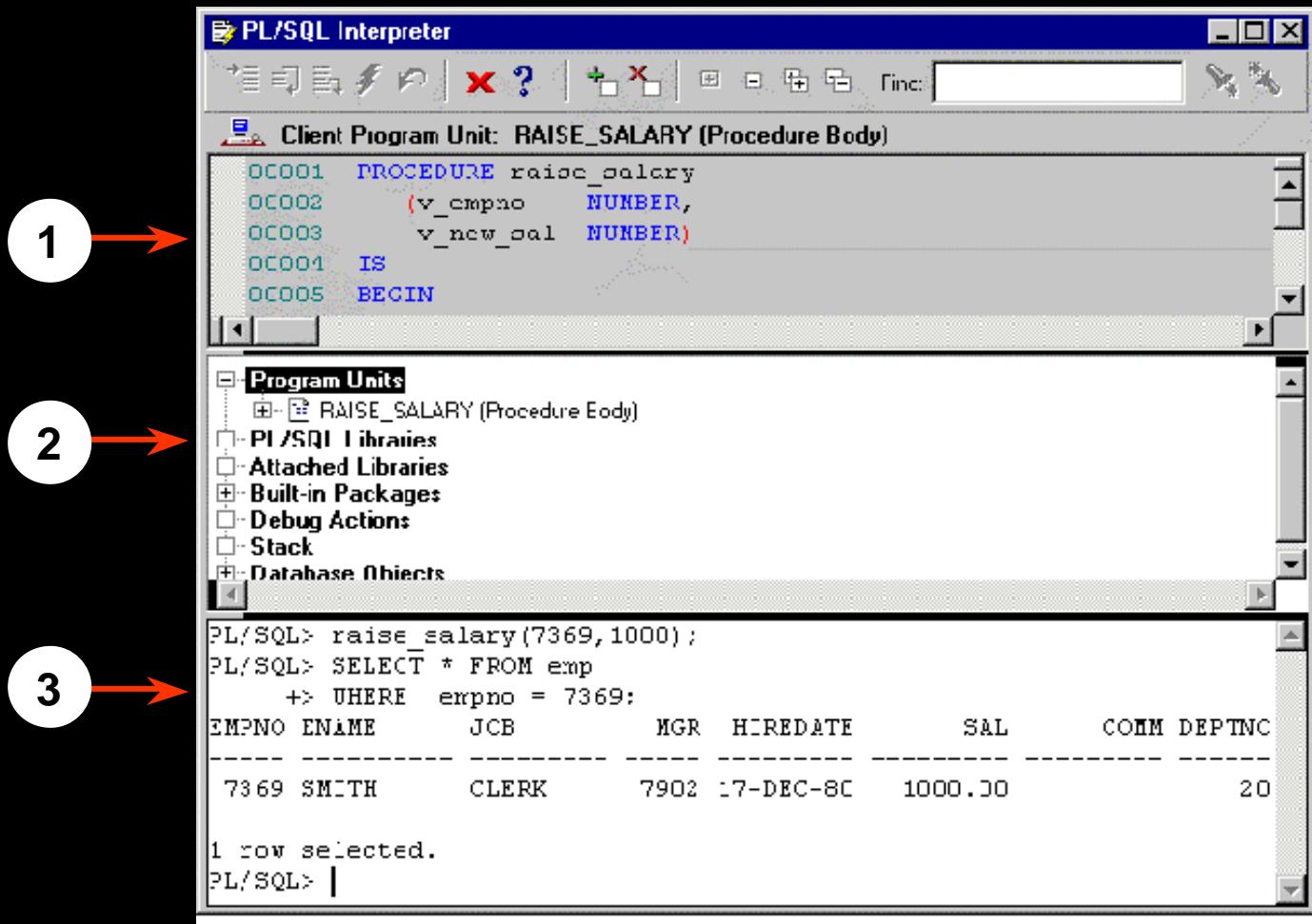
Creating a Server-Side Program Unit



Transferring Program Units Between Client and Server

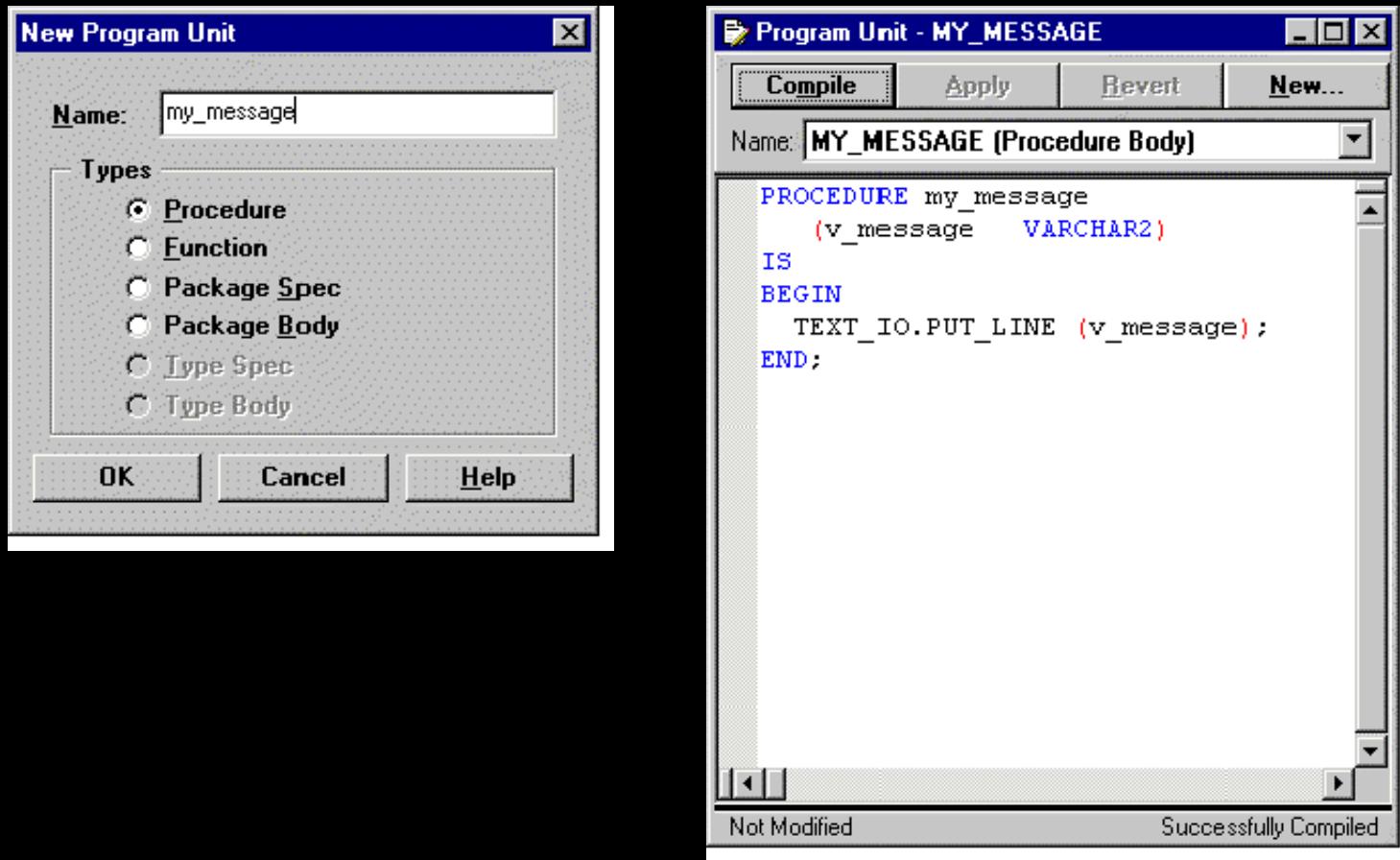


Procedure Builder Components: The PL/SQL Interpreter



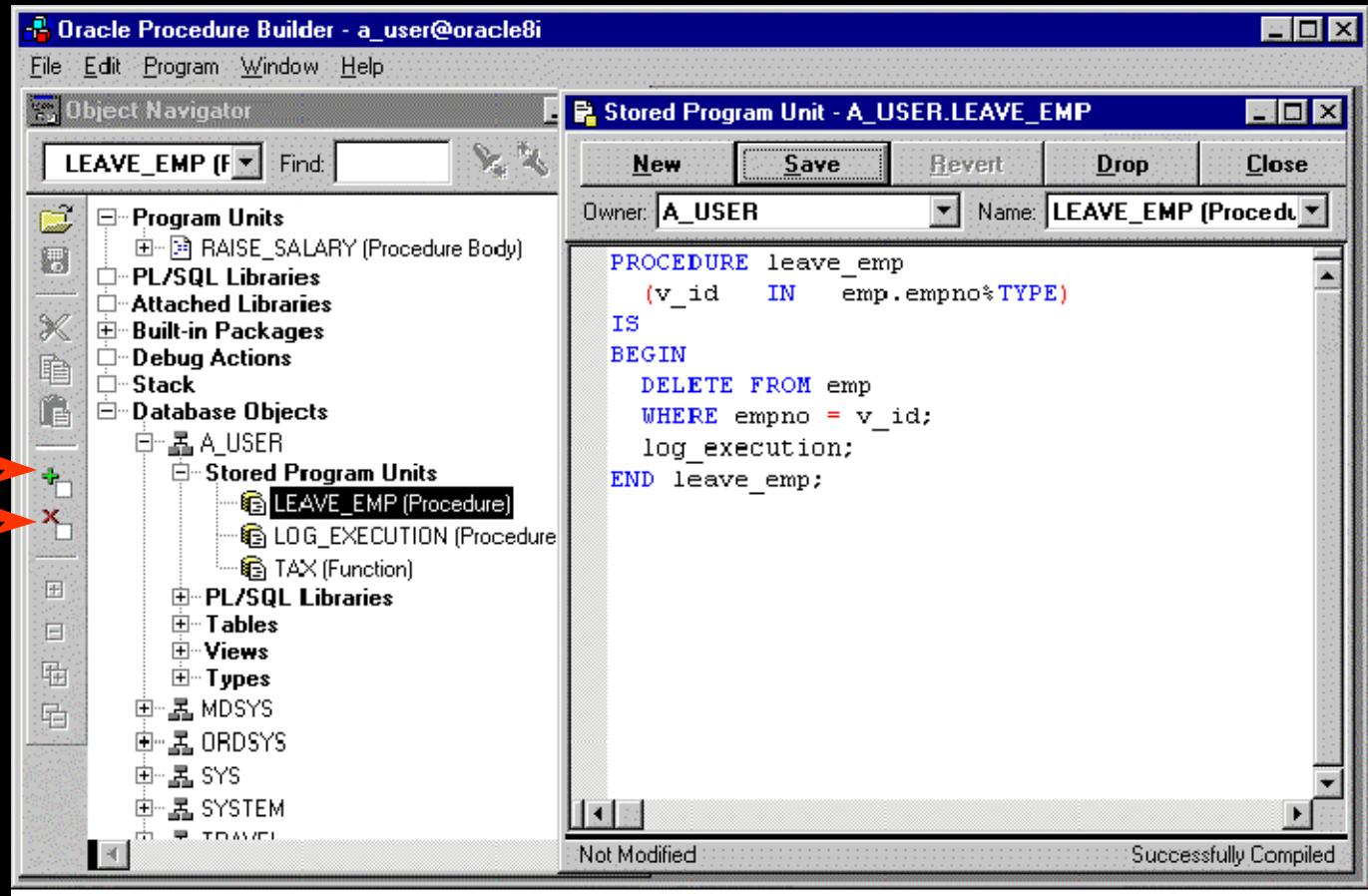
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Creating Client-Side Program Units

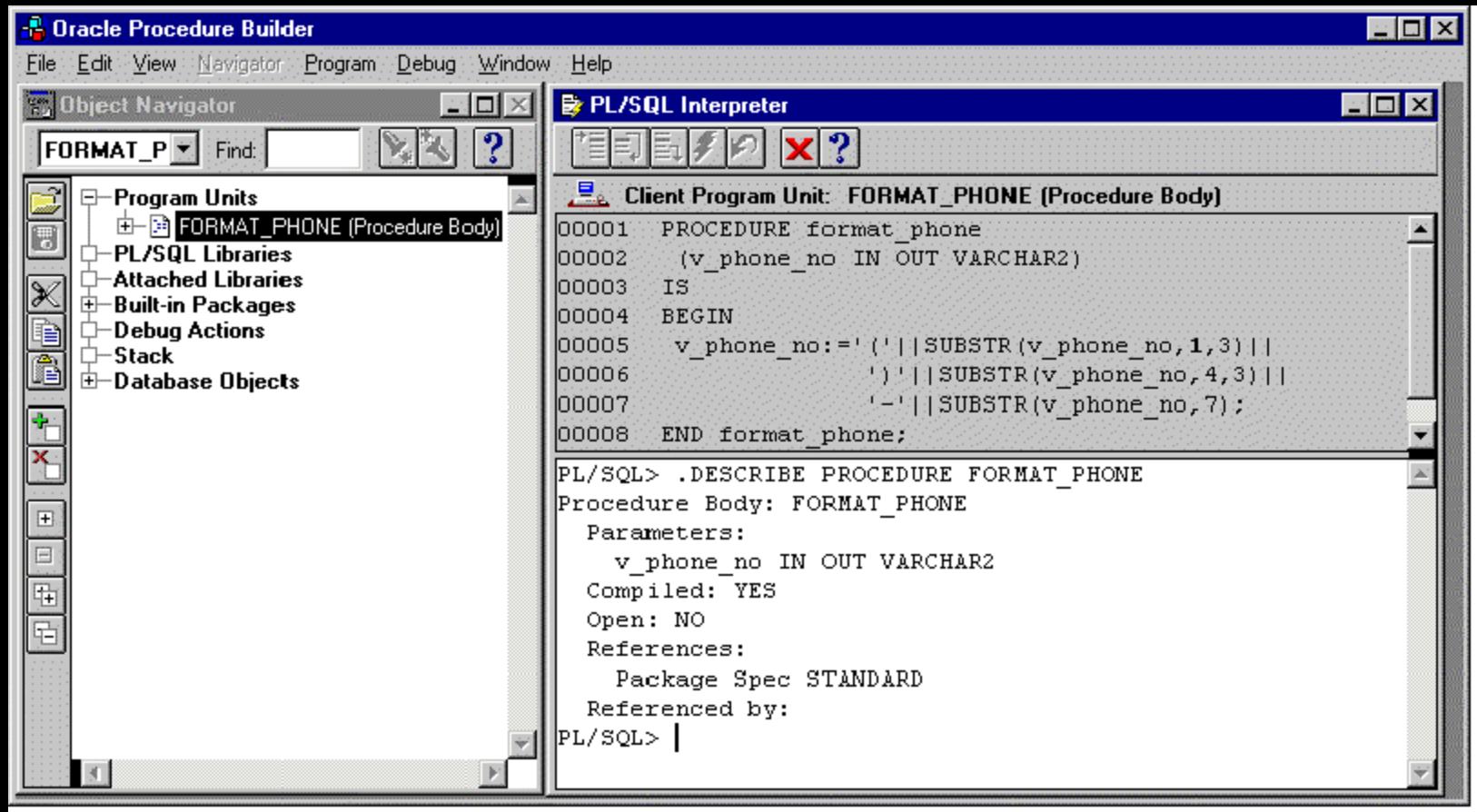


Creating Server-Side Program Units

Create
Delete



The DESCRIBE Command in Procedure Builder

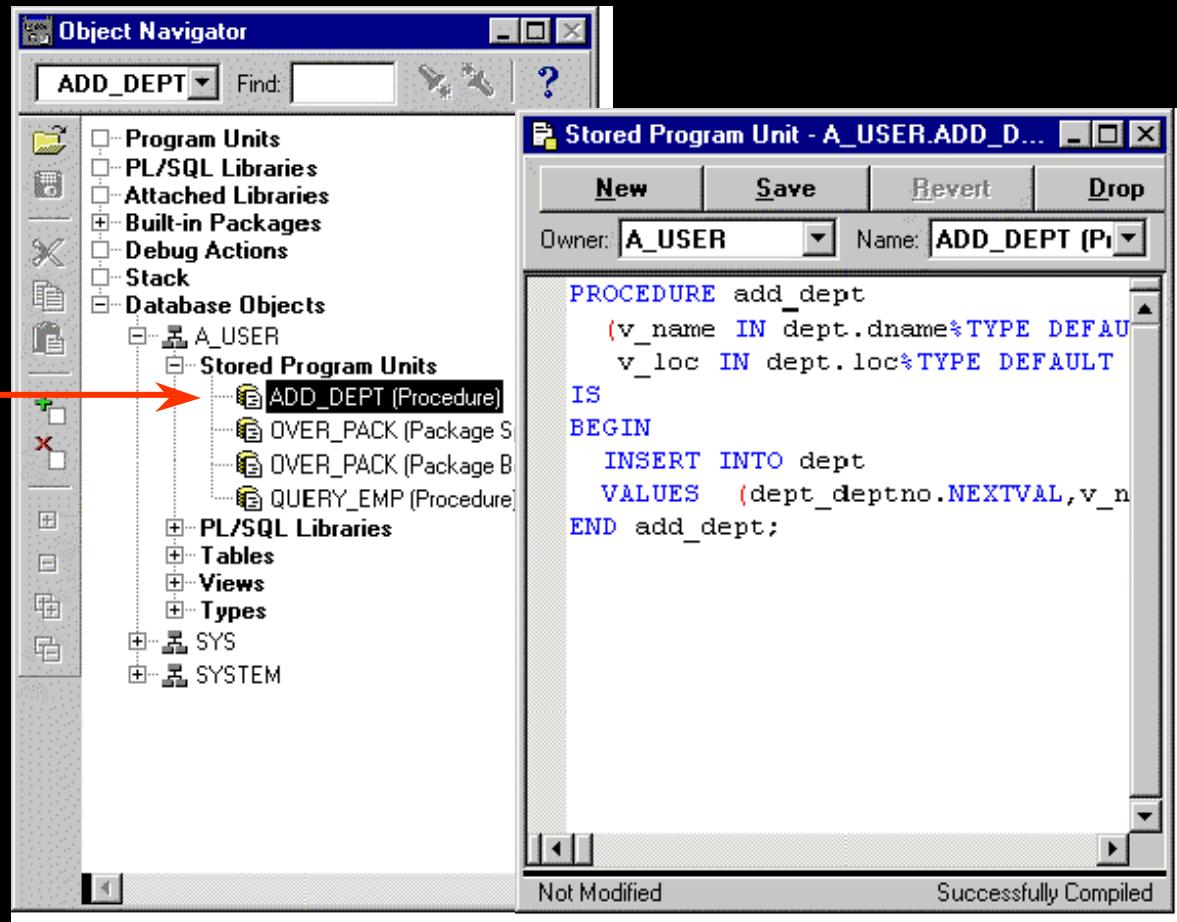


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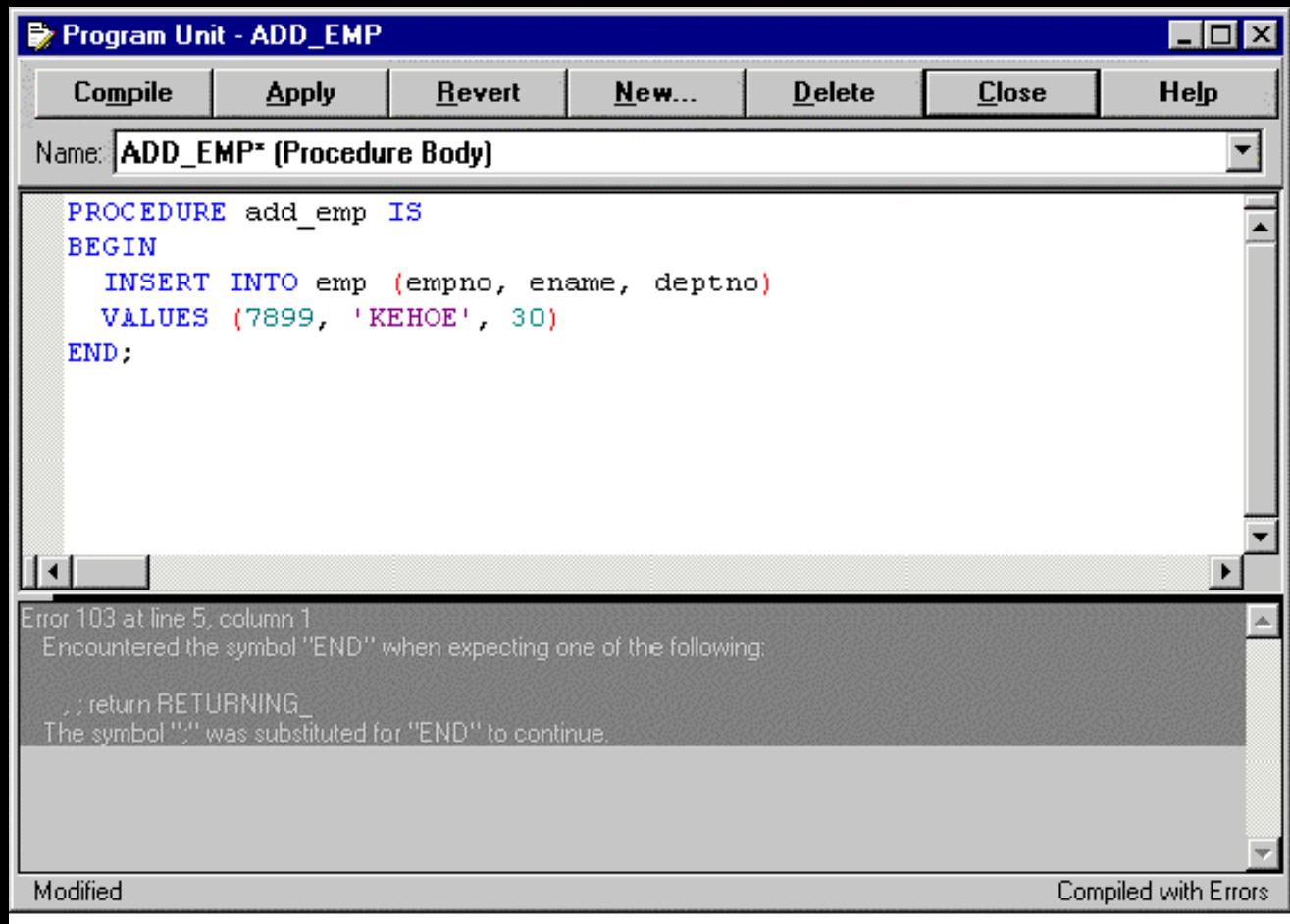
Listing Code of Stored Program Units

Stored
procedure
icon

Expand →
and →
Collapse
buttons



Navigating Compilation Errors in Procedure Builder



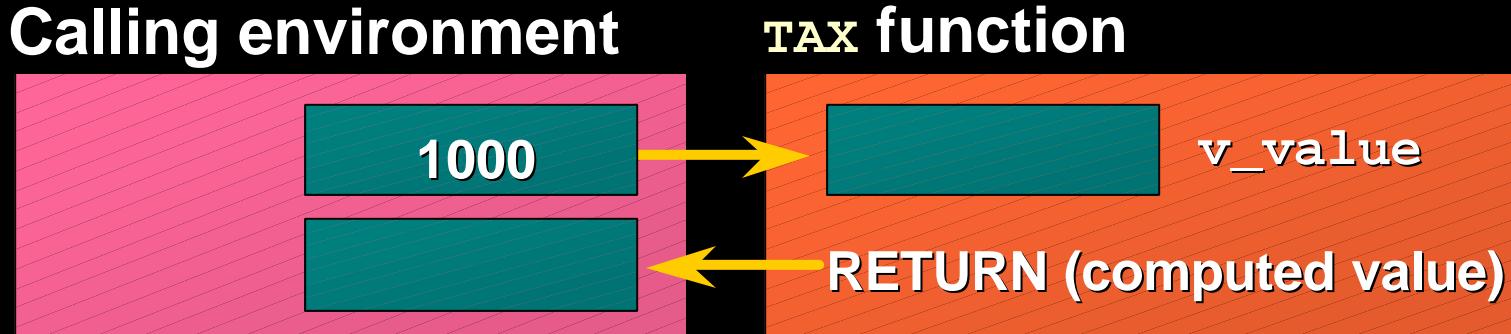
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Procedure Builder Built-in Package: TEXT_IO

- The **TEXT_IO** package:
 - Contains a procedure **PUT_LINE**, which writes information to the PL/SQL Interpreter window
 - Is used for client-side program units
- The **TEXT_IO.PUT_LINE** accepts one parameter

```
PL/SQL> TEXT_IO.PUT_LINE(1);  
1
```

Executing Functions in Procedure Builder: Example

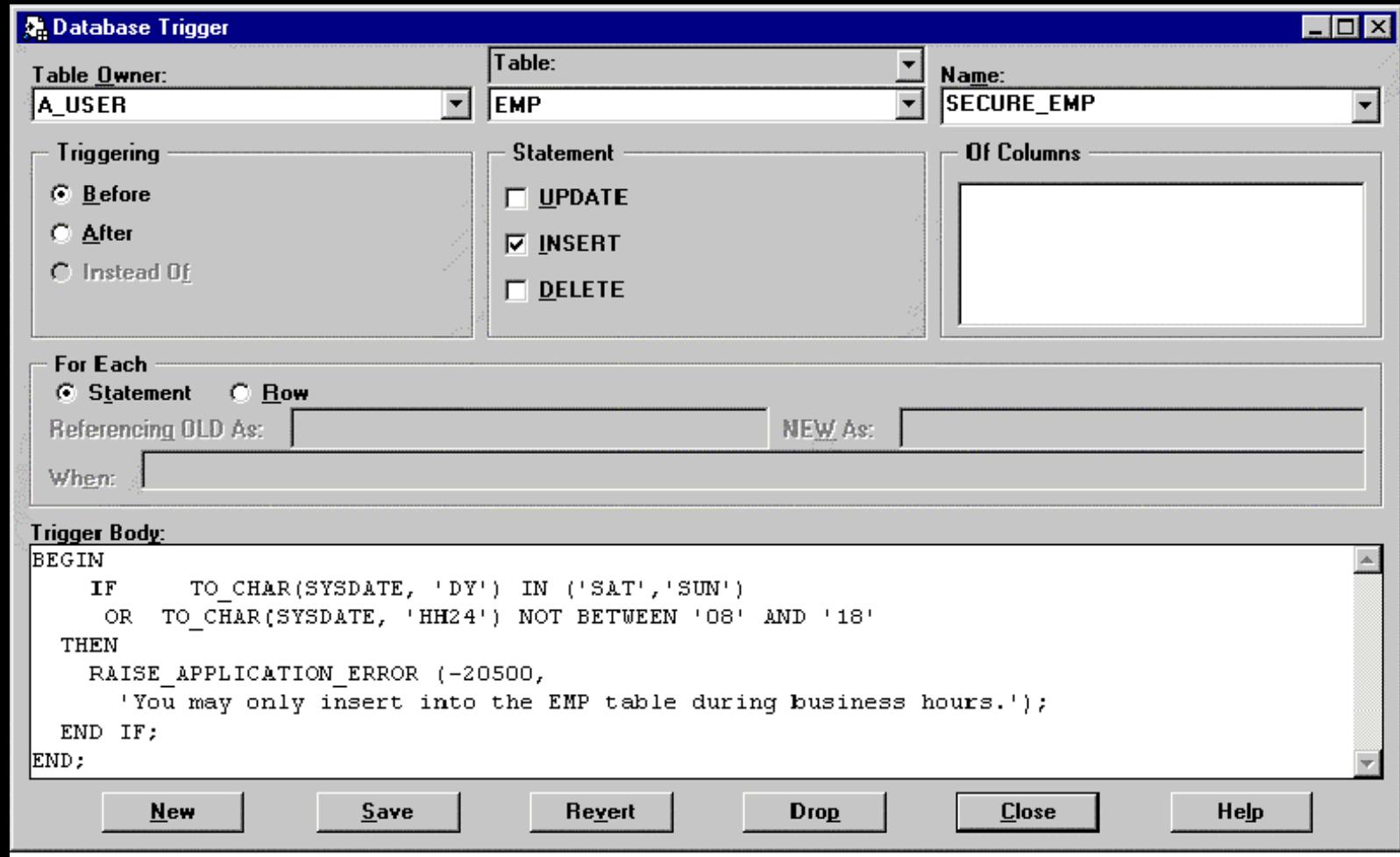


Display the tax based on a specified value.

```
PL/SQL> .CREATE NUMBER x PRECISION 4
PL/SQL> :x := tax(1000);
PL/SQL> TEXT_IO.PUT_LINE (TO_CHAR(:x));
80
```

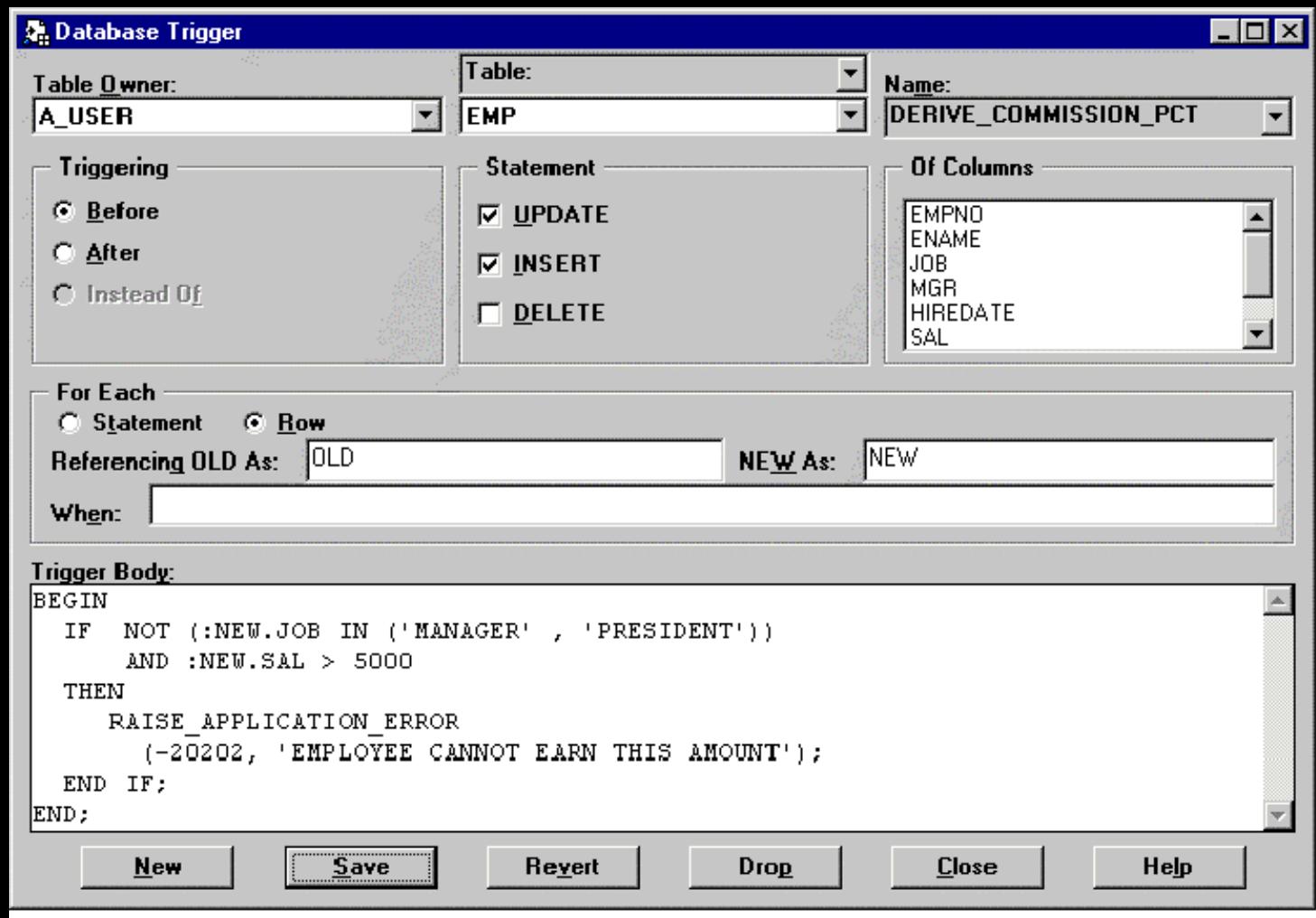
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Creating Statement Triggers



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Creating Row Triggers



Removing Server-Side Program Units

Using Procedure Builder:

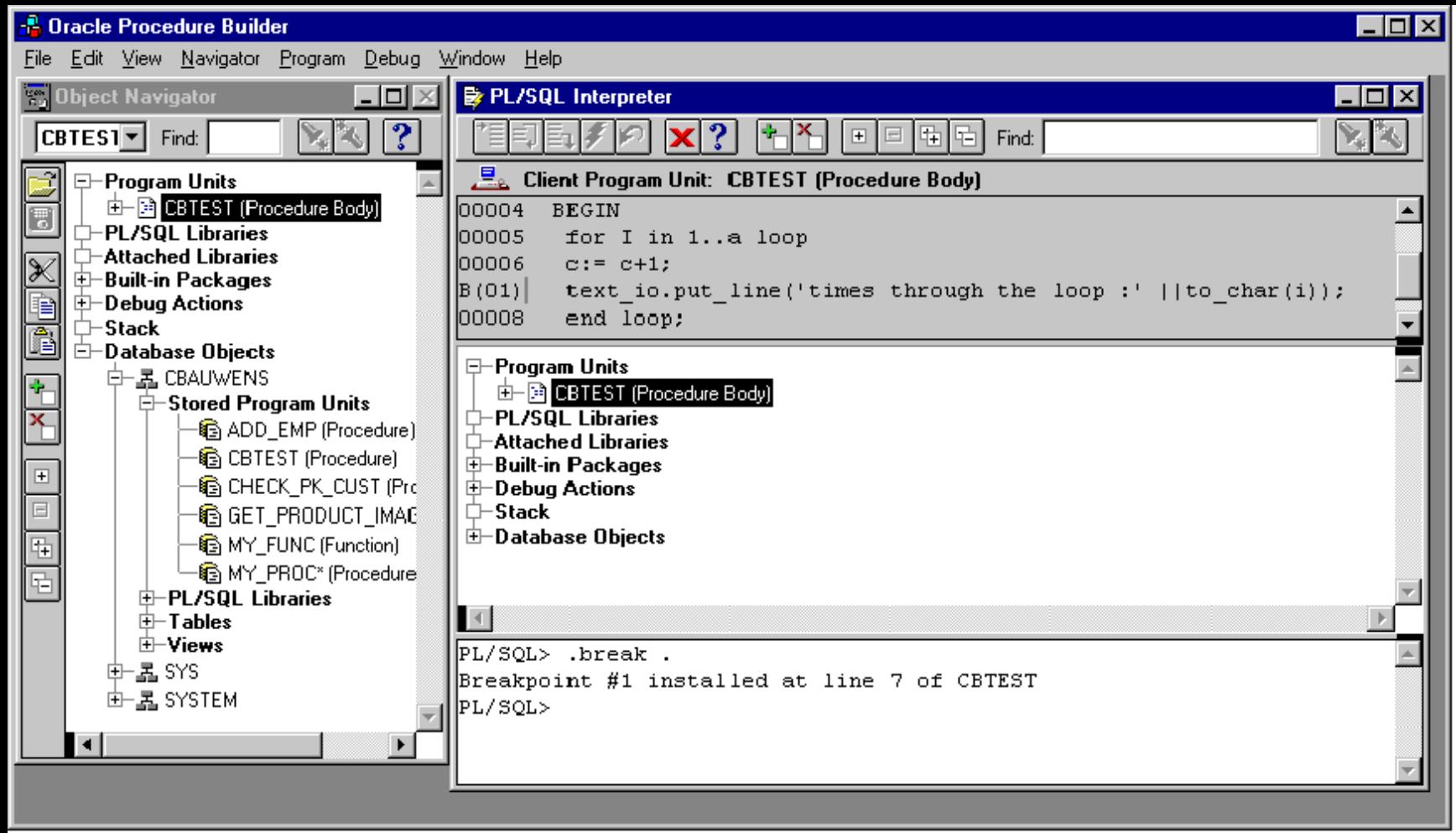
- 1. Connect to the database.**
- 2. Expand the Database Objects node.**
- 3. Expand the schema of the owner of the program unit.**
- 4. Expand the Stored Program Units node.**
- 5. Click the program unit that you want to drop.**
- 6. Click Delete in the Object Navigator.**
- 7. Click Yes to confirm.**

Removing Client-Side Program Units

Using Procedure Builder:

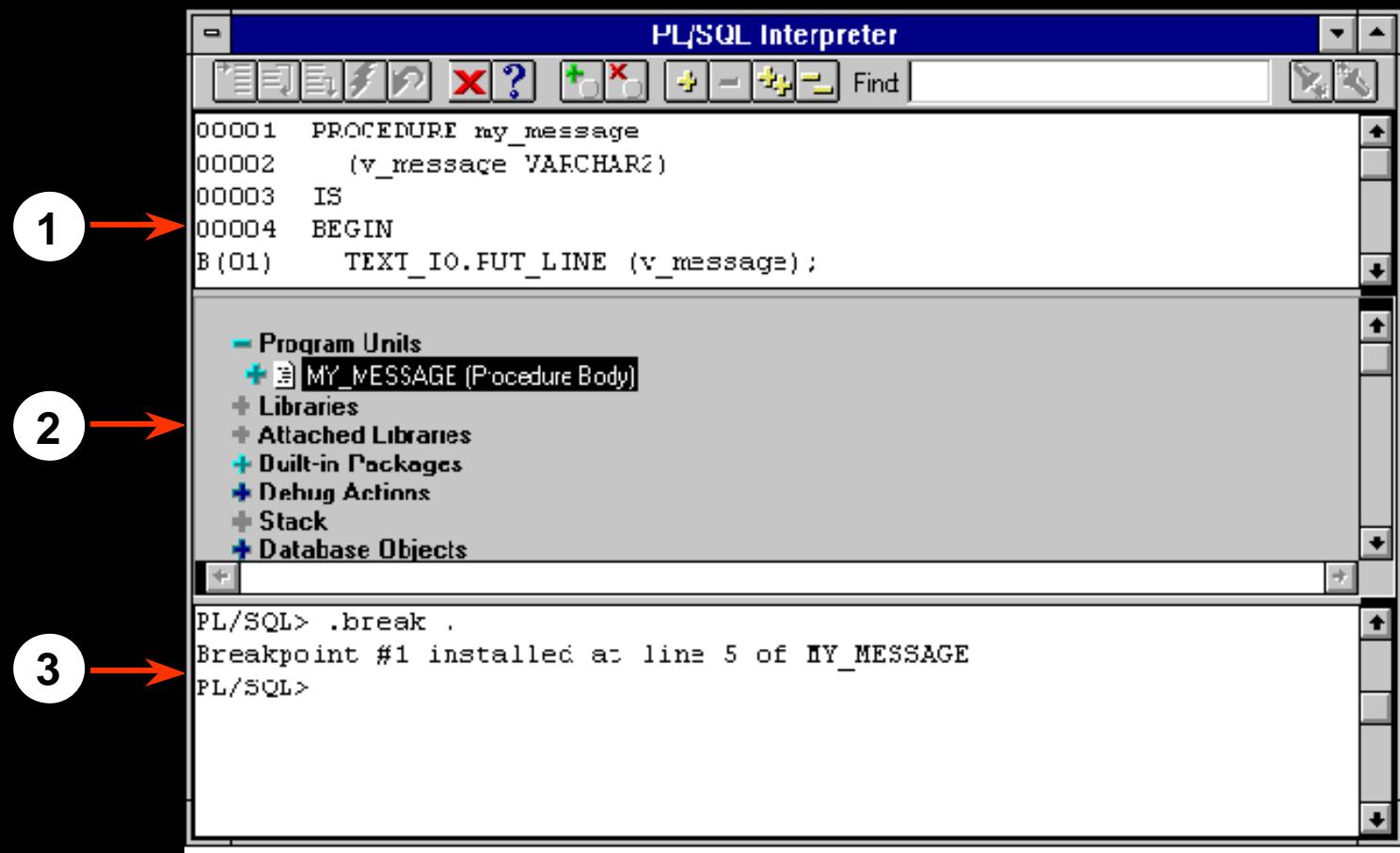
- 1. Expand the Program Units node.**
- 2. Click the program unit that you want to remove.**
- 3. Click Delete in the Object Navigator.**
- 4. Click Yes to confirm.**

Debugging Subprograms by Using Procedure Builder



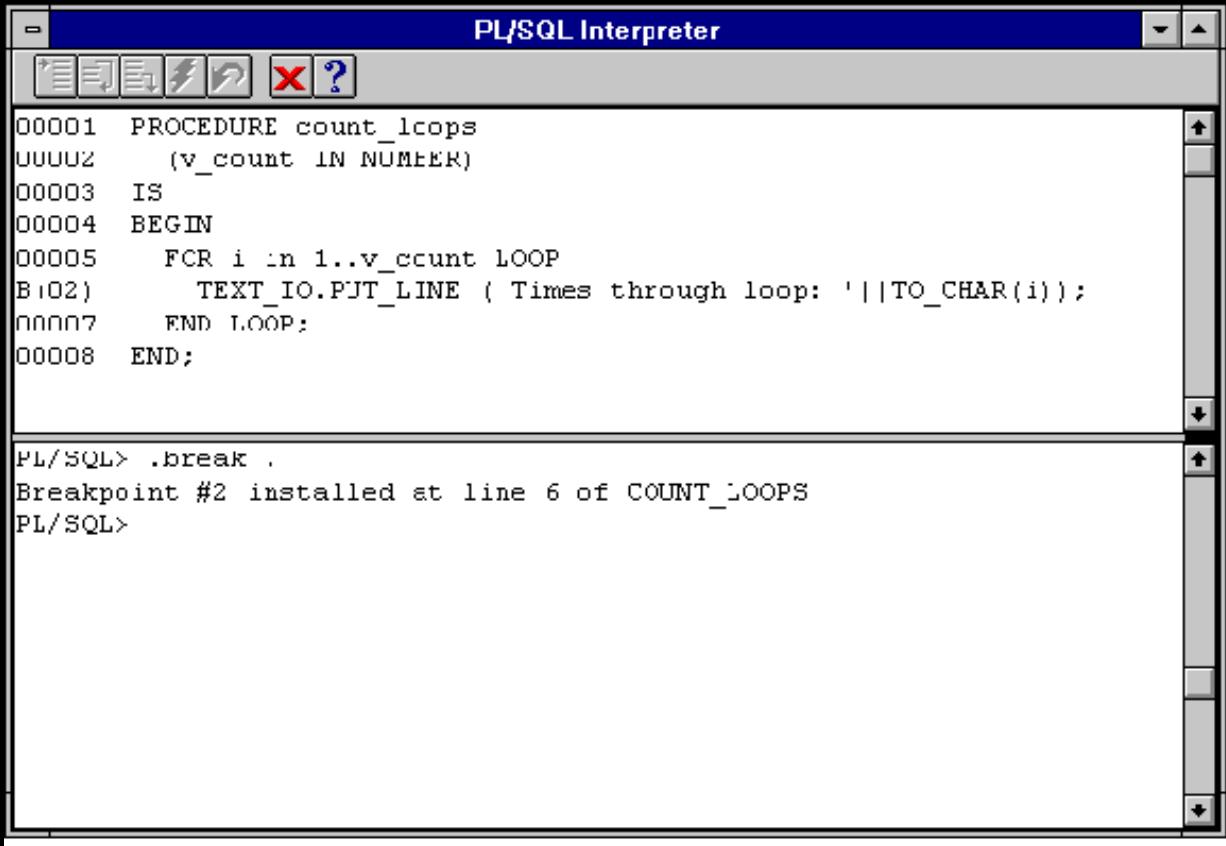
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Listing Code in the Source Pane



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Setting a Breakpoint

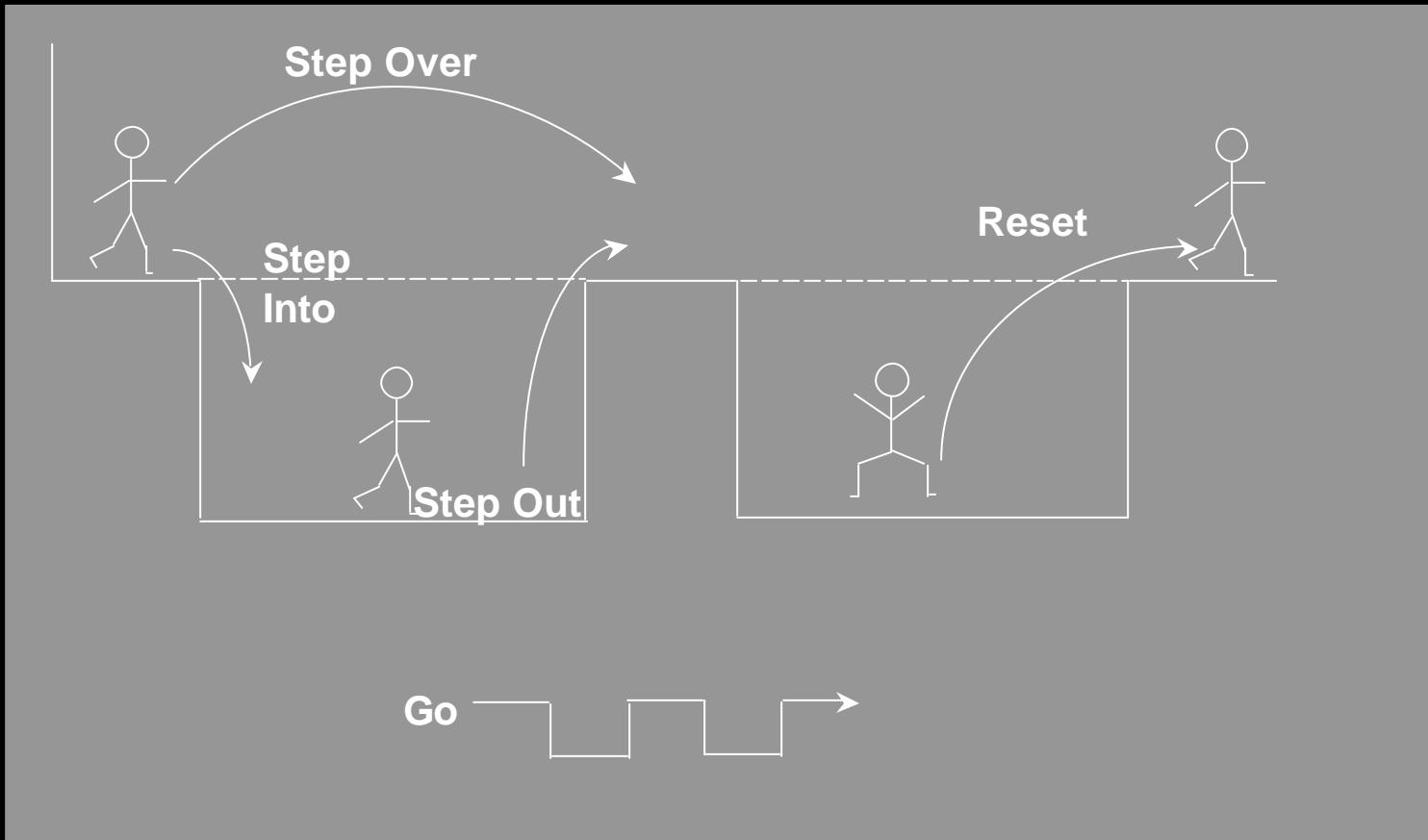


The screenshot shows the PL/SQL Interpreter window. The top menu bar has icons for file, edit, run, and help. The main area displays a PL/SQL procedure named COUNT_LOOPS. A circled number 1 with an arrow points to the first line of the procedure. A circled number 2 with an arrow points to the command ".break ." entered in the command line at the bottom.

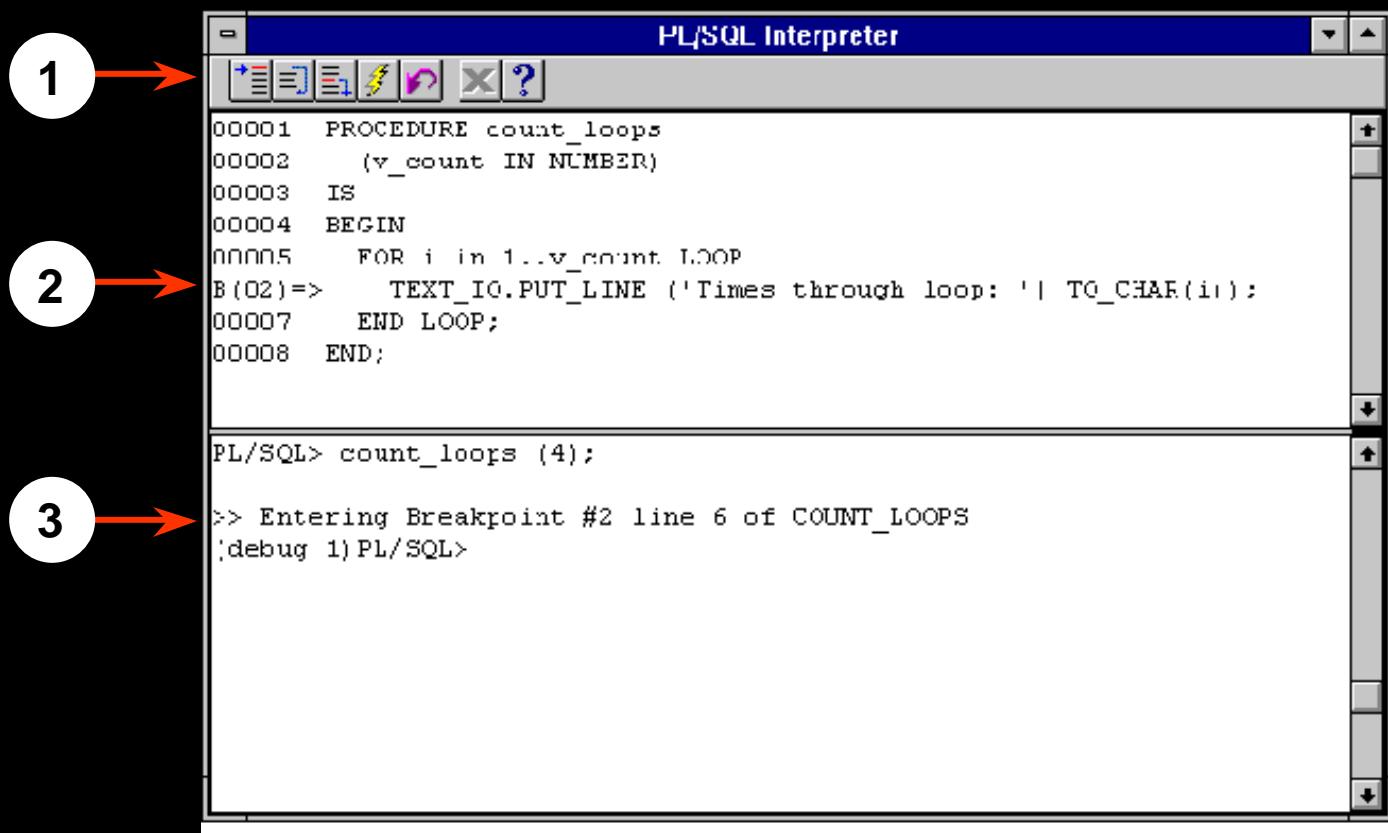
```
00001 PROCEDURE count_loops
00002   (v_count IN NUMBER)
00003 IS
00004 BEGIN
00005   FOR i IN 1..v_count LOOP
00006     TEXT_IO.PUT_LINE ( Times through loop: |||TO_CHAR(i));
00007   END LOOP;
00008 END;
```

```
PL/SQL> .break .
Breakpoint #2 installed at line 6 of COUNT_LOOPS
PL/SQL>
```

Debug Commands

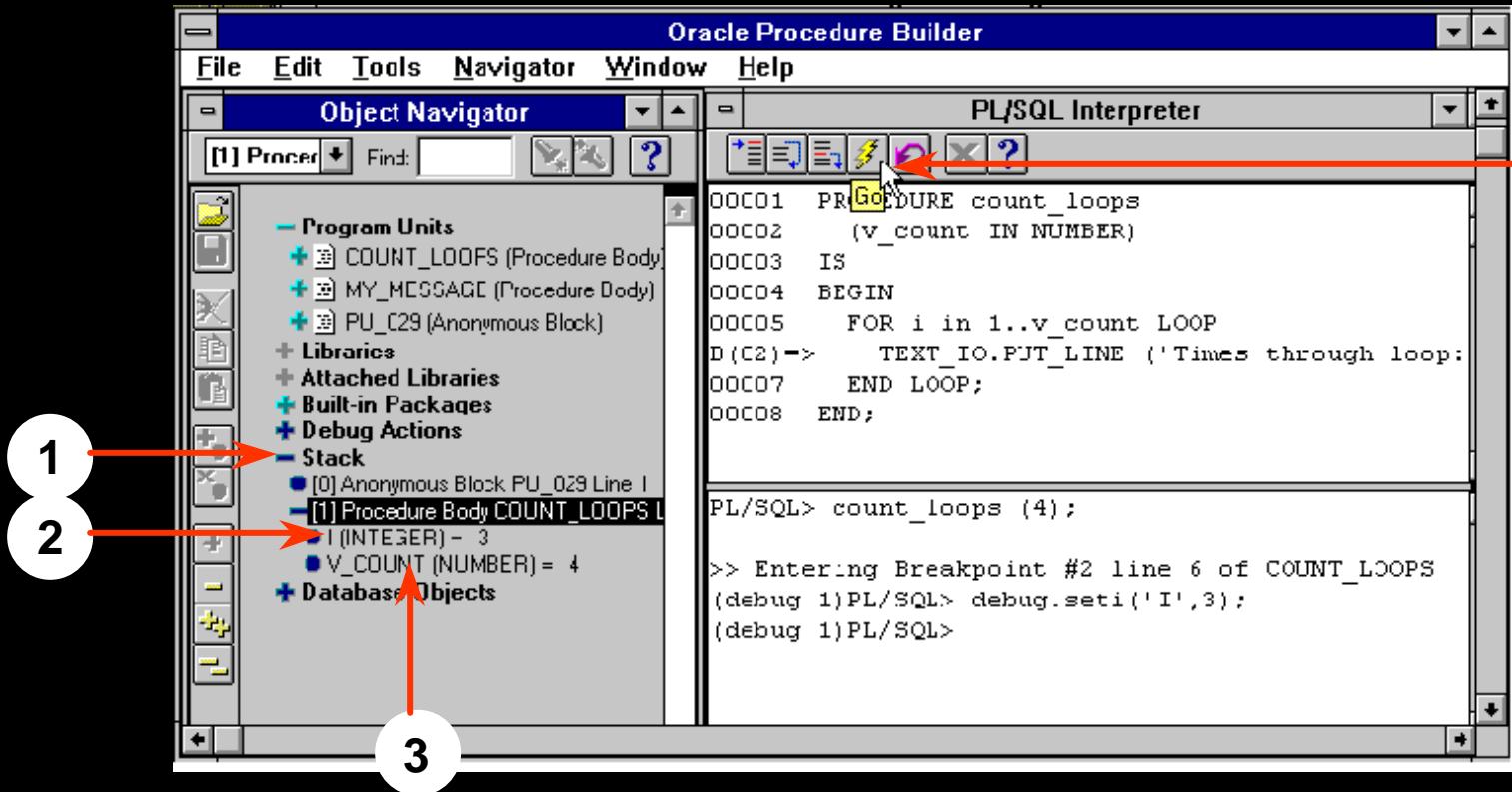


Stepping through Code



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Changing a Value



Summary

In this appendix, you should have learned how to:

- **Use Procedure Builder:**
 - Application partitioning
 - Built-in editors
 - GUI execution environment
- **Describe the components of Procedure Builder**
 - Object Navigator
 - Program Unit Editor
 - PL/SQL Interpreter
 - Debugger

D REF Cursors

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Cursor Variables

- Cursor variables are like C or Pascal pointers, which hold the memory location (address) of an item instead of the item itself
- In PL/SQL, a pointer is declared as `REF x`, where `REF` is short for `REFERENCE` and `x` stands for a class of objects
- A cursor variable has the data type `REF CURSOR`
- A cursor is static, but a cursor variable is dynamic
- Cursor variables give you more flexibility

Why Use Cursor Variables?

- You can use cursor variables to pass query result sets between PL/SQL stored subprograms and various clients.
- PL/SQL can share a pointer to the query work area in which the result set is stored.
- You can pass the value of a cursor variable freely from one scope to another.
- You can reduce network traffic by having a PL/SQL block open (or close) several host cursor variables in a single round trip.

Defining REF CURSOR Types

- Define a REF CURSOR type.

```
Define a REF CURSOR type
TYPE ref_type_name IS REF CURSOR [RETURN return_type];
```

- Declare a cursor variable of that type.

```
ref_cv ref_type_name;
```

- Example:

```
DECLARE
TYPE DeptCurTyp IS REF CURSOR RETURN
departments%ROWTYPE;
dept_cv DeptCurTyp;
```

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Using the OPEN-FOR, FETCH, and CLOSE Statements

- The **OPEN-FOR** statement associates a cursor variable with a multirow query, executes the query, identifies the result set, and positions the cursor to point to the first row of the result set.
- The **FETCH** statement returns a row from the result set of a multirow query, assigns the values of select-list items to corresponding variables or fields in the **INTO** clause, increments the count kept by **%ROWCOUNT**, and advances the cursor to the next row.
- The **CLOSE** statement disables a cursor variable.

An Example of Fetching

```
DECLARE
    TYPE EmpCurTyp IS REF CURSOR;
    emp_cv    EmpCurTyp;
    emp_rec   employees%ROWTYPE;
    sql_stmt  VARCHAR2(200);
    my_job    VARCHAR2(10) := 'ST_CLERK';
BEGIN
    sql_stmt := 'SELECT * FROM employees
                WHERE job_id = :j';
    OPEN emp_cv FOR sql_stmt USING my_job;
LOOP
    FETCH emp_cv INTO emp_rec;
    EXIT WHEN emp_cv%NOTFOUND;
    -- process record
END LOOP;
CLOSE emp_cv;
END;
/
```

