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Integrated Cloud Applications & Platform Services

# Oracle Database 12c R2: Develop PL/SQL Program Units

Student Guide - Volume II

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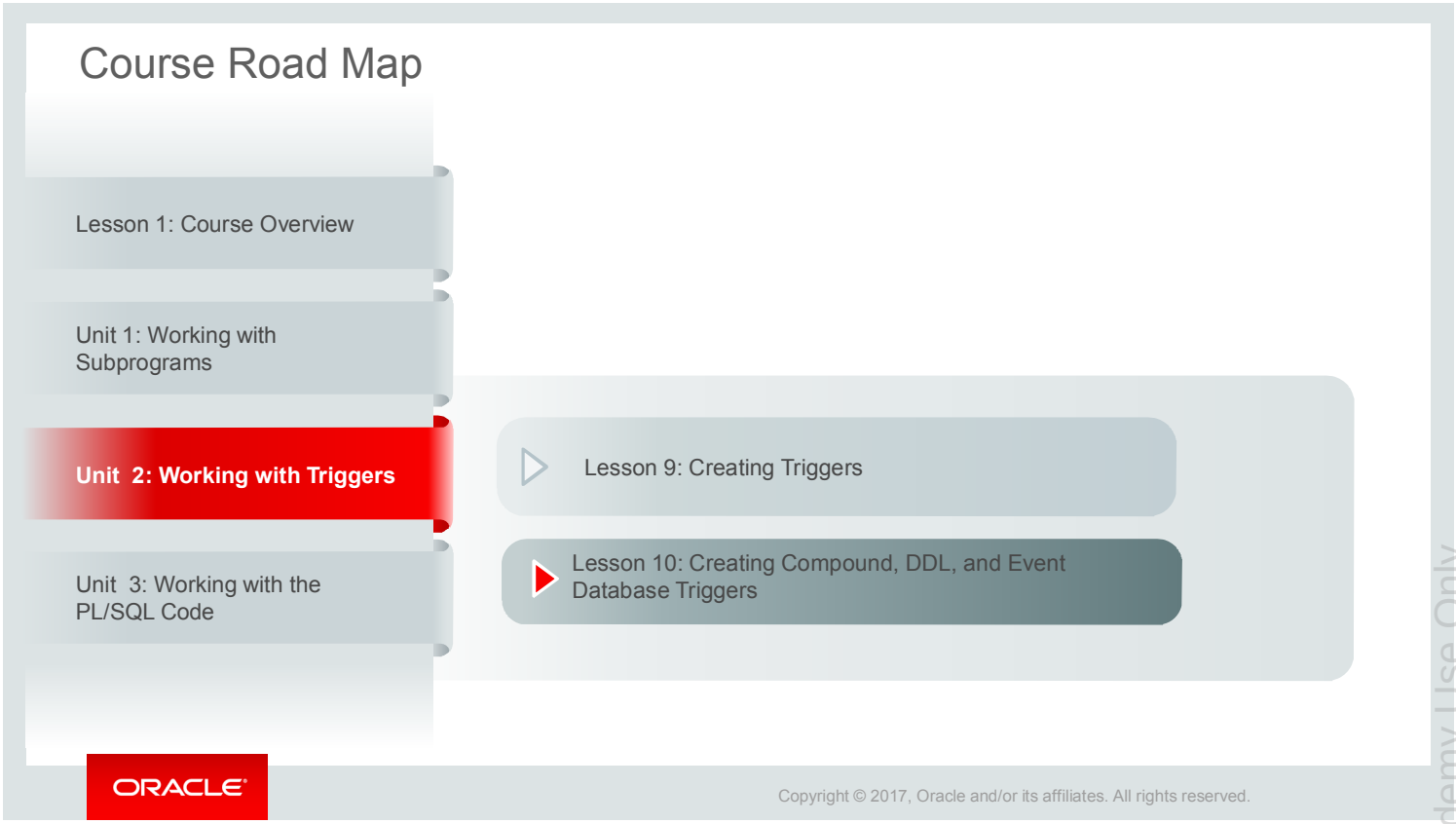
# Creating Compound, DDL, and Event Database Triggers

# Objectives

After completing this lesson, you should be able to:

- Describe compound triggers
- Describe mutating tables
- Create triggers on DDL statements
- Create triggers on system events
- Display information about triggers




In Unit 2, you learn to create and use triggers in database applications.

# Lesson Agenda

- Create compound DML triggers
- Resolve mutating table errors
- Schema triggers
- Database triggers
- Guidelines for designing triggers

## What is a Compound Trigger?

- A single trigger on a table that allows you to specify actions for each of the following four timing points:
  - `BEFORE`
  - `BEFORE EACH ROW`
  - `AFTER EACH ROW`
  - `AFTER`
- Each timing instance has an executable part and an optional exception handling section.
- All the timing instances access a common PL/SQL state.



A compound trigger is a single trigger on a table that allows you to specify actions for each of the four triggering timing points:

- Before the triggering statement
- Before each row that the triggering statement affects
- After each row that the triggering statement affects
- After the triggering statement

You use a compound trigger when you want all the timing instances to access a common PL/SQL state. The common PL/SQL state is established when the triggering statement starts and is destroyed when the triggering statement completes.

However, in some situations where you may have to write DML statements in the trigger body, you can use compound triggers.

## Working with Compound Triggers

- The compound trigger body supports a common PL/SQL state that the code for each timing point can access.
- The compound trigger common state is:
  - Established when the triggering statement starts
  - Destroyed when the triggering statement completes
- A compound trigger has a declaration section and a section for each of its timing points.
- The section of each timing point may have an optional exception handling section



The compound trigger body supports a common PL/SQL state that the code for each timing point can access. The common state is automatically destroyed when the firing statement completes, even when the firing statement causes an error.

Your applications can avoid the mutating table error by allowing rows destined for a second table (such as a history table or an audit table) to accumulate and then bulk-insert them.

Compound triggers make PL/SQL easier for you to use and improve runtime performance and scalability.

## Why Compound Triggers?

You can use compound triggers to:

- Program an approach where you want the actions you implement for the various timing points to share common data
- Accumulate rows destined for a second table so that you can periodically bulk-insert them
- Avoid the mutating-table error (`ORA-04091`)



The current PL/SQL state is stored before starting the execution of the trigger and destroyed after completing the execution of the trigger. All the trigger timing points can access the same PL/SQL state in such scenario.

If you are inserting values into a second table while executing the trigger body, compound triggers allow you to accumulate all the newly inserted rows and bulk insert them into the table at periodic intervals. Thus improving the performance of the PL/SQL block.

What is ORA-4091?

Consider a trigger, you have defined for event `BEFORE INSERT` on a table `T`. In the trigger body definition, you execute a DML statement on the same table `T`, such action would result in `ORA-4091: table T mutating, trigger/function may not see it`. The trigger execution here is initiated to modify the table. When you try to modify it again in the trigger body, it might lead to an inconsistent state, thereby giving the `ORA-4091` error.

## Compound Trigger Structure

```
CREATE OR REPLACE TRIGGER schema.trigger
FOR dml_event_clause ON schema.table
COMPOUND TRIGGER
[ declare_section ]
timing_point_section [ timing_point_section ]... END [ trigger ] ;
```



The slide illustrates the structure of a compound trigger. The difference between a simple trigger and a compound trigger syntax is the `COMPOUND TRIGGER` clause.

The optional declarative part of a compound trigger declares variables and subprograms that all of its timing-point sections can use. When the trigger fires, the declarative part runs before any timing-point sections run, thus creating the PL/SQL state of the trigger. The variables and subprograms exist for the duration of the triggering statement.

The compound triggers further have the timing point sections for the timing points – `BEFORE`, `BEFORE  FOR EACH ROW`, `AFTER`, `AFTER FOR EACH ROW`.

## Compound Trigger Structure for Views

```
CREATE trigger FOR dml_event_clause ON view
COMPOUND TRIGGER
INSTEAD OF EACH ROW IS
BEGIN
statement;
END INSTEAD OF EACH ROW;
```



A compound trigger defined on a view has only an `INSTEAD OF` timing point section defined in the trigger body.

## Compound Trigger Restrictions

- A compound trigger must be a DML trigger defined on either a table or a view.
- An exception that occurs in one section must be handled in that section. It cannot transfer control to another section.
- A timing-point section cannot handle exceptions raised in another timing-point section.
- `:OLD` and `:NEW` cannot appear in the declaration, `BEFORE STATEMENT`, or the `AFTER STATEMENT` sections.
- Only the `BEFORE EACH ROW` section can change the value of `:NEW`.



Following are some of the restrictions when working with compound triggers:

- A compound trigger must be a DML trigger.
- A compound trigger must be defined on either a table or a view.
- An exception that occurs in one section must be handled in that section. It cannot transfer control to another section.
- `:OLD`, `:NEW`, and `:PARENT` cannot appear in the declaration section, the `BEFORE STATEMENT` section, or the `AFTER STATEMENT` section.

# Lesson Agenda

- Create compound DML triggers
- Resolve mutating table errors
- Schema triggers
- Database triggers
- Guidelines for designing triggers

## Mutating Tables

- A mutating table is:
  - A table that is being modified by an `UPDATE`, `DELETE`, or `INSERT` statement

  or
  - A table that might be updated by the effects of a `DELETE CASCADE` constraint
- The session that issued the triggering statement cannot query or modify a mutating table.
- This restriction prevents a trigger from seeing inconsistent data.
- This restriction applies to all triggers that use the `FOR EACH ROW` clause.
- Views being modified in the `INSTEAD OF` triggers are not considered mutating.





## Rules Governing Triggers

Reading and writing data by using triggers is subject to certain rules. The restrictions apply only to row triggers, unless a statement trigger is fired as a result of `ON DELETE CASCADE`.

### Mutating Tables

A mutating table is a table that is currently being modified by an `UPDATE`, `DELETE`, or `INSERT` statement, or a table that might need to be updated by the effects of a declarative `DELETE CASCADE` referential integrity action. For `STATEMENT` triggers, a table is not considered a mutating table.

A mutating table error (`ORA-4091`) occurs when a row-level trigger attempts to change or examine a table that is already undergoing change via a DML statement.

The triggered table itself is a mutating table, as well as any table referencing it with the `FOREIGN KEY` constraint. This restriction prevents a row trigger from seeing an inconsistent set of data.

# 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;
/
```

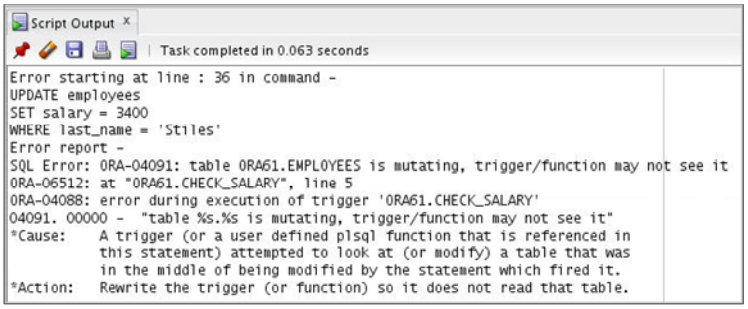


The CHECK_SALARY trigger in the slide example attempts to guarantee that whenever a new employee is added to the EMPLOYEES table or whenever an existing employee's salary or job ID is changed, the employee's salary falls within the established salary range for the employee's job.

When an employee record is updated, the CHECK_SALARY trigger is fired for each row that is updated. The trigger code queries the same table that is being updated. Therefore, it is said that the EMPLOYEES table is a mutating table.

# Mutating Table: Example

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






In the example in the slide, the trigger code tries to read or select data from a mutating table.

If you restrict the salary within a range between the minimum existing value and the maximum existing value, then you get a runtime error. The `EMPLOYEES` table is mutating or is in a state of change; therefore, the trigger cannot read from it.

Remember that functions can also cause a mutating table error when they are invoked in a DML statement.

**Possible Solutions**

Possible solutions to this mutating table problem include the following:

- Use a compound trigger as described earlier in this lesson.
- Store the summary data (the minimum salaries and the maximum salaries) in another summary table, which is kept up-to-date with other DML triggers.
- Store the summary data in a PL/SQL package, and access the data from the package. This can be done in a `BEFORE` statement trigger.

## Using a Compound Trigger to Resolve the Mutating Table Error

```
CREATE OR REPLACE TRIGGER check_salary
  FOR INSERT OR UPDATE OF salary, job_id
  ON employees
  WHEN (NEW.job_id <> 'AD_PRES')
  COMPOUND TRIGGER

  TYPE salaries_t            IS TABLE OF employees.salary%TYPE;
  min_salaries               salaries_t;
  max_salaries               salaries_t;

  TYPE department_ids_t       IS TABLE OF employees.department_id%TYPE;
  department_ids              department_ids_t;

  TYPE department_salaries_t  IS TABLE OF employees.salary%TYPE
                                INDEX BY VARCHAR2(80);
  department_min_salaries     department_salaries_t;
  department_max_salaries     department_salaries_t;

  -- example continues on next slide
```



The CHECK_SALARY compound trigger resolves the mutating table error in the earlier example. This is achieved by storing the values in PL/SQL collections, and then performing a bulk insert/update in the “before statement” section of the compound trigger.

In the example in the slide, PL/SQL collections are used. The element types used are based on the SALARY and DEPARTMENT_ID columns from the EMPLOYEES table.

To create collections, you define a collection type and then declare variables of that type. Collections are instantiated when you enter a block or subprogram, and cease to exist when you exit. min_salaries is used to hold the minimum salary for each department and max_salaries is used to hold the maximum salary for each department.

## Using a Compound Trigger to Resolve the Mutating Table Error

```
. . .
BEFORE STATEMENT IS
  BEGIN
    SELECT MIN(salary), MAX(salary), NVL(department_id, -1)
     BULK COLLECT INTO  min_Salaries, max_salaries, department_ids
    FROM    employees
    GROUP BY department_id;
    FOR j IN 1..department_ids.COUNT() LOOP
      department_min_salaries(department_ids(j)) := min_salaries(j);
      department_max_salaries(department_ids(j)) := max_salaries(j);
    END LOOP;
END BEFORE STATEMENT;
AFTER EACH ROW IS
  BEGIN
    IF :NEW.salary < department_min_salaries(:NEW.department_id)
      OR :NEW.salary > department_max_salaries(:NEW.department_id) THEN
      RAISE_APPLICATION_ERROR(-20505,'New Salary is out of acceptable
                                      range');
    END IF;
  END AFTER EACH ROW;
END check_salary;
```



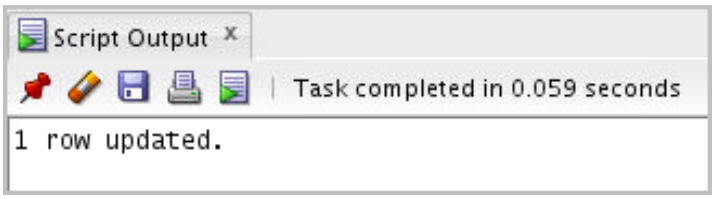
`department_ids` is used to hold the department IDs. If the employee who earns the minimum or maximum salary does not have an assigned department, you use the NVL function to store –1 for the department id, instead of `NULL`.

Next, you collect the minimum salary, maximum salary, and the department ID using a bulk insert into the `min_salaries`, `max_salaries`, and `department_ids` respectively grouped by department ID. The select statement returns 13 rows. The values of the department_ids are used as an index for the `department_min_salaries` and `department_max_salaries` tables. Therefore, the index for those two tables (`VARCHAR2`) represents the actual `department_ids`.

After each row is added, if the new salary is less than the minimum salary for that department or greater than the department's maximum salary, then an error message is displayed.

To test the newly created compound trigger, issue the following statement:

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



To ensure that the salary for employee Stiles was updated, issue the following query by using the F9 key in SQL Developer:

```
SELECT employee_id, first_name,
last_name, job_id, department_id,salary
FROM employees
WHERE last_name = 'Stiles';
```


Query Result

SQL | All Rows Fetched: 1 in 0.001 seconds

| | EMPLOYEE_ID | FIRST_NAME | LAST_NAME | JOB_ID | DEPARTMENT_ID | SALARY |
|---|---|---|---|---|---|---|
| 1 | 138 | Stephen | Stiles | ST_CLERK | 50 | 3400 |

# Lesson Agenda

- Create compound DML triggers
- Resolve mutating table errors
- Schema triggers
- Database triggers
- Guidelines for designing triggers

# Creating Triggers on DDL Statements

```
CREATE [OR REPLACE] TRIGGER trigger_name
BEFORE | AFTER -- Timing
[ddl_event1 [OR ddl_event2 OR ...]]
ON {DATABASE | SCHEMA}
trigger_body
```

| Sample DDL Events | Fires When |
|---|---|
| CREATE | Any database object is created using the CREATE command. |
| ALTER | Any database object is altered using the ALTER command. |
| DROP | Any database object is dropped using the DROP command. |



You can specify one or more types of DDL statements that can cause the trigger to fire. You can create triggers for these events on `DATABASE` or `SCHEMA` unless otherwise noted. You can also specify `BEFORE` and `AFTER` for the timing of the trigger. The Oracle database fires the trigger in the existing user transaction.

You cannot specify as a triggering event any DDL operation performed through a PL/SQL procedure.

The trigger body in the syntax in the slide represents a complete PL/SQL block.

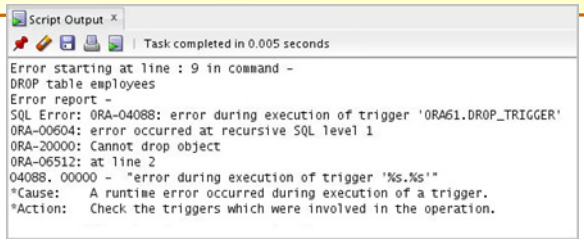
DDL triggers fire only if the object being created is a cluster, function, index, package, procedure, role, sequence, synonym, table, tablespace, trigger, type, view, or user.

# Creating Triggers on DDL Statements -Example

```
CREATE OR REPLACE TRIGGER drop_trigger
BEFORE DROP ON ora61.SCHEMA
BEGIN
RAISE_APPLICATION_ERROR ( num => -20000, msg => 'Cannot drop object');
END;
/
```

To check the execution of this trigger

```
DROP TABLE employees;
```



# Lesson Agenda

- Create compound DML triggers
- Resolve mutating table errors
- Schema triggers
- Database triggers
- Guidelines for designing triggers

## Creating Database Triggers

- Triggering user event:
  - Logging on or off
- Triggering a database event:
  - Shutting down or starting up the database
  - A specific error (or any error) being raised



Before coding the trigger body, decide on the components of the trigger.

Triggers on system events can be defined at the database or schema level. For example, a database shutdown trigger is defined at the database level. Triggers on DDL statements, or a user logging on or off, can also be defined at either the database level or the schema level. Triggers on DML statements are defined on a specific table or a view.

A trigger defined at the database level fires for all users, whereas a trigger defined at the schema or table level fires only when the triggering event involves that schema or table.

# Creating Triggers on System Events

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

| Database Event | Triggers Fires When |
|---|---|
| AFTER SERVERERROR | An Oracle error is raised |
| AFTER LOGON | A user logs on to the database |
| BEFORE LOGOFF | A user logs off the database |
| AFTER STARTUP | The database is opened |
| BEFORE SHUTDOWN | The database is shut down normally |



You can create triggers for the events listed in the table in the slide on `DATABASE` or `SCHEMA`, except `SHUTDOWN` and `STARTUP`, which apply only to `DATABASE`.

## LOGON and LOGOFF Triggers: Example

```
-- Create the log_trig_table shown in the notes page
-- first
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;
/
```



You can create these triggers to monitor how often you log on and off, or you may want to write a report that monitors the length of time for which you are logged on. When you specify `ON SCHEMA`, the trigger fires for the specific user. If you specify `ON DATABASE`, the trigger fires for all users.

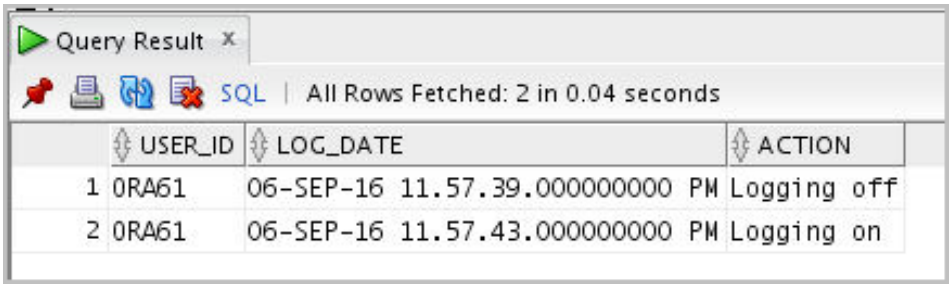
The definition of the `log_trig_table` used in the slide examples is as follows:

```
CREATE TABLE log_trig_table(
  user_id  VARCHAR2(30),
  log_date TIMESTAMP,
  action  VARCHAR2(40))
  /
```

To see the execution of these triggers you can disconnect from the database and connect with the database. Then execute

```
select * from log_trib_table;
```

You can see the output as:



# Lesson Agenda

- Create compound DML triggers
- Resolve mutating table errors
- Schema triggers
- Database triggers
- Guidelines for designing triggers

## Guidelines for Designing Triggers

- You can design triggers to:
  - ensure that whenever a specific event occurs, any necessary actions are done.
- Don’t create triggers:
  - which duplicate the function of the database
  - which are recursive
- You can create stored procedures and invoke them in a trigger, if the PL/SQL code is very lengthy.



- Use triggers to ensure that whenever a specific event occurs, any necessary actions are done.

  For example, use a trigger to ensure that whenever anyone updates a table, its log file is updated.
- Don’t create triggers that duplicate database features.

  For example, don’t create a trigger to reject invalid data if you can do the same with constraints.
- Don’t create recursive triggers.

  For example, don’t create an AFTER UPDATE trigger that issues an UPDATE statement on the table on which the trigger is defined. The trigger fires recursively until it runs out of memory.

## Quiz

Which of the following statements are true for a trigger?

a. A trigger is defined with a `CREATE TRIGGER` statement.
b. A trigger's source code is contained in the `USER_TRIGGERS` data dictionary.
c. A trigger is explicitly invoked.
d. A trigger is implicitly invoked by DML.
e. `COMMIT`, `SAVEPOINT`, and `ROLLBACK` are not allowed when working with a trigger.



**Answer: a, b, d, e**

# Summary

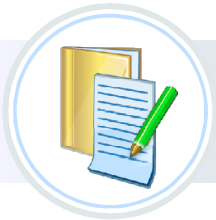
In this lesson, you should have learned how to:

- Describe compound triggers
- Describe mutating tables
- Create triggers on DDL statements
- Create triggers on system events
- Display information about triggers

# Practice 10 Overview: Creating Compound, DDL, and Event Database Triggers

This practice covers the following topics:

- Creating advanced triggers to manage data integrity rules
- Creating triggers that cause a mutating table exception
- Creating triggers that use package state to solve the mutating table problem





In this practice, you implement a simple business rule for ensuring data integrity of employees' salaries with respect to the valid salary range for their job. You create a trigger for this rule.

During this process, your new triggers cause a cascading effect with triggers created in the practice section of the previous lesson. The cascading effect results in a mutating table exception on the `JOBS` table. You then create a PL/SQL package and additional triggers to solve the mutating table issue.

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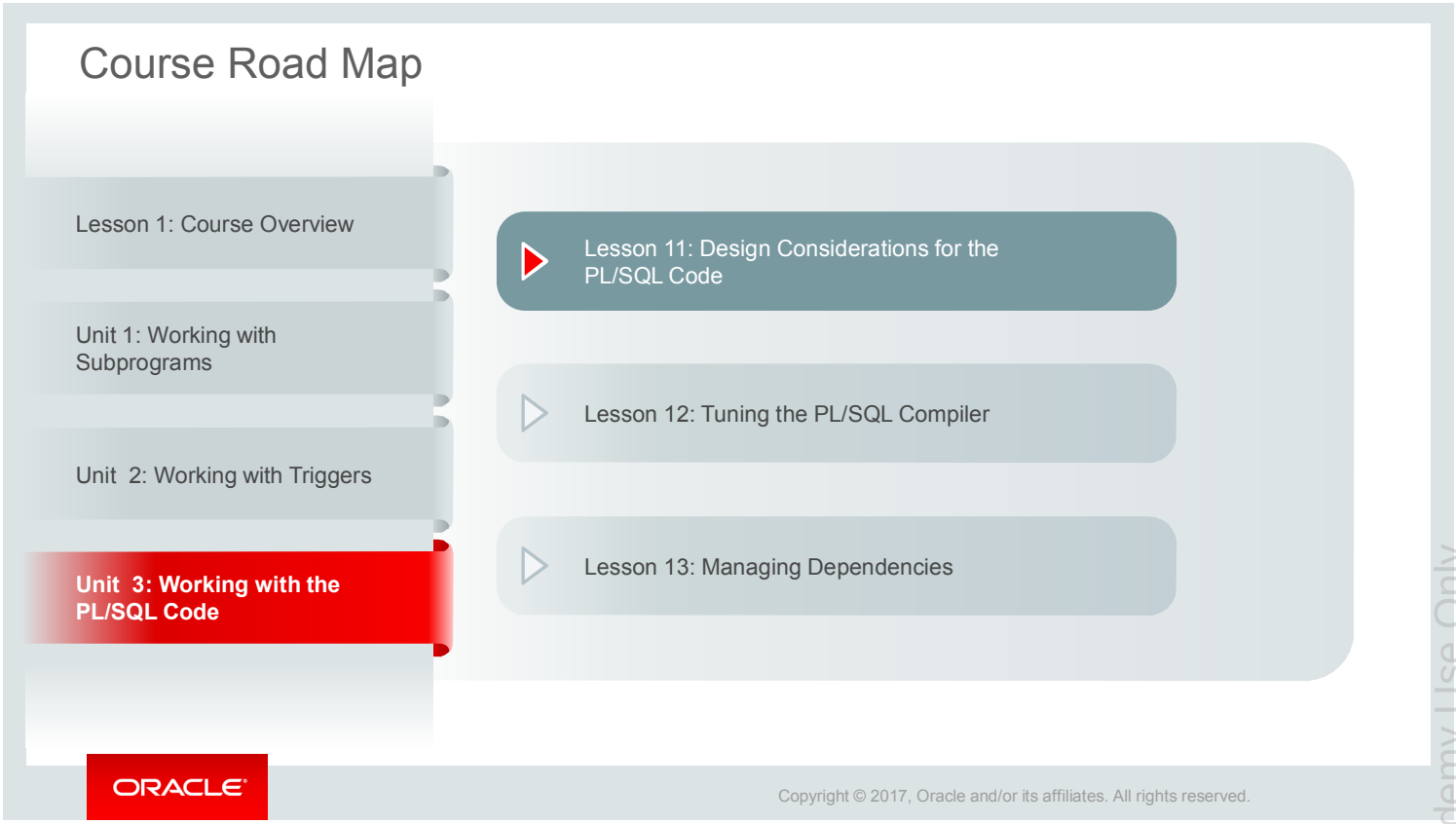
# Design Considerations for the PL/SQL Code

# Objectives

After completing this lesson, you should be able to:

- Write standard PL/SQL code
- Grant and control runtime privileges of subprograms
- Create and use autonomous transactions
- Use `NOCOPY`, `PARALLEL_ENABLE`, and `DETERMINISTIC` clauses for optimization
- Use result caching for optimization
- Use bulk binding for optimization




In Unit 3, you will learn the design aspects of the PL/SQL code. You will also learn how to use the PL/SQL compiler and how to manage dependencies among different objects in the database application.

# Lesson Agenda

- Standardization of the code
- Managing security for PL/SQL packages and subprograms
- Design considerations for autonomous transactions
- Performance optimization in PL/SQL blocks
  - NO COPY clause
  - PARALLEL_ENABLE clause
  - RESULT_CACHE clause
  - DETERMINISTIC clause
  - RETURNING clause
- Bulk Binding

## Standardizing Constants and Exceptions

- Standardizing helps to:
  - Develop programs that are consistent
  - Promote a higher degree of code reuse
  - Ease code maintenance
  - Implement company standards across entire applications
- Constants and exceptions are typically implemented by using a bodiless package (that is, a package specification).
- Start with standardization of:
  - Exception names
  - Constant definitions



When several developers are writing their own exception handlers in an application, there could be inconsistencies in the handling of error situations. Unless certain standards are adhered to, the situation can become confusing because of the different approaches followed in handling the same error or because of the display of conflicting error messages that confuse users. To overcome these, you can:

- Implement company standards that use a consistent approach to error handling across the entire application
- Create predefined, generic exception handlers that produce consistency in the application
- Write and call programs that produce consistent error messages

Good programming environments promote naming and coding standards. In PL/SQL, a good place to start implementing naming and coding standards is with commonly used constants and exceptions that occur in the application domain.

The PL/SQL package specification construct is an excellent component to support standardization because all identifiers declared in the package specification are public. They are visible to the subprograms that are developed by the owner of the package and all code with `EXECUTE` rights to the package specification.

## Standardizing Exceptions

Create a standardized error-handling package that includes all named and programmer-defined exceptions to be used in the application.

```
CREATE OR REPLACE PACKAGE error_pkg IS
  e_fk_err      EXCEPTION;
  e_seq_nbr_err EXCEPTION;
  PRAGMA EXCEPTION_INIT (e_fk_err, -2292);
  PRAGMA EXCEPTION_INIT (e_seq_nbr_err, -2277);
  ...
END error_pkg;
/
```



In the slide, the `error_pkg` package is a standardized exception package. It declares a set of programmer-defined exception identifiers. An internally defined exception does not have a name unless either PL/SQL or you give it one. The example shown in the slide uses the `PRAGMA EXCEPTION_INIT` directive to associate selected exception names with an Oracle database error number. This enables you to refer to any of the exceptions in a standard way in your applications, as in the following example:

```
BEGIN
  DELETE FROM departments
WHERE department_id = deptno;
  ...
EXCEPTION
  WHEN error_pkg.e_fk_err THEN
  ...
  WHEN OTHERS THEN
  ...
END;
/
```

The PL/SQL block here refers to `e_fk_err` mapped onto error number `ORA-2292`, which is a constraint violation error.

## Standardizing Exception Handling

Consider writing a subprogram with common exception handling. The exception-handling code should:

- Display errors based on SQLCODE and SQLERRM values for exceptions
- Track runtime errors by using parameters in your code to identify:
  - The procedure in which the error occurred
  - The location (line number) of the error
  - RAISE_APPLICATION_ERROR with appropriate error code and message

```
RAISE_APPLICATION_ERROR(-20001, 'My first error', TRUE);
```



Standardized exception handling can be implemented either as a standalone subprogram or a subprogram added to the package that defines the standard exceptions.

Consider creating a package for exception handling in your application with the following:

- Every named exception that is to be used in the application
- All unnamed, programmer-defined exceptions that are used in the application. These are error numbers –20000 through –20999.
- A program to call RAISE_APPLICATION_ERROR based on package exceptions
- A program to display an error based on the values of SQLCODE and SQLERRM
- Additional objects, such as error log tables, and programs to access the tables

A common practice is to use parameters that identify the name of the procedure and the location in which the error has occurred. This enables you to keep track of runtime errors more easily. An alternative is to use the RAISE_APPLICATION_ERROR built-in procedure to keep a stack trace of exceptions that can be used to track the call sequence leading to the error. To do this, set the third optional argument to TRUE. If you specify TRUE for the third parameter, PL/SQL puts error_code on top of the error stack. Otherwise, PL/SQL replaces the error stack with error_code.

For example:

```
RAISE_APPLICATION_ERROR(-20001, 'My first error', TRUE);
```

## Standardizing Constants

For programs that use local variables whose values should not change:

- Convert the variables to constants to reduce maintenance and debugging
- Create one central package specification and place all constants in it

```
CREATE OR REPLACE PACKAGE constant_pkg IS
  c_order_received CONSTANT VARCHAR(2) := 'OR';
  c_order_shipped  CONSTANT VARCHAR(2) := 'OS';
  c_min_sal        CONSTANT NUMBER(3)  := 900;
END constant_pkg;
```



By definition, a variable's value changes, whereas a constant's value cannot be changed. If you have programs that use local variables whose values should not and do not change, then convert those variables to constants. This can help with the maintenance and debugging of your code.

Consider creating a single shared package with all your constants in it. This makes maintenance and change of the constants much easier. This procedure or package can be loaded on system startup for better performance.

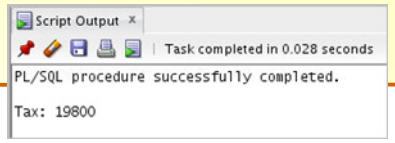
The example in the slide shows the `constant_pkg` package containing a few constants. Refer to any of the package constants in your application as required. Here is an example:

```
BEGIN
  UPDATE employees
     SET salary  = salary + 200
  WHERE salary <= constant_pkg.c_min_sal;
END;
/
```

## Local Subprograms

A local subprogram is a PROCEDURE or FUNCTION defined at the end of the declarative section in a subprogram.

```
CREATE PROCEDURE employee_sal(p_id NUMBER) IS
   v_emp employees%ROWTYPE;
   FUNCTION tax(p_salary VARCHAR2) RETURN NUMBER IS
   BEGIN
     RETURN p_salary * 0.825;
   END tax;
BEGIN
   SELECT * INTO v_emp
   FROM EMPLOYEES WHERE employee_id = p_id;
   DBMS_OUTPUT.PUT_LINE('Tax: '|| tax(v_emp.salary));
END;
/
EXECUTE employee_sal(100)
```






Local subprograms reduce the size of a module by removing redundant code. This is one of the main reasons for creating a local subprogram. If a module needs the same routine several times and only this module needs the routine, then define it as a local subprogram.

You can define a named PL/SQL block in the declarative section of any PL/SQL program, procedure or function. Local subprograms have the following characteristics:

- They are accessible to only the block in which they are defined.
- They are compiled as part of their enclosing blocks.

The benefits of local subprograms are:

- Reduction of repetitive code
- Improved code readability and ease of maintenance
- Less administration because there is one program to maintain instead of two

The concept is simple. The example shown in the slide illustrates this with a basic example of an income tax calculation of an employee's salary.

# Lesson Agenda

- Standardization of the code
- Managing security for PL/SQL packages and subprograms
- Design considerations for autonomous transactions
- Performance optimization in PL/SQL blocks
  - NO COPY clause
  - PARALLEL_ENABLE clause
  - RESULT_CACHE clause
  - DETERMINISTIC clause
  - RETURNING clause
- Bulk Binding

## Definer’s and Invoker’s Rights

- You can control access to privileges required to execute a PL/SQL subprogram by using Definer’s or Invoker’s rights
- With Definer’s rights, the subprogram executes with the access privileges of the owner of the procedure.
- With Invoker’s rights, the subprogram executes with the privileges of the user who invokes the procedures



Suppose user **bixby** creates a procedure that is designed to modify table `cust_records` and then he/she grants the `EXECUTE` privilege on this procedure to user **rlayton**. If **bixby** had created the procedure with definer's rights, then the procedure looks for table `cust_records` in **bixby's** schema. Had the procedure been created with invoker's rights, then when **rlayton** runs it, the procedure looks for table `cust_records` in **rlayton's** schema.

By default, all procedures are considered definer's rights procedures. You can designate a procedure to be an invoker's rights procedure by using the `AUTHID CURRENT_USER` clause when you create or modify it, or you can use the `AUTHID DEFINER` clause to make it a definer's rights procedure.

## Specifying Invoker's Rights: Setting AUTHID to CURRENT_USER

```
CREATE OR REPLACE PROCEDURE add_dept(
  p_id NUMBER, p_name VARCHAR2) AUTHID CURRENT_USER IS
BEGIN
  INSERT INTO departments
  VALUES (p_id, p_name, NULL, NULL);
END;
```

When used with standalone functions, procedures, or packages:

- Names used in queries, DML, Native Dynamic SQL, and DBMS_SQL package are resolved in the invoker's schema
- Calls to other packages, functions, and procedures are resolved in the definer's schema



### Specifying Invoker's Rights

You can set the invoker's rights for different PL/SQL subprogram constructs as follows:

```
CREATE FUNCTION name RETURN type AUTHID CURRENT_USER IS...
CREATE PROCEDURE name AUTHID CURRENT_USER IS…
CREATE PACKAGE name AUTHID CURRENT_USER IS…
CREATE TYPE name AUTHID CURRENT_USER IS OBJECT…
```

The default is AUTHID DEFINER, which specifies that the subprogram executes with the privileges of its owner. Most supplied PL/SQL packages such as DBMS_LOB, DBMS_ROWID, and so on, are invoker-rights packages.

#### Name Resolution

For a definer's rights procedure, all external references are resolved in the definer's schema. For an invoker's rights procedure, the resolution of external references depends on the kind of statement in which they appear:

- Names used in queries, DML statements, dynamic SQL, and DBMS_SQL are resolved in the invoker's schema.
- All other statements, such as calls to packages, functions, and procedures, are resolved in the definer's schema.

## Granting Privileges to Invoker's Rights Unit

- When the invoker is a lower-privilege user, then the definer can grant privileges to execute a subprogram or a PL/SQL package to the invoking user.
- The SQL `GRANT` command grants roles to PL/SQL packages and standalone subprograms:
  - Create an IR unit.
  - Grant roles using the IR unit.
- The following command grants the read and execute roles to the `scott.func` function and the `sys.pkg` package:

```
GRANT read, execute TO FUNCTION scott.func, PACKAGE sys.pkg
```



Before Oracle Database 12*c*, a definer's rights unit always ran with the privileges of the definer and an invoker's rights unit always ran with the privileges of the invoker. If you wanted to create a PL/SQL unit that all users could invoke, even if their privileges were lower than yours, it had to be a definer's rights unit. The unit always ran with all the definer privileges, regardless of which user invoked it.

As of Oracle Database 12*c*, you can grant roles to individual PL/SQL packages and standalone subprograms. Instead of a designer's rights unit, you can create an invoker's rights unit and then grant it roles. The invoker's rights unit runs with the privileges of both the invoker and the roles, but without any additional privileges that you have.

You grant roles to an invoker's rights unit so that users with lower privileges than yours can run the unit with only the privileges needed to do so. There is no reason to grant roles to a designer's rights unit, because its invokers run it with all your privileges.

Using the SQL `GRANT` command, you can grant roles to PL/SQL packages and standalone stored subprograms. Roles granted to a PL/SQL unit do not affect compilation. They affect the privilege checking of SQL statements that the unit issues at run time; the unit runs with the privileges of both its own roles and any other currently enabled roles.

# Lesson Agenda

- Standardization of the code
- Managing security for PL/SQL packages and subprograms
- Design considerations for autonomous transactions
- Performance optimization in PL/SQL blocks
  - NO COPY clause
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  - RESULT_CACHE clause
  - DETERMINISTIC clause
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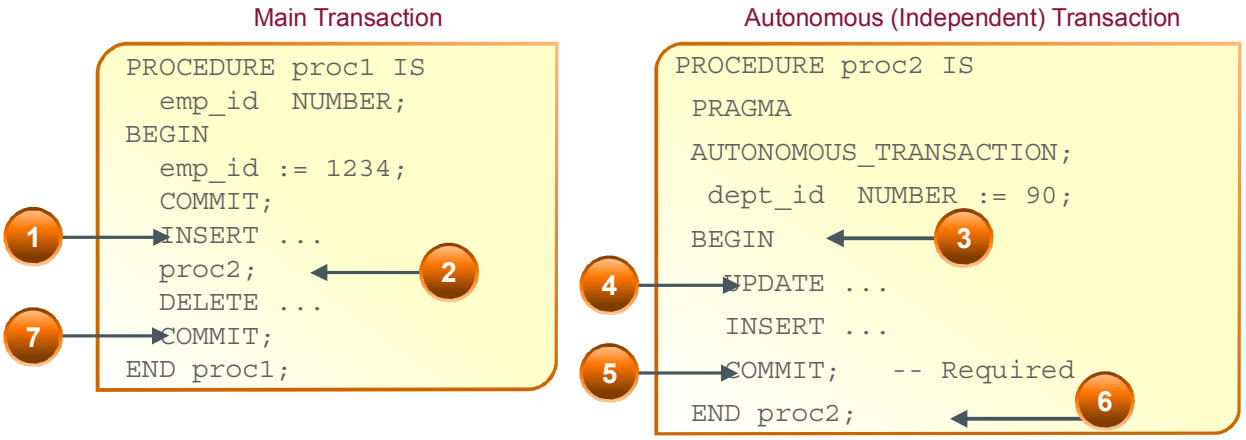
- Bulk Binding

# Autonomous Transactions

- Are independent transactions started by another main transaction
- Are defined with `PRAGMA AUTONOMOUS_TRANSACTION`






A transaction is a series of statements doing a logical unit of work that completes or fails as an integrated unit. Often, one transaction starts another that may need to operate outside the scope of the transaction that started it. That is, in an existing transaction, a required independent transaction may need to commit or roll back changes without affecting the outcome of the starting transaction. For example, in a stock-purchase transaction, the customer's information must be committed regardless of whether the overall stock purchase completes. Or, while running that same transaction, you want to log messages to a table even if the overall transaction rolls back.

The slide depicts the behavior of an autonomous transaction:

1. The main transaction begins.
2. A `proc2` procedure is called to start the autonomous transaction.
3. The main transaction is suspended.
4. The autonomous transactional operation begins.
5. The autonomous transaction ends with a commit or rollback operation.
6. The main transaction is resumed.
7. The main transaction ends.

## Features of Autonomous Transactions

- Are independent of the main transaction
- Suspend the calling transaction until the autonomous transactions are completed
- Are not nested transactions
- Don’t roll back if the main transaction rolls back
- Enable the changes to become visible to other transactions upon a commit
- Are started and ended by individual subprograms and not by nested or anonymous PL/SQL blocks



Autonomous transactions exhibit the following features:

- Although called within a transaction, autonomous transactions are independent of that transaction; that is, they aren’t nested transactions.
- If the main transaction rolls back, autonomous transactions don’t.
- Changes made by an autonomous transaction become visible to other transactions when the autonomous transaction commits.
- With their stack-like functionality, only the “top” transaction is accessible at any given time. After completion, the autonomous transaction is popped and the calling transaction is resumed.
- There are no limits other than resource limits on how many autonomous transactions can be recursively called.
- Autonomous transactions must be explicitly committed or rolled back; otherwise, an error is returned when attempting to return from the autonomous block.
- You can’t use `PRAGMA` to mark all subprograms in a package as autonomous. Only individual routines can be marked autonomous.
- You can’t mark a nested or anonymous PL/SQL block as autonomous.

## Using Autonomous Transactions: Example

```
CREATE TABLE usage (card_id NUMBER, loc NUMBER)
/
CREATE TABLE txn (acc_id NUMBER, amount NUMBER)
/
CREATE OR REPLACE PROCEDURE log_usage (p_card_id NUMBER, p_loc NUMBER) IS
  PRAGMA AUTONOMOUS_TRANSACTION;
BEGIN
  INSERT INTO usage
  VALUES (p_card_id, p_loc);
  COMMIT;
END log_usage;
/
CREATE OR REPLACE PROCEDURE bank_trans(p_cardnbr NUMBER,p_loc NUMBER) IS
BEGIN
   INSERT INTO txn VALUES (9001, 1000);
   log_usage (p_cardnbr, p_loc);
END bank_trans;
/
EXECUTE bank_trans(50, 2000)
```

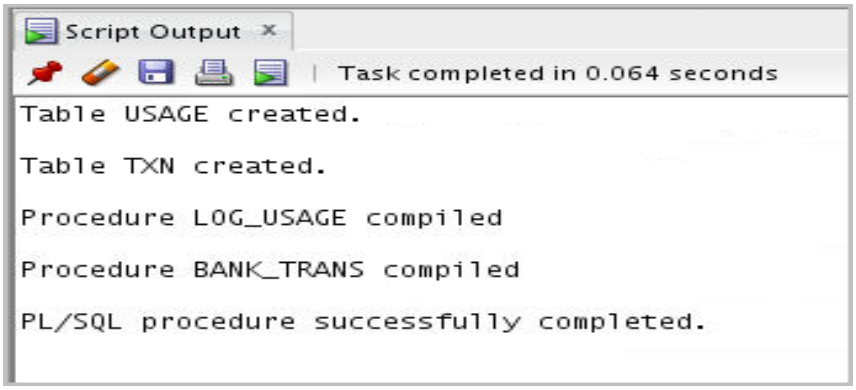


To define autonomous transactions, you use `PRAGMA AUTONOMOUS_TRANSACTION`. `PRAGMA` instructs the PL/SQL compiler to mark a routine as autonomous (independent). In this context, the term “routine” includes top-level (not nested) anonymous PL/SQL blocks; local, standalone, and packaged functions and procedures; methods of a SQL object type; and database triggers. You can code `PRAGMA` anywhere in the declarative section of a routine. However, for readability, it is best placed at the top of the `Declaration` section.

In the example in the slide, you track where the bankcard is used, regardless of whether the transaction is successful. The following are the benefits of autonomous transactions:

- After starting, an autonomous transaction is fully independent. It shares no locks, resources, or commit dependencies with the main transaction, so you can log events, increment retry counters, and so on even if the main transaction rolls back.
- Autonomous transactions help you build modular, reusable software components. For example, stored procedures can start and finish autonomous transactions on their own. A calling application need not know about a procedure’s autonomous operations and the procedure need not know about the application’s transaction context. That makes autonomous transactions less error-prone than regular transactions and easier to use.

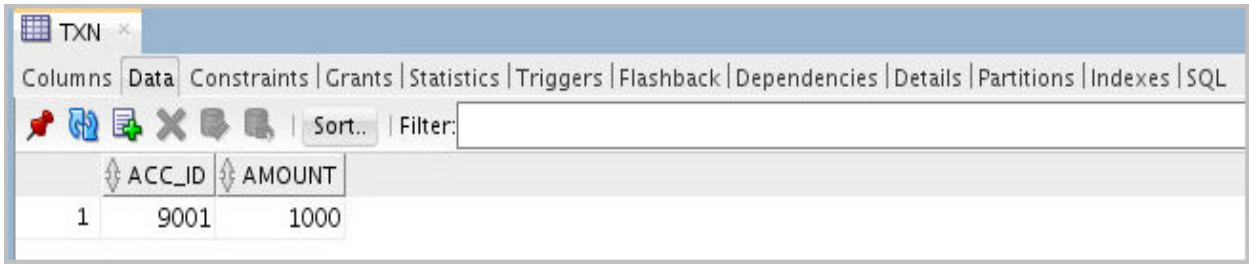
The output of the previous slide examples, the TXN and USAGE tables, are as follows:

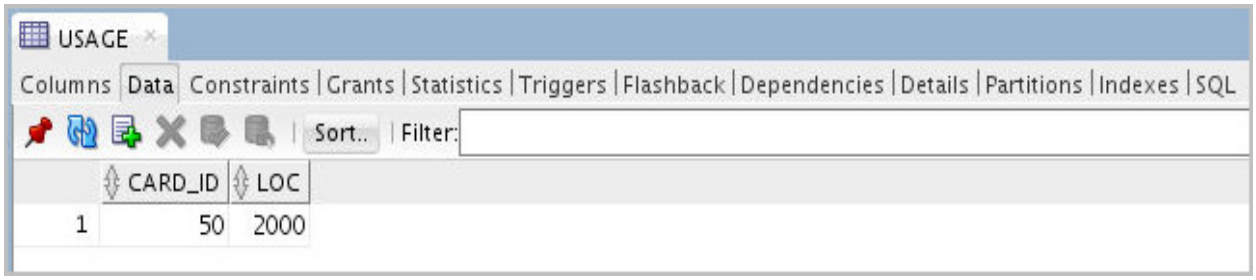



To run the code on the previous page, enter the following code:

```
EXECUTE bank_trans(50, 2000)
```

Use the Data tab in the Tables node of the Object Navigator tree to display the values in the TXN and USAGE tables as follows:



# Lesson Agenda

- Standardization of the code
- Managing security for PL/SQL packages and subprograms
- Design considerations for autonomous transactions
- Performance optimization in PL/SQL blocks
  - NO COPY clause
  - PARALLEL_ENABLE clause
  - RESULT_CACHE clause
  - DETERMINISTIC clause
  - RETURNING clause
- Bulk Binding

## Using the NOCOPY Hint

- Allows the PL/SQL compiler to pass OUT and IN OUT parameters by reference rather than by value
- Enhances performance by reducing overhead when passing parameters

```
DECLARE
  TYPE     rec_emp_type IS TABLE OF employees%ROWTYPE;
  rec_emp  rec_emp_type;
  PROCEDURE populate(p_tab IN OUT NOCOPY emptabtype)IS
    BEGIN
    . . .
    END;
BEGIN
  populate(rec_emp);
END;
/
```



Note that PL/SQL subprograms support three parameter-passing modes: IN, OUT, and IN OUT. By default:

- The IN parameter is passed by reference. A pointer to the IN actual parameter is passed to the corresponding formal parameter. So, both the parameters reference the same memory location, which holds the value of the actual parameter.
- The OUT and IN OUT parameters are passed by value. The value of the OUT or IN OUT actual parameter is copied into the corresponding formal parameter. Then, if the subprogram exits normally, the values assigned to the OUT and IN OUT formal parameters are copied into the corresponding actual parameters.

Copying parameters that represent large data structures (such as collections, records, and instances of object types) with OUT and IN OUT parameters slows down execution and uses up memory. To prevent this overhead, you can specify the NOCOPY hint, which enables the PL/SQL compiler to pass the OUT and IN OUT parameters by reference.

The slide shows an example of declaring an IN OUT parameter with the NOCOPY hint.

## Effects of the NOCOPY Hint

- If the subprogram exits with an exception that is not handled:
  - You cannot rely on the values of the actual parameters passed to a NOCOPY parameter
  - Any incomplete modifications are not “rolled back”
- The remote procedure call (RPC) protocol enables you to pass parameters only by value.



As a trade-off for better performance, the NOCOPY hint enables you to trade well-defined exception semantics for better performance. Its use affects exception handling in the following ways:

- Because NOCOPY is a hint and not a directive, the compiler can pass NOCOPY parameters to a subprogram by value or by reference. So, if the subprogram exits with an unhandled exception, you cannot rely on the values of the NOCOPY actual parameters.
- By default, if a subprogram exits with an unhandled exception, the values assigned to its OUT and IN OUT formal parameters are not copied to the corresponding actual parameters, and the changes appear to roll back. However, when you specify NOCOPY, assignments to the formal parameters immediately affect the actual parameters as well. So, if the subprogram exits with an unhandled exception, the (possibly unfinished) changes are not “rolled back.”
- Currently, the RPC protocol enables you to pass parameters only by value. So, exception semantics can change without notification when you partition applications. For example, if you move a local procedure with NOCOPY parameters to a remote site, those parameters are no longer passed by reference.

## When Does the PL/SQL Compiler Ignore the NOCOPY Hint?

The NOCOPY hint has no effect if:

- The actual parameter:
  - Is an element of associative arrays (index-by tables)
  - Is constrained (for example, by scale or NOT NULL)
  - And formal parameter are records, where one or both records were declared by using %ROWTYPE or %TYPE, and constraints on corresponding fields in the records differ
  - Requires an implicit data type conversion
- The subprogram is involved in an external or RPC



In the following cases, the PL/SQL compiler ignores the NOCOPY hint and uses the by-value parameter-passing method (with no error generated):

- The actual parameter is an element of associative arrays (index-by tables). This restriction does not apply to entire associative arrays.
- The actual parameter is constrained (by scale or NOT NULL). This restriction does not extend to constrained elements or attributes. Also, it does not apply to size-constrained character strings.
- The actual and formal parameters are records; one or both records were declared by using %ROWTYPE or %TYPE, and constraints on corresponding fields in the records differ.
- The actual and formal parameters are records; the actual parameter was declared (implicitly) as the index of a cursor FOR loop, and constraints on corresponding fields in the records differ.
- Passing the actual parameter requires an implicit data-type conversion.
- The subprogram is involved in an external or RPC.

## Using the PARALLEL_ENABLE Hint

- Can be used in functions as an optimization hint
- Indicates that a function can be used in a parallelized query or parallelized DML statement

```
CREATE OR REPLACE FUNCTION f2 (p_p1 NUMBER)
  RETURN NUMBER PARALLEL_ENABLE IS
BEGIN
  RETURN p_p1 * 2;
END f2;
```



The PARALLEL_ENABLE keyword can be used in the syntax for declaring a function. It is an optimization hint that indicates that the function can be used in a parallelized query or parallelized DML statement. Oracle's parallel execution feature divides the work of executing a SQL statement across multiple processes. Functions called from a SQL statement that is run in parallel can have a separate copy run in each of these processes, with each copy called for only the subset of rows that are handled by that process.

For DML statements, before Oracle 8*i*, the parallelization optimization looked to see whether a function was noted as having all four of RNDS, WNDS, RNPS, and WNPS specified in a PRAGMA RESTRICT_REFERENCES declaration; those functions that were marked as neither reading nor writing to either the database or package variables could run in parallel. Again, those functions defined with a CREATE FUNCTION statement had their code implicitly examined to determine whether they were actually pure enough; parallelized execution might occur even though a PRAGMA cannot be specified on these functions.

The PARALLEL_ENABLE keyword is placed after the return value type in the declaration of the function, as shown in the example in the slide.

**Note:** The function should not use session state, such as package variables, because those variables may not be shared among the parallel execution servers.

## Using the Cross-Session PL/SQL Function Result Cache

- Each time a result-cached PL/SQL function is called with different parameter values, those parameters and their results are stored in cache.
- The function result cache is stored in a shared global area (SGA), making it available to any session that runs your application.
- Subsequent calls to the same function with the same parameters uses the result from cache.
- Performance and scalability are improved.
- This feature is used with functions that are called frequently and dependent on information that changes infrequently.



This caching mechanism provides you with a language-supported and system-managed means for storing the results of PL/SQL functions in a SGA, which is available to every session that runs your application. The caching mechanism is both efficient and easy to use, and it relieves you of the burden of designing and developing your own caches and cache-management policies.

Each time a result-cached PL/SQL function is called with different parameter values, those parameters and their results are stored in the cache. Subsequently, when the same function is called with the same parameter values, the result is retrieved from the cache, instead of being recomputed. If a database object that was used to compute a cached result is updated, the cached result becomes invalid and must be recomputed.

Use the result-caching feature with functions that are called frequently and are dependent on information that never changes or changes infrequently.

**Note:** For additional information about Cross-Session PL/SQL Function Result Cache, refer to the *Oracle Database Advanced PL/SQL* course, the *Oracle Database SQL and PL/SQL New Features* course, or *Oracle Database PL/SQL Language Reference*.

## Declaring and Defining a Result-Cached Function: Example

- Use the `RESULT_CACHE` clause to enable result-caching for a function.
- Example:

```
CREATE OR REPLACE FUNCTION get_hire_date (emp_id NUMBER)
 RETURN VARCHAR
 RESULT_CACHE
 AUTHID CURRENT_USER
IS
  date_hired DATE;
BEGIN
  SELECT hire_date INTO date_hired
  from employees
  WHERE employee_id = emp_id;
  RETURN TO_CHAR(date_hired);
END;
/
SELECT get_hire_date(206) from DUAL;
```



Before Oracle Database 12*c*, an invoker's rights function could not be result-cached. As of 12*c*, the invoker's rights function can be result-cached.

To enable result-caching for a function, use the `RESULT_CACHE` clause. When a result-cached function is invoked, the system checks the cache. If the cache contains the result from a previous invocation of the function with the same parameter values, the system returns the cached result to the invoker and doesn't execute the function body again. If the cache does not contain the result, the system runs the function body and adds the result (for these parameter values) to the cache before returning control to the invoker.

**Note:** If function execution results in an unhandled exception, the exception result is not stored in the cache.

The code example in the slide depicts the creation of a function `get_hire_date` that takes the `employe_id` as a parameter and returns the `hire_date`.

To enable result caching in a package function, you have to include the RESULT_CACHE clause in both function declaration and function definition.

## Using the DETERMINISTIC Clause with Functions

- Specify DETERMINISTIC to indicate that the function returns the same result value whenever it is called with the same values for its arguments.
- Add the DETETMINISTIC clause in function declaration and definition.
- This helps the optimizer avoid redundant function calls.
- If a function was called previously with the same arguments, the optimizer can elect to use the previous result.
- Do not specify DETERMINISTIC for a function whose result depends on the state of session variables or schema objects.



You can use the DETERMINISTIC function clause to indicate that the function returns the same result value whenever it is called with the same values for its arguments.

When Oracle Database encounters a deterministic function, it attempts to use previously calculated results when possible rather than execute the function again. If you subsequently change the semantics of the function, you must manually rebuild all dependent function-based indexes and materialized views.

Don't specify this clause to define a function that uses package variables or that accesses the database in any way that might affect the return result of the function. The results of doing so will not be captured if Oracle Database chooses not to re-execute the function.

**Note**

- Don't specify DETERMINISTIC for a function whose result depends on the state of session variables or schema objects because results might vary across calls. Instead, consider making the function result-cached.
- For more information about the DETERMINISTIC clause, refer to *Oracle Database SQL Language Reference*.

## Using the RETURNING Clause

- Improves performance by returning column values with INSERT, UPDATE, and DELETE statements
- Eliminates the need for a SELECT statement

```
CREATE OR REPLACE PROCEDURE update_salary(p_emp_id NUMBER) IS
  v_name    employees.last_name%TYPE;
  v_new_sal employees.salary%TYPE;
BEGIN
  UPDATE employees
    SET salary = salary * 1.1
  WHERE employee_id = p_emp_id
  RETURNING last_name, salary INTO v_name, v_new_sal;
  DBMS_OUTPUT.PUT_LINE(v_name || ' new salary is ' ||
    v_new_sal);
END update_salary;
/
```

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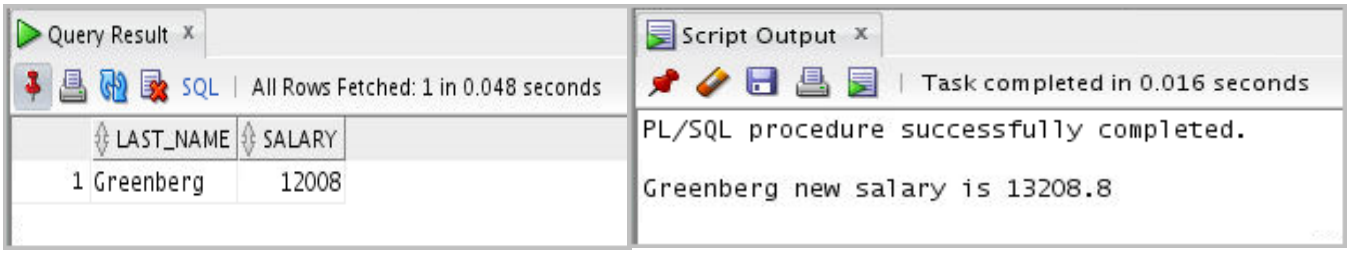
Often, applications need information about the row affected by a SQL operation; for example, to generate a report or to take a subsequent action. The INSERT, UPDATE, and DELETE statements can include a RETURNING clause, which returns column values from the affected row into PL/SQL variables or host variables. This eliminates the need to SELECT the row after an INSERT or UPDATE, or before a DELETE. As a result, fewer network round trips, less server CPU time, fewer cursors, and less server memory are required.

The example in the slide shows how to update the salary of an employee and, at the same time, retrieve the employee's last name and new salary into a local PL/SQL variable. To test the code example, issue the following commands that check the salary of employee_id 108 before updating it. Next, the procedure is invoked with the employee_id 108 as the parameter.

```
select last_name, salary from employees where employee_id=108;
/
EXECUTE update_salary(108)
```



# Lesson Agenda

- Standardization of code
- Managing security for PL/SQL packages and subprograms
- Design considerations for autonomous transactions
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  - NO COPY clause
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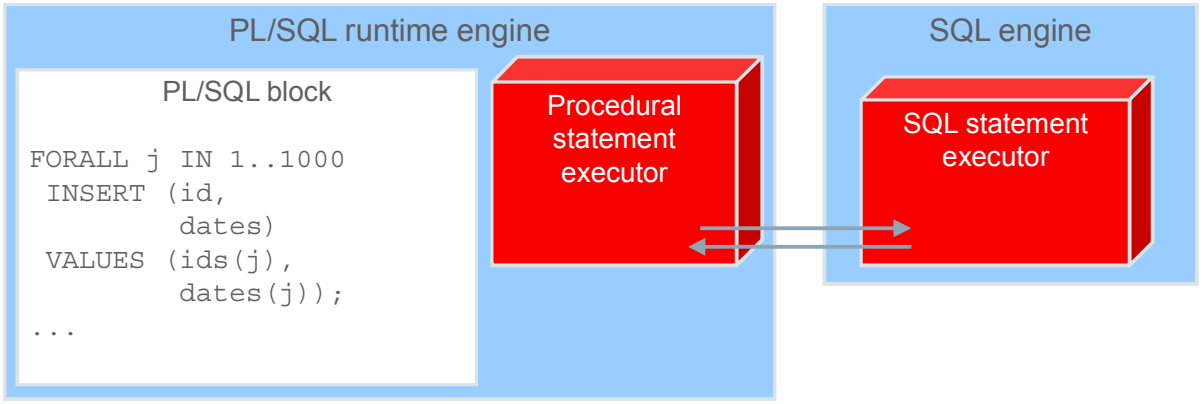
- Bulk Binding

## Using Bulk Binding

Binds whole arrays of values in a single operation, rather than using a loop to perform a `FETCH`, `INSERT`, `UPDATE`, and `DELETE` operation multiple times






The Oracle server uses two engines to run PL/SQL blocks and subprograms:

- The PL/SQL runtime engine, which runs procedural statements, but passes the SQL statements to the SQL engine
- The SQL engine, which parses and executes the SQL statement and, in some cases, returns data to the PL/SQL engine

During execution, every SQL statement causes a context switch between the two engines, which results in a performance penalty for excessive amounts of SQL processing. This is typical of applications that have a SQL statement in a loop that uses values from indexed collections. Collections include nested tables, varying arrays, index-by tables, and host arrays.

Performance can be substantially improved by minimizing the number of context switches through the use of bulk binding. Bulk binding causes an entire collection to be bound in one call, a context switch, to the SQL engine. That is, a bulk bind process passes the entire collection of values back and forth between the two engines in a single context switch, compared with incurring a context switch for each collection element in an iteration of a loop. The more rows affected by a SQL statement, the greater the performance gain with bulk binding.

## Bulk Binding: Syntax and Keywords

- The FORALL keyword instructs the PL/SQL engine to bulk bind input collections before sending them to the SQL engine.

```
FORALL index IN lower_bound .. upper_bound
  [SAVE EXCEPTIONS]
  sql_statement;
```

- The BULK COLLECT keyword instructs the SQL engine to bulk bind output collections before returning them to the PL/SQL engine.

```
... BULK COLLECT INTO
      collection_name[,collection_name] ...
```



Use bulk binds to improve the performance of:

- DML statements that reference collection elements
- SELECT statements that reference collection elements
- Cursor FOR loops that reference collections and the RETURNING INTO clause

The FORALL keyword instructs the PL/SQL engine to bulk bind input collections before sending them to the SQL engine. Although the FORALL statement contains an iteration scheme, it is not a FOR loop.

The BULK COLLECT keyword instructs the SQL engine to bulk bind output collections, before returning them to the PL/SQL engine. This enables you to bind locations into which SQL can return the retrieved values in bulk. Thus, you can use these keywords in the SELECT INTO, FETCH INTO, and RETURNING INTO clauses.

# Bulk Binding FORALL: Example

```
CREATE TABLE parts1 ( pnum INTEGER, pname VARCHAR2(15) );
/
CREATE TABLE parts2 ( pnum INTEGER, pname VARCHAR2(15) );
/
DECLARE
TYPE NumTab IS TABLE OF parts1.pnum%TYPE INDEX BY PLS_INTEGER;
TYPE NameTab IS TABLE OF parts1.pname%TYPE INDEX BY PLS_INTEGER;
pnums NumTab;
pnames NameTab;
iterations CONSTANT PLS_INTEGER := 50000;
t1 INTEGER;
t2 INTEGER;
t3 INTEGER;
```

# Bulk Binding FORALL: Example

```
BEGIN
 FOR j IN 1..iterations LOOP -- populate collections
pnums(j) := j;
 pnames(j) := 'Part No. ' || TO_CHAR(j);
END LOOP;
t1 := DBMS_UTILITY.get_time;
FOR i IN 1..iterations LOOP
INSERT INTO parts1 (pnum, pname) VALUES (pnums(i), pnames(i));
END LOOP;
t2 := DBMS_UTILITY.get_time;
FORALL i IN 1..iterations
INSERT INTO parts2 (pnum, pname) VALUES (pnums(i), pnames(i));
t3 := DBMS_UTILITY.get_time;
```

# Bulk Binding FORALL: Example

```
DBMS_OUTPUT.PUT_LINE('Execution Time (secs)');
DBMS_OUTPUT.PUT_LINE('--------------------');
DBMS_OUTPUT.PUT_LINE('FOR LOOP: ' || TO_CHAR((t2 - t1)/100));
DBMS_OUTPUT.PUT_LINE('FORALL: ' || TO_CHAR((t3 - t2)/100));
COMMIT;
END;
/
```

```
PL/SQL procedure successfully completed.

Execution Time (secs)
---------------------
FOR LOOP: .62
FORALL:   .02
```

## Using BULK COLLECT INTO with Queries

The SELECT statement supports the BULK COLLECT INTO syntax.

```
CREATE PROCEDURE get_departments(p_loc NUMBER) IS
  TYPE dept_tab_type IS
    TABLE OF departments%ROWTYPE;
  v_depts dept_tab_type;
BEGIN
  SELECT * BULK COLLECT INTO v_depts
  FROM departments
  WHERE location_id = p_loc;
  FOR i IN 1 .. v_depts.COUNT LOOP
    DBMS_OUTPUT.PUT_LINE(v_depts(i).department_id
     ||' '|| v_depts(i).department_name);
  END LOOP;
END;
```



By using BULK COLLECT INTO, you can quickly obtain a set of rows without using a cursor mechanism.

The example reads all the department rows for a specified region into a PL/SQL table, whose contents are displayed with the FOR loop that follows the SELECT statement.

## Using BULK COLLECT INTO with Cursors

The FETCH statement has been enhanced to support the BULK COLLECT INTO syntax.

```
CREATE OR REPLACE PROCEDURE get_departments(p_loc NUMBER) IS
  CURSOR cur_dept IS
    SELECT * FROM departments
    WHERE location_id = p_loc;
  TYPE dept_tab_type IS TABLE OF cur_dept%ROWTYPE;
  v_depts dept_tab_type;
BEGIN
  OPEN cur_dept;
  FETCH cur_dept BULK COLLECT INTO v_depts;
  CLOSE cur_dept;
 FOR i IN 1 .. v_depts.COUNT LOOP
    DBMS_OUTPUT.PUT_LINE(v_depts(i).department_id
     ||' '|| v_depts(i).department_name);
  END LOOP;
END;
```



The example in the slide shows how BULK COLLECT INTO can be used with cursors.
You can also add a LIMIT clause to control the number of rows fetched in each operation. The code example in the slide could be modified as follows:

```
CREATE OR REPLACE PROCEDURE get_departments(p_loc NUMBER,
  p_nrows NUMBER) IS
  CURSOR dept_csr IS SELECT *
  FROM departments
  WHERE location_id = p_loc;
  TYPE dept_tabtype IS TABLE OF dept_csr%ROWTYPE;
  depts dept_tabtype;
BEGIN
  OPEN dept_csr;
  FETCH dept_csr BULK COLLECT INTO depts LIMIT p_nrows;
  CLOSE dept_csr;
  DBMS_OUTPUT.PUT_LINE(depts.COUNT||' rows read');
END;
```

## Using BULK COLLECT INTO with a RETURNING Clause

```
CREATE OR REPLACE PROCEDURE raise_salary(p_rate NUMBER) IS
   TYPE emplist_type IS TABLE OF NUMBER;
   TYPE numlist_type IS TABLE OF employees.salary%TYPE
     INDEX BY BINARY_INTEGER;
   v_emp_ids  emplist_type := emplist_type(100,101,102,104);
   v_new_sals numlist_type;
BEGIN
  FORALL i IN v_emp_ids.FIRST .. v_emp_ids.LAST
    UPDATE employees
      SET commission_pct = p_rate * salary
    WHERE employee_id = v_emp_ids(i)
    RETURNING salary BULK COLLECT INTO v_new_sals;
  FOR i IN 1 ..   v_new_sals.COUNT LOOP
    DBMS_OUTPUT.PUT_LINE(v_new_sals(i));
  END LOOP;
END;
```



Bulk binds can be used to improve the performance of FOR loops that reference collections and return DML. If you have, or plan to have, PL/SQL code that does this, then you can use the FORALL keyword, along with the RETURNING and BULK COLLECT INTO keywords, to improve performance.

In the slide, the salary information is retrieved from the EMPLOYEES table and collected into the new_sals array. The new_sals collection is returned in bulk to the PL/SQL engine.

The example in the slide shows a FOR loop that is used to iterate through the new salary data received from the UPDATE operation and then process the results.

## Quiz

The NOCOPY hint allows the PL/SQL compiler to pass OUT and IN OUT parameters by reference rather than by value. This enhances performance by reducing overhead when passing parameters.

a. True

b. False





**Answer: a**

PL/SQL subprograms support three parameter-passing modes: IN, OUT, and IN OUT.

By default:

- The IN parameter is passed by reference. A pointer to the IN actual parameter is passed to the corresponding formal parameter. So, both the parameters reference the same memory location, which holds the value of the actual parameter.
- The OUT and IN OUT parameters are passed by value. The value of the OUT or IN OUT actual parameter is copied into the corresponding formal parameter. Then, if the subprogram exits normally, the values assigned to the OUT and IN OUT formal parameters are copied into the corresponding actual parameters.

Copying parameters that represent large data structures (such as collections, records, and instances of object types) with OUT and IN OUT parameters slows down execution and uses up memory. To prevent this overhead, you can specify the NOCOPY hint, which enables the PL/SQL compiler to pass OUT and IN OUT parameters by reference.

## Summary

In this lesson, you should have learned how to:

- Create standard constants and exceptions
- Write and call local subprograms
- Control the runtime privileges of a subprogram
- Perform autonomous transactions
- Grant roles to PL/SQL packages and stored subprograms
- Pass parameters by reference using a `NOCOPY` hint
- Use the `PARALLEL ENABLE` hint for optimization
- Use the cross-session PL/SQL function result cache
- Use the `DETERMINISTIC` clause with functions
- Use the `RETURNING` clause and bulk binding with DML



The lesson provides insights into managing your PL/SQL code by defining constants and exceptions in a package specification. This enables a high degree of reuse and standardization of code.

Local subprograms can be used to simplify and modularize a block of code where the subprogram functionality is repeatedly used in the local block.

The runtime security privileges of a subprogram can be altered by using definer's or invoker's rights.

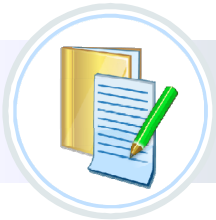
Autonomous transactions can be executed without affecting an existing main transaction.

You should understand how to obtain performance gains by using the `NOCOPY` hint, bulk binding and the `RETURNING` clauses in SQL statements, and the `PARALLEL_ENABLE` hint for optimization of functions.

# Practice 11 Overview: Design Considerations for PL/SQL Code

This practice covers the following topics:

- Creating a package that uses bulk fetch operations
- Creating a local subprogram to perform an autonomous transaction to audit a business operation





In this practice, you create a package that performs a bulk fetch of employees in a specified department. The data is stored in a PL/SQL table in the package. You also provide a procedure to display the contents of the table.

You add an `add_employee` procedure to the package that inserts new employees. The procedure uses a local autonomous subprogram to write a log record each time the `add_employee` procedure is called, whether it successfully adds a record or not.

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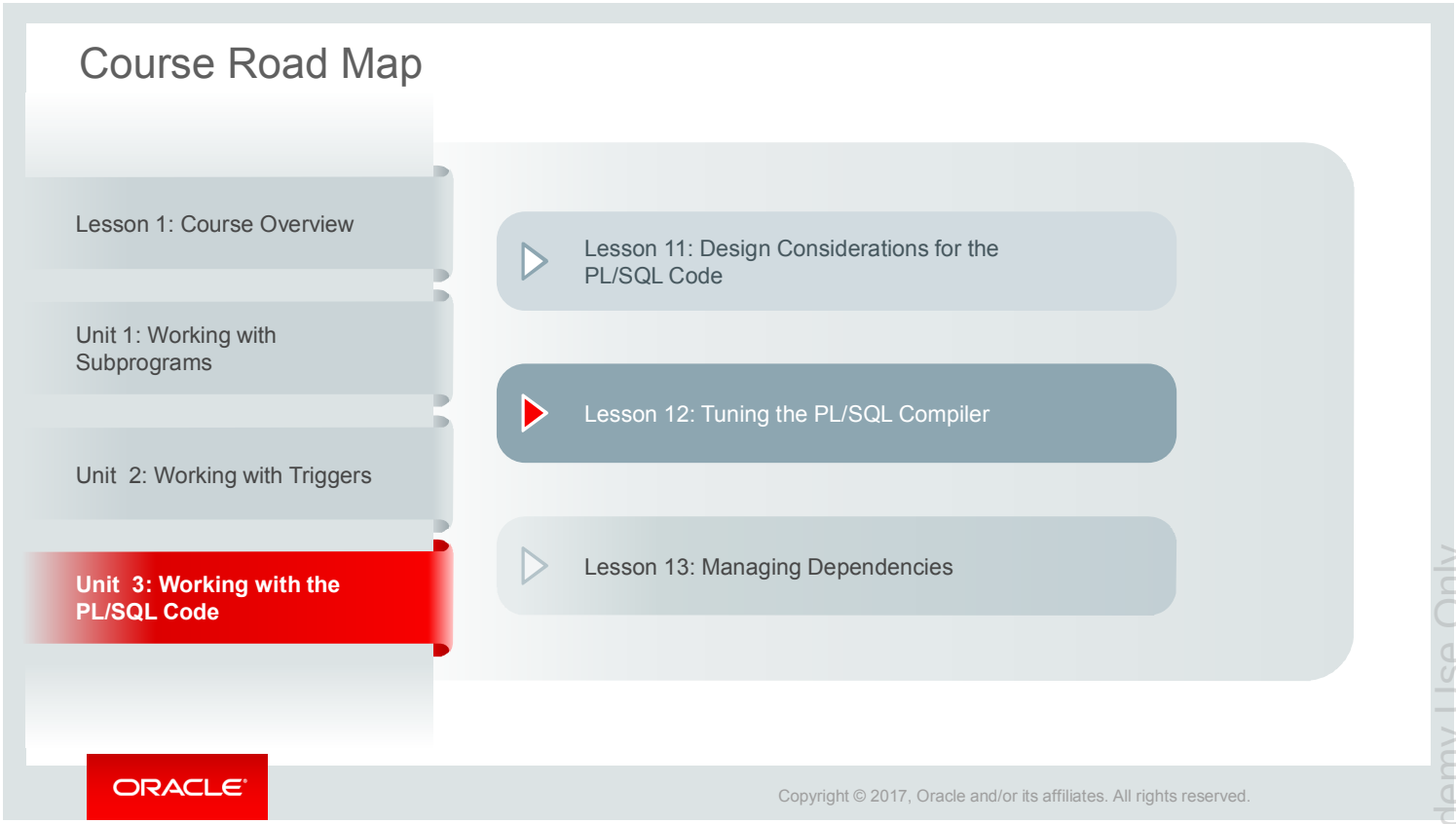
# Tuning the PL/SQL Compiler

# Objectives

After completing this lesson, you should be able to:

- Use the PL/SQL compiler initialization parameters
- Use the PL/SQL compile-time warnings




In Unit 3, you will learn the design aspects of the PL/SQL code. You will also learn how to use PL/SQL compiler and how to manage dependencies among different objects in the database application.

# Lesson Agenda

- Using PL/SQL initialization parameters
- Using the PL/SQL compile-time warnings:
  - Using the `PLSQL_WARNING` initialization parameter
  - Using the `DBMS_WARNING` package subprograms

# Optimizing PL/SQL Compiler Performance

- The PL/SQL compiler implicitly rearranges the code for better performance.
- The compiler behavior is defined by its initialization parameters.
- You can use initialization parameters to tune the performance of the compiler according to the application requirement.

## Initialization Parameters for PL/SQL Compilation

| Compilation Parameter | Description |
|---|---|
| PLSCOPE_SETTINGS | Controls the compile-time collection, cross-reference, and storage of the PL/SQL source text identifier data |
| PLSQL_CCFLAGS | Lets you control conditional compilation of each PL/SQL unit independently |
| PLSQL_CODE_TYPE | Specifies the compilation mode for PL/SQL units - INTERPRETED (the default) or NATIVE |
| PLSQL_OPTIMIZE_LEVEL | Specifies the optimization level at which to compile PL/SQL units |
| PLSQL_WARNINGS | Enables or disables the reporting of warning messages by the PL/SQL compiler, and specifies which warning messages to show as errors |
| NLS_LENGTH_SEMANTICS | Lets you create CHAR and VARCHAR2 columns by using either byte-length or character-length semantics |



- PLSCOPE_SETTINGS determines whether the compiler should collect data about the identifiers in the PL/SQL program unit and provide it to the static data dictionary views. The collected data includes information about identifier types, usages, and location of each usage in the source code.

  The PLSCOPE_SETTINGS parameter can assume either 'IDENTIFIERS:ALL' or 'IDENTIFIERS:NONE'.
- PLSQL_CCFLAGS lets you control the conditional compilation of each program unit. Conditional compilation lets you customize the functionality of a PL/SQL application without removing the source text. For example:
  - Using new features with the latest database release and disabling them when running the application in an older database release.
  - Activate debugging or tracing statements in the development environment and hide them when running the application at a production site.
- The PLSQL_CODE_TYPE parameter can have either INTERPRETED or NATIVE as its value. It determines the mode of compilation.

  The PL/SQL statements in a PL/SQL unit are compiled into an intermediate form, system code, which is stored in the catalog and interpreted at run time. This is the default behavior when the PLSQL_CODE_TYPE parameter is set to INTERPRETED value.

  When the PLSQL_CODE_TYPE value is set to NATIVE, the PL/SQL statements in a PL/SQL unit are compiled into native code and stored in the catalog. The native code need not be interpreted at run time, so it runs faster.

- The PLSQL_OPTIMIZE_LEVEL parameter can have a value in the 0-3 range. A higher value of the parameter implies a greater level of optimization.
- The PLSQL_WARNINGS parameter configures the response of the application to various PL/SQL warnings in the application.
- The NLS_LENGTH_SEMANTICS parameter determines whether the compiler should use byte-length or character-length semantics for the VARCHAR2 and CHAR variables in the PL/SQL program unit.

The values at the time of compilation of PLSQL_CCFLAGS, PLSQL_CODE_TYPE, PLSQL_OPTIMIZE_LEVEL, PLSQL_WARNINGS, and NLS_LENGTH_SEMANTICS initialization parameters are stored with the unit's metadata. You can view information about the settings of these parameters with the ALL_PLSQL_OBJECT_SETTINGS view.

## Using the Initialization Parameters for PL/SQL Compilation

- PLSQL_CODE_TYPE: Specifies the compilation mode for PL/SQL library units

```
PLSQL_CODE_TYPE = { INTERPRETED | NATIVE }
```

- PLSQL_OPTIMIZE_LEVEL: Specifies the optimization level to be used to compile PL/SQL library units

```
PLSQL_OPTIMIZE_LEVEL = { 0 | 1 | 2 | 3}
```



PLSQL_CODE_TYPE determines the compilation mode for the PL/SQL program unit. When the value of this parameter is changed, it has no effect on PL/SQL library units that have already been compiled. The value of this parameter is stored persistently with each library unit. If a PL/SQL library unit is compiled natively, all subsequent automatic recompilations of that library unit will use native compilation.

PLSQL_OPTIMIZE_LEVEL defines the extent of optimization applicable to the compilation of the program unit.

PLSQL_OPTIMIZE_LEVEL, when set to 0: the compiler would not reorder the code for better performance.

PLSQL_OPTIMIZE_LEVEL, when set to 1: applies a wide range of optimizations to PL/SQL programs, including the elimination of unnecessary computations and exceptions, but generally does not move the source code out of its original source order

PLSQL_OPTIMIZE_LEVEL, when set to 2: applies a wide range of modern optimization techniques beyond those of level 1, including changes that may move the source code relatively far from its original location.

PLSQL_OPTIMIZE_LEVEL, when set to 3: applies a wide range of optimization techniques beyond those of level 2, automatically including techniques not specifically requested

## Displaying the PL/SQL Initialization Parameters

Use the USER|ALL|DBA_PLSQL_OBJECT_SETTINGS data dictionary views to display the settings for a PL/SQL object:

```
DESCRIBE USER_PLSQL_OBJECT_SETTINGS;
```

```
Name                 Null     Type
-------------------- -------- --------------
NAME                 NOT NULL VARCHAR2(128)
TYPE                          VARCHAR2(12)
PLSQL_OPTIMIZE_LEVEL          NUMBER
PLSQL_CODE_TYPE               VARCHAR2(4000)
PLSQL_DEBUG                   VARCHAR2(4000)
PLSQL_WARNINGS                VARCHAR2(4000)
NLS_LENGTH_SEMANTICS          VARCHAR2(4000)
PLSQL_CCFLAGS                 VARCHAR2(4000)
PLSCOPE_SETTINGS              VARCHAR2(4000)
ORIGIN_CON_ID                 NUMBER
```





The columns of the USER_PLSQL_OBJECTS_SETTINGS data dictionary view are:

- **Owner:** The owner of the object. This column is not displayed in the USER_PLSQL_OBJECTS_SETTINGS view.
- **Name:** The name of the object
- **Type:** The available choices are PROCEDURE, FUNCTION, PACKAGE, PACKAGE BODY, TRIGGER, TYPE, TYPE BODY, or any other user-defined objects.
- **PLSQL_OPTIMIZE_LEVEL:** The optimization level that was used to compile the object
- **PLSQL_CODE_TYPE:** The compilation mode for the object
- **PLSQL_DEBUG:** Specifies whether or not the object was compiled for debugging
- **PLSQL_WARNINGS:** The compiler warning settings used to compile the object
- **NLS_LENGTH_SEMANTICS:** The NLS length semantics used to compile the object
- **PLSQL_CCFLAGS:** The conditional compilation flag used to compile the object
- **PLSCOPE_SETTINGS:** Controls the compile-time collection, cross reference, and storage of PL/SQL source code identifier data
- **ORIGIN_CON_ID**: The identifier of the container where the data originates. This value is 0 for non-container databases.

# Displaying and Setting PL/SQL Initialization Parameters

```
SELECT name, type, plsql_code_type,
       plsql_optimize_level
FROM   user_plsql_object_settings;
```

| | NAME | TYPE | PLSQL_OPTIMIZE_LEVEL |
|---|---|---|---|
| 1 | ADD_COL | PROCEDURE | INTERPRETED |
| 2 | ADD_DEPARTMENT | PROCEDURE | INTERPRETED |
| 3 | ADD_DEPARTMENT_NOEX | PROCEDURE | INTERPRETED |
| 4 | ADD_DEPT | PROCEDURE | INTERPRETED |
| 5 | ADD_JOB_HISTORY | PROCEDURE | INTERPRETED |
| 6 | ADD_ROW | PROCEDURE | INTERPRETED |
| 7 | ANNUAL_SAL | FUNCTION | INTERPRETED |
| 8 | AUDIT_EMP_VALUES | TRIGGER | INTERPRETED |
| 9 | BANK_TRANS | PROCEDURE | INTERPRETED |
| 10 | CHECK_SALARY | TRIGGER | INTERPRETED |

- Set the compiler initialization parameter's value by using the `ALTER SYSTEM` or `ALTER SESSION` statements.
- The parameters' values are accessed when the `CREATE OR REPLACE` statement is executed.



You can set the value of the compilation parameter through ALTER SESSION as follows:

```
ALTER SESSION SET PLSQL_OPTIMIZE_LEVEL=1;
```

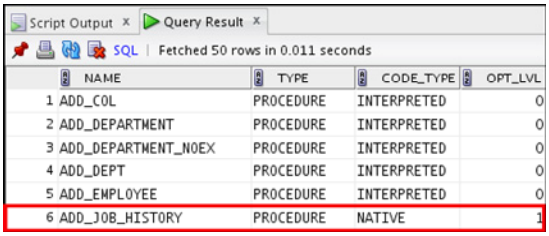
## Changing PL/SQL Initialization Parameters: Example

```
ALTER SESSION SET PLSQL_OPTIMIZE_LEVEL = 1;
ALTER SESSION SET PLSQL_CODE_TYPE = 'NATIVE';
```

```
Session altered.

Session altered.
```

```
-- code displayed in the notes page
CREATE OR REPLACE PROCEDURE add_job_history
. . .
```

```
@code_11_09_sa.sql
```




| | NAME | TYPE | CODE_TYPE | OPT_LVL |
|---|---|---|---|---|
| 1 | ADD_COL | PROCEDURE | INTERPRETED | 0 |
| 2 | ADD_DEPARTMENT | PROCEDURE | INTERPRETED | 0 |
| 3 | ADD_DEPARTMENT_NOEX | PROCEDURE | INTERPRETED | 0 |
| 4 | ADD_DEPT | PROCEDURE | INTERPRETED | 0 |
| 5 | ADD_EMPLOYEE | PROCEDURE | INTERPRETED | 0 |
| 6 | ADD_JOB_HISTORY | PROCEDURE | NATIVE | 1 |



To change a compiled PL/SQL object from the interpreted code type to the native code type, you must first set the `PLSQL_CODE_TYPE` parameter to `NATIVE` (optionally set the other parameters) and then recompile the program.

To enforce native compilation to all PL/SQL code, you must recompile each one. Scripts (in the `rdmbs/admin` directory) are provided for you to achieve conversion to full native compilation (`dbmsupgnv.sql`) or full interpreted compilation (`dbmsupgin.sql`). The `add_job_history` procedure is created as follows:

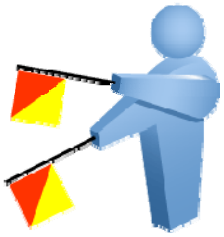
```
CREATE OR REPLACE PROCEDURE add_job_history
   (  p_emp_id          job_history.employee_id%type
    , p_start_date      job_history.start_date%type
    , p_end_date        job_history.end_date%type
    , p_job_id          job_history.job_id%type
    , p_department_id   job_history.department_id%type )
 IS
 BEGIN
   INSERT INTO job_history (employee_id, start_date,
                    end_date, job_id, department_id)
      VALUES(p_emp_id, p_start_date, p_end_date,
             p_job_id, p_department_id);
 END add_job_history;
/
```

# Lesson Agenda

- Using PL/SQL initialization parameters
- Using the PL/SQL compile-time warnings:
  - Using the `PLSQL_WARNING` initialization parameter
  - Using the `DBMS_WARNING` package subprograms

## PL/SQL Compile-Time Warnings

- Messages from compiler that help in improving code maintainability
- Developers can use them to reduce the chances of bugs creeping in to the application.
- A PL/SQL unit flagged with warnings may execute successfully, but might exhibit unexpected behavior or inefficient performance.
- All PL/SQL warning messages use the prefix `PLW`.





To make your programs more robust and avoid problems at run time, you can turn on checking for certain warning conditions. These conditions are not serious enough to produce an error and keep you from compiling a subprogram. They may point out something in the subprogram that produces an undefined result or might create a performance problem.

With the PL/SQL compiler-warning feature, compiling a PL/SQL program could have the following two possible outcomes:

- Success with compilation warnings
- Failure with compilation errors and compilation warnings

Note that the compiler may issue warning messages even on a successful compile. A compilation error must be corrected to be able to use the stored procedure, whereas a warning is for informational purposes.

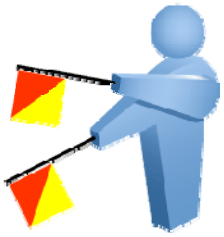
**Examples of warning messages**

**SP2-0804:** Procedure created with compilation warnings

**PLW-07203:** Parameter `"IO_TBL"` may benefit from use of the `NOCOPY` compiler hint.

## Benefits of Compiler Warnings

- Make programs more robust and avoid problems at run time
- Identify potential performance problems
- Identify factors that produce undefined results



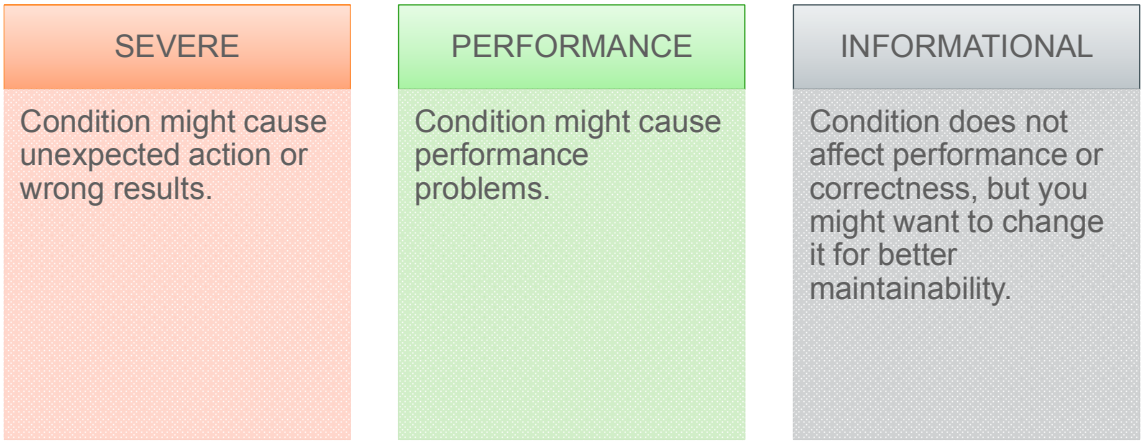


Using compiler warnings can help you to:

- Make your programs more robust and avoid problems at run time
- Identify potential performance problems
- Identify factors that produce undefined results

All PL/SQL warning messages use the prefix `PLW`.

## Categories of PL/SQL Compile-Time Warning Messages






PL/SQL warning messages are divided into categories, so that you can suppress or display groups of similar warnings during compilation. The categories are:

- `SEVERE`: Messages for conditions that may cause unexpected behavior or wrong results, such as aliasing problems with parameters
- `PERFORMANCE`: Messages for conditions that may cause performance problems, such as passing a `VARCHAR2` value to a `NUMBER` column in an `INSERT` statement
- `INFORMATIONAL`: Messages for conditions that do not have an effect on performance or correctness, but that you may want to change to make the code more maintainable, such as unreachable code that can never be executed

## Enabling Warning Messages

You can enable displaying warning messages by using one of the following methods:

- The PLSQL_WARNINGS initialization parameter
- The DBMS_WARNING package





You can enable the display of compiler warning messages by using one of the following methods:

**The PLSQL_WARNINGS Initialization Parameter**

The PLSQL_WARNINGS parameter enables or disables warning messages being reported by the PL/SQL compiler and specifies which warning messages to show as errors. The settings for the PLSQL_WARNINGS parameter are stored along with each compiled subprogram. You can use the PLSQL_WARNINGS initialization parameter to do the following:

- Enable or disable the reporting of all warnings, warnings of a selected category, or specific warning messages.
- Treat all warnings, a selected category of warning, or specific warning messages as errors.
- Following is the syntax to do so:

  ```
  PLSQL_WARNINGS = '<DISABLE | ENABLE | ERROR>:<ALL | INFORMATIONAL | PERFORMANCE | SEVERE>'
  PLSQL_WARNINGS = 'DISABLE:<warning#>'ENABLE:<warning#>', 'ERROR:<warning#>'
  ```

  You can disable or enable certain category of warnings. You can also configure the compiler to report certain category of warnings as errors.
  Through the PLSQL_WARNINGS parameter you can enable, disable, or report specific warnings as errors.

**The DBMS_WARNING Package**

The DBMS_WARNING package provides a way to manipulate the behavior of PL/SQL warning messages, in particular by reading and changing the setting of the PLSQL_WARNINGS initialization parameter, to control what kinds of warnings are suppressed, displayed, or treated as errors. This package provides the interface to query, modify, and delete current system or session settings.

## Setting Compiler Warning Levels: Using PLSQL_WARNINGS, Examples

```
ALTER SESSION
SET plsql_warnings = 'enable:severe',
     'enable:performance',
    'disable:informational';
```

```
Session altered.
```

```
ALTER SESSION
SET plsql_warnings = 'enable:severe';
```

```
Session altered.
```

```
ALTER SESSION SET PLSQL_WARNINGS='ENABLE:SEVERE',
        'DISABLE:PERFORMANCE' , 'ERROR:05003';
```

```
Session altered.
```



You can use the ALTER SESSION or ALTER SYSTEM command to change the PLSQL_WARNINGS initialization parameter. The graphic in the slide shows the various examples of enabling and disabling compiler warnings.

**Example 1**

In this example, you are enabling SEVERE and PERFORMANCE warnings and disabling INFORMATIONAL warnings.

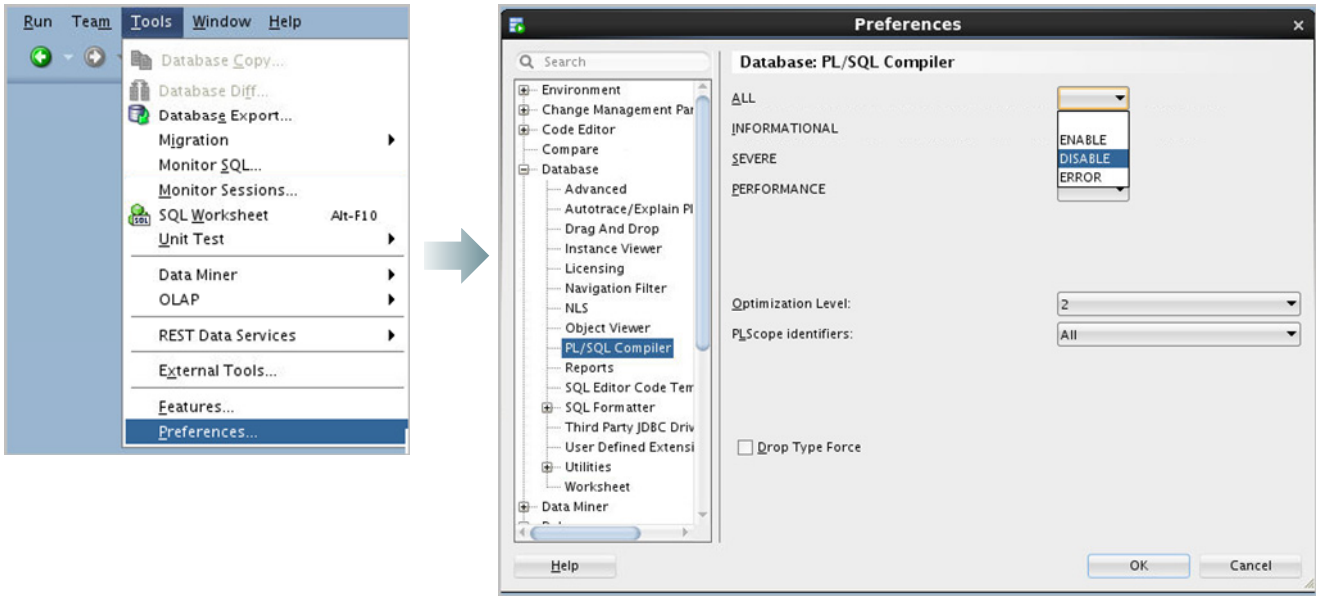
**Example 2**

In the second example, you are enabling only SEVERE warnings.

**Example 3**

You can treat particular messages as errors, instead of warnings. In this example, if you know that the warning message PLW-05003 represents a serious problem in your code; ERROR:05003 in the PLSQL_WARNINGS setting makes that condition trigger an error message (PLS_05003) instead of a warning message. An error message causes the compilation to fail. In this example, you are also disabling PERFORMANCE warnings.

# Enabling Compiler Warnings: Using PLSQL_WARNINGS in SQL Developer






The PL/SQL Compiler pane specifies options for compilation of PL/SQL subprograms.

**Setting and Viewing the PL/SQL Compile-Time Warning Messages Categories in SQL Developer**

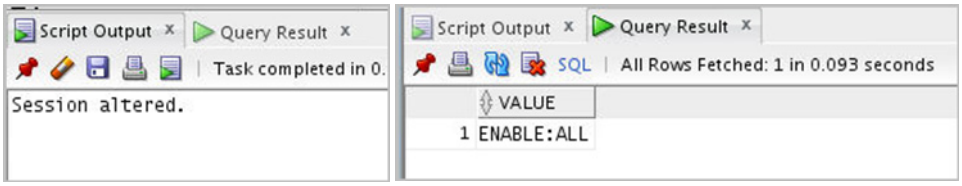
You can control the display of informational, severe, and performance-related messages. The **ALL** type overrides any individual specifications for the other types of messages. For each type of message, you can specify any of the following:

- **No entry (blank):** Use any value specified for **ALL**; and if no value is specified, use the Oracle default.
- **Enable:** Enable the display of all messages of this category.
- **Disable:** Disable the display of all messages of this category.
- **Error:** Enable the display of only error messages of this category.

## Viewing the Current Setting of PLSQL_WARNINGS

You can examine the current setting for the PLSQL_WARNINGS parameter by issuing a SELECT statement on the V$PARAMETER view.

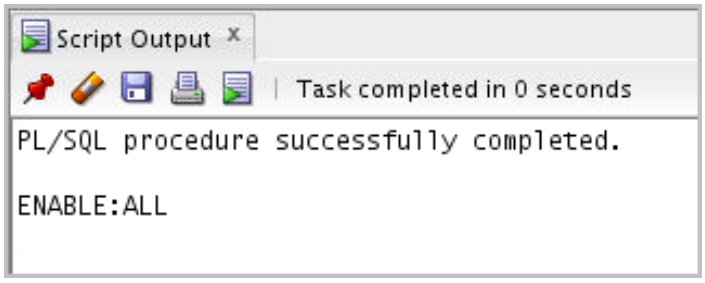
```
ALTER SESSION SET plsql_warnings = 'enable:severe',
'enable:performance','enable:informational';
/
SELECT value FROM v$parameter WHERE name='plsql_warnings';
/
```






Alternatively, you can use the DBMS_WARNING.GET_WARNING_SETTING_STRING package and procedure to retrieve the current settings for the PLSQL_WARNINGS parameter:

```
DECLARE s VARCHAR2(1000);
BEGIN
  s := dbms_warning.get_warning_setting_string();
  dbms_output.put_line (s);
END;
/
```



## Viewing Compiler Warnings

- You can view compiler warnings through:
  - SQL*Plus with SHOW ERRORS command
  - Data Dictionary views





You can use SQL*Plus to see any warnings raised as a result of the compilation of a PL/SQL block. SQL*Plus indicates that a compilation warning has occurred. The ***"SP2-08xx: <object> created with compilation warnings."*** message is displayed for objects compiled .You must enable the compiler warnings before compiling the program. You can display the compiler warning messages by using any of the following methods:

**Using the SQL*Plus `SHOW ERRORS` Command**

This command displays any compiler errors including the new compiler warnings and informational messages. This command is invoked immediately after a `CREATE [PROGEDURE|FUNCTION|PACKAGE]` command is used. The `SHOW ERRORS` command displays warnings and compiler errors. New compiler warnings and informational messages are "interleaved" with compiler errors when `SHOW ERRORS` is invoked.

**Using Data Dictionary Views**

You can select from the `USER_|ALL_|DBA_ERRORS` data dictionary views to display PL/SQL compiler warnings. The `ATTRIBUTES` column of these views has a new attribute called `WARNING` and the warning message displays in the `TEXT` column.

# SQL*Plus Warning Messages: Example

```
CREATE OR REPLACE PROCEDURE bad_proc(p_out …) IS
   BEGIN
   . . .;
   END;
   /

SP2-0804: Procedure created with compilation warnings.
```

```
Procedure BAD_PROC compiled
Errors: check compiler log
Errors for PROCEDURE ORA61.BAD_PROC:

LINE/COL ERROR
-------- -----------------------------------------------------------------
1/26     PLS-00103: Encountered the symbol "?" when expecting one of the following:

         in out <an identifier> <a double-quoted delimited-identifier>
         table ... columns long double ref char time timestamp
         interval date binary national character nchar
```



Use the `SHOW ERRORS` command in SQL*Plus to display the compilation errors of a stored procedure. When you specify this option with no arguments, SQL*Plus displays the compilation errors for the most recently created or altered stored procedure. If SQL*Plus displays a compilation warnings message after you create or alter a stored procedure, you can use `SHOW ERRORS` commands to obtain more information.

With the introduction of support for PL/SQL warnings, the range of feedback messages is expanded to include a third message as follows:

```
SP2-08xx: <object> created with compilation warnings.
```

This enables you to differentiate between the occurrence of a compilation warning and a compilation error. You must correct an error if you want to use the stored procedure, whereas a warning is for informational purposes only.

The `SP2` prefix is included with the warning message because this provides you with the ability to look up the corresponding message number in the *SQL*Plus User's Guide and Reference* to determine the cause and action for the particular message.

**Note:** You can also view the compiler errors and warnings by using the `USER_|ALL_|DBA_ERRORS` data dictionary views.

## Defining PLSQL_WARNINGS for Program Units

- The settings for the PLSQL_WARNINGS parameter are stored along with each compiled subprogram.
- If you recompile the subprogram using one of the following statements, the current settings for that session are used:
  - CREATE OR REPLACE
  - ALTER . . . COMPILE
- If you recompile the subprogram using the ALTER . . . COMPILE statement with the REUSE SETTINGS clause, the original setting stored with the program is used.



As already stated, the PLSQL_WARNINGS parameter can be set at the session level or at the system level.

The settings for the PLSQL_WARNINGS parameter are stored along with each compiled subprogram. If you recompile the subprogram with a CREATE OR REPLACE statement, the current settings for that session are used. If you recompile the subprogram with an ALTER . . . COMPILE statement, then the current session setting is used unless you specify the REUSE SETTINGS clause in the statement, which uses the original setting that is stored with the subprogram.

# Lesson Agenda

- Using the PL/SQL initialization parameters
- Using the PL/SQL compile-time warnings:
  - Using the `PLSQL_WARNING` initialization parameter
  - Using the `DBMS_WARNING` package subprograms

## Using the DBMS_WARNINGS Package

You can use the DBMS_WARNINGS package to:

- Manipulate the behavior of PL/SQL warning messages
- Change the definition of PLSQL_WARNINGS parameter
- Query, modify, and delete current system or session settings



Use the DBMS_WARNING package to programmatically manipulate the behavior of PL/SQL warning settings for the current system or session. The DBMS_WARNING package provides a way to manipulate the behavior of PL/SQL warning messages, in particular by reading and changing the setting of the PLSQL_WARNINGS initialization parameter, to control the types of warnings suppressed, displayed, or treated as errors. This package provides the interface to query, modify, and delete current system or session settings.

The DBMS_WARNING package is valuable if you are writing a development environment that compiles PL/SQL subprograms. By using the package interface routines, you can control PL/SQL warning messages programmatically to suit your requirements.

## Using the DBMS_WARNING Package Subprograms

| Scenario | Subprograms to Use |
|---|---|
| Set warnings | ADD_WARNING_SETTING_CAT (procedure)<br>ADD_WARNING_SETTING_NUM (procedure) |
| Query warnings | GET_WARNING_SETTING_CAT (function)<br>GET_WARNING_SETTING_NUM (function)<br>GET_WARNING_SETTING_STRING (function) |
| Replace warnings | SET_WARNING_SETTING_STRING (procedure) |
| Get the warnings' categories names | GET_CATEGORY (function) |



The following is a list of the DBMS_WARNING subprograms:

- ADD_WARNING_SETTING_CAT: Modifies the current session or system warning settings of the warning_category previously supplied
- ADD_WARNING_SETTING_NUM: Modifies the current session or system warning settings of the warning_number previously supplied
- GET_CATEGORY: Returns the category name, given the message number
- GET_WARNING_SETTING_CAT: Returns the specific warning category in the session
- GET_WARNING_SETTING_NUM: Returns the specific warning number in the session
- GET_WARNING_SETTING_STRING: Returns the entire warning string for the current session
- SET_WARNING_SETTING_STRING: Replaces previous settings with the new value

**Note:** For additional information about the preceding subprograms, refer to *Oracle Database PL/SQL Packages and Types Reference or Oracle Database PL/SQL Packages and Types Reference* (as applicable to the version you are using).

## The DBMS_WARNING Procedures: Syntax, Parameters, and Allowed Values

```
EXECUTE DBMS_WARNING.ADD_WARNING_SETTING_CAT (-
  warning_category      IN       VARCHAR2,
  warning_value         IN       VARCHAR2,
  scope                 IN       VARCAHR2);
```

```
EXECUTE DBMS_WARNING.ADD_WARNING_SETTING_NUM (-
  warning_number        IN       NUMBER,
  warning_value         IN       VARCHAR2,
  scope                 IN       VARCAHR2);
```

```
EXECUTE DBMS_WARNING.SET_WARNING_SETTING_STRING (-
   warning_value        IN       VARCHAR2,
   scope                IN       VARCHAR2);
```



The `warning_category` is the name of the category. The allowed values are:

- `ALL`
- `INFORMATIONAL`
- `SEVERE`
- `PERFORMANCE`.

The `warning_value` is the value for the category. The allowed values are:

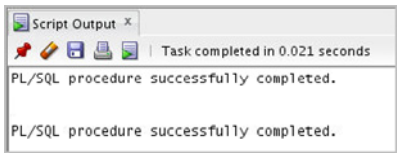
- `ENABLE`
- `DISABLE`
- `ERROR`

The `warning_number` is the warning message number. The allowed values are all valid warning numbers.

The `scope` specifies whether the changes are being performed in the session context or the system context. The allowed values are `SESSION` or `SYSTEM`. Using `SYSTEM` requires the `ALTER SYSTEM` privilege.

## The DBMS_WARNING Procedures: Example

```
-- Establish the following warning setting string in the
-- current session:
-- ENABLE:INFORMATIONAL,
-- DISABLE:PERFORMANCE,
-- ENABLE:SEVERE

EXECUTE DBMS_WARNING.SET_WARNING_SETTING_STRING(-
  'ENABLE:ALL', 'SESSION');

EXECUTE DBMS_WARNING.ADD_WARNING_SETTING_CAT(-
  'PERFORMANCE','DISABLE', 'SESSION');
```






By using the SET_WARNING_SETTING_STRING procedure, you can set one warning setting. If you have multiple warning settings, you should perform the following steps:

1. Call SET_WARNING_SETTING_STRING to set the initial warning setting string.
2. Call ADD_WARNING_SETTING_CAT (or ADD_WARNING_SETTING_NUM) repeatedly to add more settings to the initial string.

The example in the slide establishes the following warning setting string in the current session:
ENABLE:INFORMATIONAL,DISABLE:PERFORMANCE,ENABLE:SEVERE

## The DBMS_WARNING Functions: Syntax, Parameters, and Allowed Values

```
DBMS_WARNING.GET_WARNING_SETTING_CAT (-
   warning_category IN  VARCHAR2) RETURN warning_value;
```

```
DBMS_WARNING.GET_WARNING_SETTING_NUM (-
   warning_number IN NUMBER) RETURN warning_value;
```

```
DBMS_WARNING.GET_WARNING_SETTING_STRING
  RETURN pls_integer;
```

```
DBMS_WARNING.GET_CATEGORY (-
  warning_number  IN   pls_integer) RETURN VARCHAR2;
```



The warning_category is the name of the category. The allowed values are:

- ALL
- INFORMATIONAL
- SEVERE
- PERFORMANCE

The warning_number is the warning message number. The allowed values are all valid warning numbers.

The scope specifies whether the changes are being performed in the session context or the system context. The allowed values are SESSION or SYSTEM. Using SYSTEM requires the ALTER SYSTEM privilege.

**Note:** Use the GET_WARNING_SETTING_STRING function when you do not have the SELECT privilege on the v$parameter or v$parameter2 fixed tables, or if you want to parse the warning string yourself, and then modify and set the new value by using SET_WARNING_SETTING_STRING.

## The DBMS_WARNING Functions: Example

```
-- Determine the current session warning settings
SET SERVEROUTPUT ON
EXECUTE DBMS_OUTPUT.PUT_LINE( -
DBMS_WARNING.GET_WARNING_SETTING_STRING);
```

```
PL/SQL procedure successfully completed.

ENABLE:INFORMATIONAL,DISABLE:PERFORMANCE,ENABLE:SEVERE
```

```
-- Determine the category for warning message number
-- PLW-07203
SET SERVEROUTPUT ON
EXECUTE DBMS_OUTPUT.PUT_LINE( -
DBMS_WARNING.GET_CATEGORY(7203));
```

```
PL/SQL procedure successfully completed.

PERFORMANCE
```



**Note:** The message numbers must be specified as positive integers because the data type for the `GET_CATEGORY` parameter is `PLS_INTEGER` (allowing positive integer values).

## Using DBMS_WARNING: Example

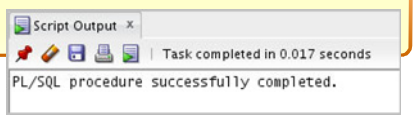
```
CREATE OR REPLACE PROCEDURE compile_code(p_pkg_name VARCHAR2) IS
  v_warn_value   VARCHAR2(200);
  v_compile_stmt VARCHAR2(200) :=
    'ALTER PACKAGE '|| p_pkg_name ||' COMPILE';

BEGIN
   v_warn_value := DBMS_WARNING.GET_WARNING_SETTING_STRING;
   DBMS_OUTPUT.PUT_LINE('Current warning settings: '||
      v_warn_value);
   DBMS_WARNING.ADD_WARNING_SETTING_CAT(
      'PERFORMANCE', 'DISABLE', 'SESSION');
   DBMS_OUTPUT.PUT_LINE('Modified warning settings: '||
      DBMS_WARNING.GET_WARNING_SETTING_STRING);
   EXECUTE IMMEDIATE v_compile_stmt;
   DBMS_WARNING.SET_WARNING_SETTING_STRING(v_warn_value,
      'SESSION');
   DBMS_OUTPUT.PUT_LINE('Restored warning settings: '||
      DBMS_WARNING.GET_WARNING_SETTING_STRING);
END;
/
```



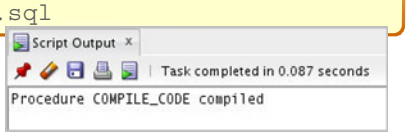
In the example in the slide, the `compile_code` procedure is designed to compile a named PL/SQL package. The code suppresses the `PERFORMANCE` category warnings. The calling environment's warning settings must be restored after the compilation is performed. The code does not know what the calling environment warning settings are; it uses the `GET_WARNING_SETTING_STRING` function to save the current setting. This value is used to restore the calling environment setting using the `DBMS_WARNING.SET_WARNING_SETTING_STRING` procedure in the last line of the example code. Before compiling the package using Native Dynamic SQL, the `compile_code` procedure alters the current session warning level by disabling warnings for the `PERFORMANCE` category. The code also prints the original, modified, and the restored warning settings.

## Using DBMS_WARNING: Example

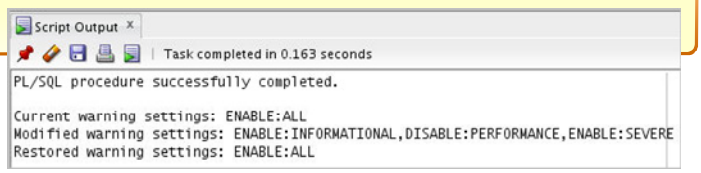
```
EXECUTE DBMS_WARNING.SET_WARNING_SETTING_STRING(-
  'ENABLE:ALL', 'SESSION');
```




```
@/home/oracle/labs/plpu/code_ex/code_ex_scripts/code_12_33_s.sql
```




```
EXECUTE compile_code('EMP_PKG');
```






The example in the slide tests the example provided in the previous slide. First, enable all compiler warnings. Next, run the script on the previous page. Finally, call the `compile_code` procedure and pass it an existing package name, `MY_PKG`, as a parameter.

## Quiz

The categories of PL/SQL compile-time warning messages are:

a. SEVERE
b. PERFORMANCE
c. INFORMATIONAL
d. All
e. CRITICAL





**Answer: a, b, c, d**

PL/SQL warning messages are divided into categories, so that you can suppress or display groups of similar warnings during compilation. The categories are:

- `SEVERE`: Messages for conditions that may cause unexpected behavior or wrong results, such as aliasing problems with parameters
- `PERFORMANCE`: Messages for conditions that may cause performance problems, such as passing a `VARCHAR2` value to a `NUMBER` column in an `INSERT` statement
- `INFORMATIONAL`: Messages for conditions that do not have an effect on performance or correctness, but that you may want to change to make the code more maintainable, such as unreachable code that can never be executed
- `ALL`: Displays all categories

# Summary

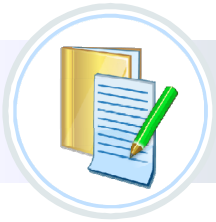
In this lesson, you should have learned how to:

- Use the PL/SQL compiler initialization parameters
- Use the PL/SQL compile-time warnings

# Practice 12 Overview: Tuning PL/SQL Compiler

This practice covers the following topics:

- Displaying the compiler initialization parameters
- Enabling native compilation for your session and compiling a procedure
- Disabling the compiler warnings, and then restoring the original session-warning settings
- Identifying the categories for some compiler-warning message numbers





In this practice, you display the compiler initialization parameters. You then enable native compilation for your session and compile a procedure. You then suppress all compiler warnings categories and then restore the original session-warning settings. Finally, you identify the categories for some compiler-warning message numbers.

13

# Managing Dependencies

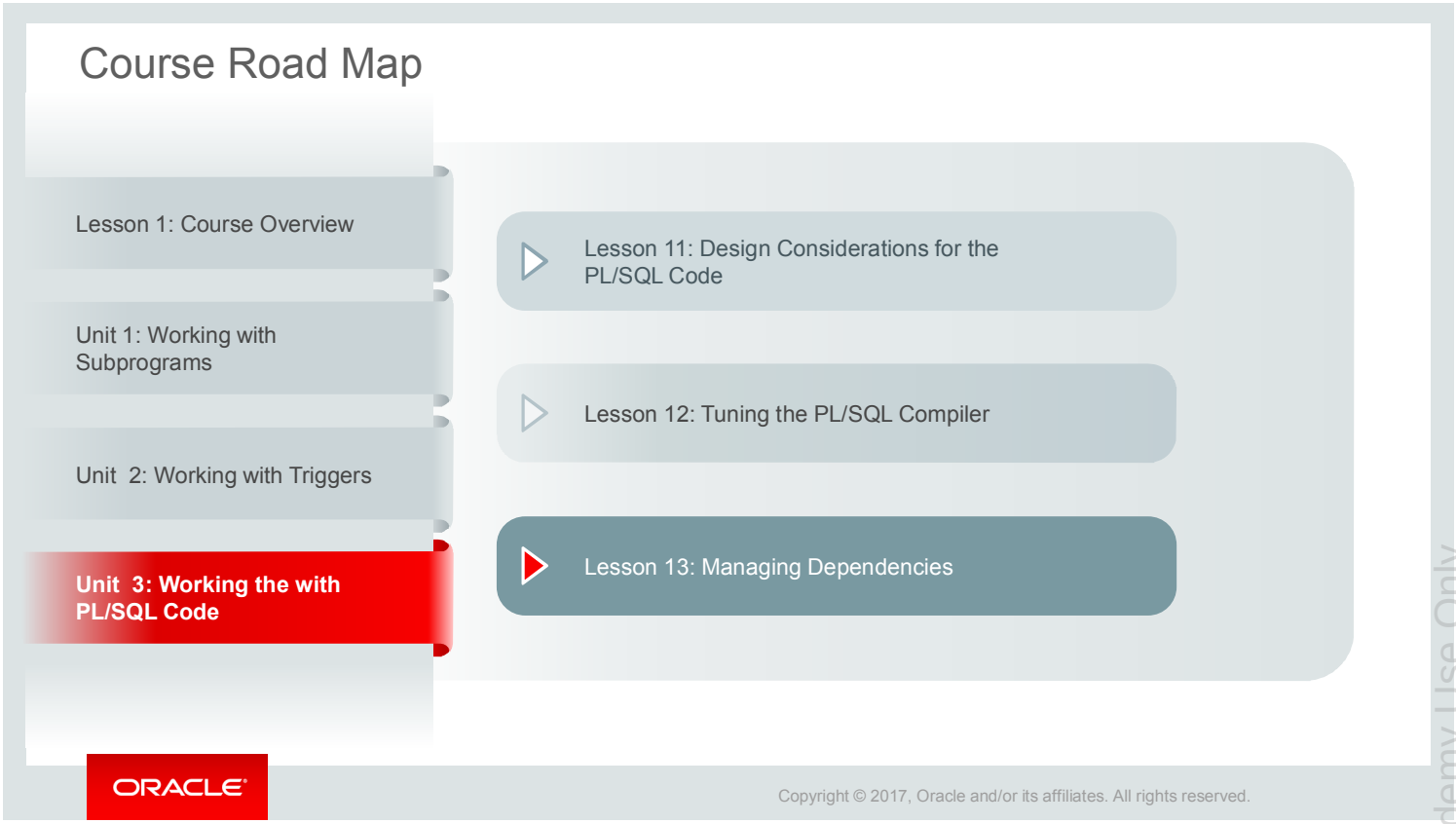
# Objectives

After completing this lesson, you should be able to:

- Track procedural dependencies
- Predict the effect of changing a database object on procedures and functions
- Manage procedural dependencies
- Manage local and remote dependencies



This lesson introduces you to object dependencies, and implicit and explicit recompilation of invalid objects.




In Unit 3, you will learn the design aspects of the PL/SQL code. You will also learn how to use PL/SQL compiler and how to manage dependencies among different objects in the database application.

# Lesson Agenda

- Schema object dependencies
- Direct and indirect dependencies
- Fine-grained dependency management
- Managing remote dependencies
- Revalidating PL/SQL program units
- Package dependency management

# What are Dependencies in a Schema?

- Dependency refers to a situation where one schema object depends on another object for its definition.

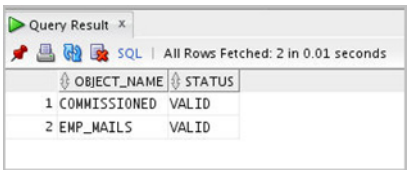
  Examples
  - There is a dependency between a view and the set of tables on which it is defined.
  - There is a dependency between the procedure and the tables on which the procedure is defined.

## How Dependencies Work?

Let us create the following views in the HR schema:

```
CREATE OR REPLACE VIEW commissioned AS SELECT first_name, last_name,
    commission_pct FROM employees WHERE commission_pct > 0.00;

CREATE OR REPLACE VIEW emp_mails AS SELECT first_name, last_name, email FROM
    employees;
```

```
SELECT object_name, status
FROM user_objects
WHERE object_type = 'VIEW'
ORDER BY object_name;
```






In the slide, we create two views – `commissioned` and `emp_mails` – on the table employees. Both the views are dependent on the schema object `employees` table.

There is a dependency between the table `employees`, and views `commissioned` and `emp_mails`. The views are dependent on the table employees.

The view `commissioned` uses columns `first_name`, `last_name`, and `commission_pct` columns of the `employees` table.

The view `emp_mails` uses columns `first_name`, `last_name`, and `email` columns of the `employees` table.

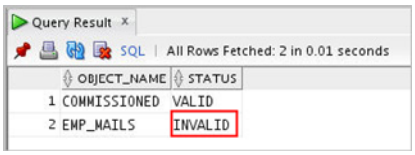
## How Dependencies Work?

Let us modify the email column of the employees table:

```
ALTER TABLE employees MODIFY email VARCHAR2(100);
```

And check the state of the views:

```
SELECT object_name, status
FROM user_objects
WHERE object_type = 'VIEW'
ORDER BY object_name;
```




You can see that after the email column in the employees table is modified, the status emp_mails view has become invalid.



When we modify the definition of the `email` column in the `employees` table, the view `emp_mails`, which uses the `email` column, has been invalidated because of the dependency between the view and the table.

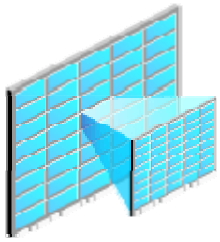
The view was defined on a different version of the `email` column, which has now changed. Therefore, the `emp_mails` view is invalidated.

## Dependent and Referenced Objects

Some types of schema objects can reference other objects in their definitions.

For example:

- A view is defined by a query that references tables.
  - View is a dependent object.
  - Tables are referenced objects.





Some types of schema objects can reference other objects in their definitions. For example, a view is defined by a query that references tables or other views, and the body of a subprogram can include SQL statements that reference other objects. If the definition of object A references object B, then A is a dependent object (with respect to B) and B is a referenced object (with respect to A).

**Dependency Issues**

- If you alter the definition of a referenced object, dependent objects may or may not continue to work properly. For example, if the table definition is changed, the procedure may or may not continue to work without error.
- The Oracle server automatically records dependencies among objects. To manage dependencies, all schema objects have a status (valid or invalid) that is recorded in the data dictionary and you can view the status in the `USER_OBJECTS` data dictionary view.
- If the status of a schema object is `VALID`, then the object has been compiled and can be immediately used when referenced.
- If the status of a schema object is `INVALID`, then the schema object must be compiled before it can be used.

The following table shows schema objects can be dependent, referenced, or both

| Object Type | Can Be Dependent or Referenced |
|---|---|
| Package body | Dependent only |
| Package specification | Both |
| Sequence | Referenced only |
| Subprogram | Both |
| Synonym | Both |
| Table | Both |
| Trigger | Both |
| User-defined object | Both |
| User-defined collection | Both |
| View | Both |

## Querying Object Dependencies: Using the USER_DEPENDENCIES View

```
desc user_dependencies;
```

Script Output

Task completed in 0.486 seconds

| Name | Null | Type |
|---|---|---|
| NAME | NOT NULL | VARCHAR2(128) |
| TYPE | | VARCHAR2(19) |
| REFERENCED_OWNER | | VARCHAR2(128) |
| REFERENCED_NAME | | VARCHAR2(128) |
| REFERENCED_TYPE | | VARCHAR2(19) |
| REFERENCED_LINK_NAME | | VARCHAR2(128) |
| SCHEMAID | | NUMBER |
| DEPENDENCY_TYPE | | VARCHAR2(4) |

```
SELECT name, type, referenced_name, referenced_type
FROM   user_dependencies
WHERE  referenced_name IN ('EMPLOYEES','EMP_VW' );
```

| | NAME | TYPE | REFERENCED_NAME | REFERENCED_TYPE |
|---|---|---|---|---|
| 1 | SECURE_EMPLOYEES | TRIGGER | EMPLOYEES | TABLE |
| 2 | DML_CALL_SQL | FUNCTION | EMPLOYEES | TABLE |
| 3 | GET_EMP | FUNCTION | EMPLOYEES | TABLE |
| 4 | SECURE_EMP | TRIGGER | EMPLOYEES | TABLE |
| 5 | EMPLOYEE_SAL | PROCEDURE | EMPLOYEES | TABLE |
| 6 | EMP_MAILS | VIEW | EMPLOYEES | TABLE |
| 7 | UPDATE_JOB_HISTORY | TRIGGER | EMPLOYEES | TABLE |
| 8 | RAISE_SAL | PROCEDURE | EMPLOYEES | TABLE |

. . .



You can determine dependencies in the schema from the USER_DEPENDENCIES data dictionary view.

The ALL_DEPENDENCIES and DBA_DEPENDENCIES views contain the additional OWNER column, which references the owner of the object.

**The USER_DEPENDENCIES Data Dictionary View Columns**

The columns of the USER_DEPENDENCIES data dictionary view are as follows:

- NAME: The name of the dependent object
- TYPE: The type of the dependent object (PROCEDURE, FUNCTION, PACKAGE, PACKAGE BODY, TRIGGER, or VIEW)
- REFERENCED_OWNER: The schema of the referenced object
- REFERENCED_NAME: The name of the referenced object
- REFERENCED_TYPE: The type of the referenced object
- REFERENCED_LINK_NAME: The database link used to access the referenced object
- SCHEMA_ID: Opaque schema identifier (16 bytes)
- DEPENDENCY_TYPE: Indicates whether the dependency is a REF dependency

## Querying an Object's Status

Every database object has one of the following status values:

| Status | Description |
|---|---|
| VALID | The object was successfully compiled by using the current definition in the data dictionary. |
| COMPILED WITH ERRORS | The most recent attempt to compile the object produced errors. |
| INVALID | The object is marked invalid because an object that it references has changed. (Only a dependent object can be invalid.) |
| UNAUTHORIZED | An access privilege on a referenced object was revoked. (Only a dependent object can be unauthorized.) |



Every database object has one of the status values shown in the table in the slide.

**Note:** The `USER_OBJECTS`, `ALL_OBJECTS`, and `DBA_OBJECTS` static data dictionary views do not distinguish between `Compiled with errors`, `Invalid`, and `Unauthorized`; instead, they describe all these as `INVALID`.

# Categorizing Dependencies

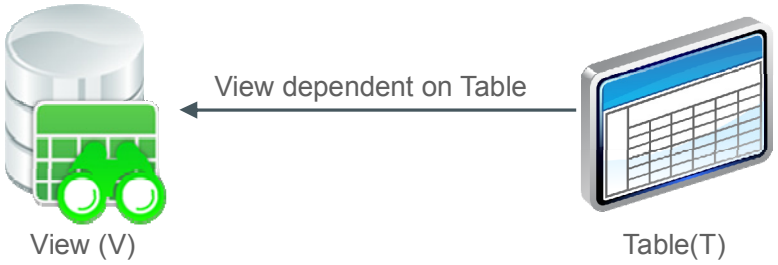
- Local dependencies – Both the referenced and dependent objects are on the same database. Oracle Database manages them implicitly. There are two types of dependencies in local dependencies using the internal tables.
  - Direct dependencies
  - Indirect dependencies
- Remote dependencies – The referenced and dependent objects are on different nodes across the network. Oracle Database uses different mechanisms to manage remote dependencies, depending on the objects involved.

# Lesson Agenda

- Schema object dependencies
- Direct and indirect dependencies
- Fine-grained dependency management
- Managing remote dependencies
- Revalidating PL/SQL program units
- Package dependency management

## Direct Dependencies

- When a view V is defined on a table T, there is a direct dependency of the view V on the table T.
- Direct dependents are invalidated only by changes to the referenced objects that affect them.

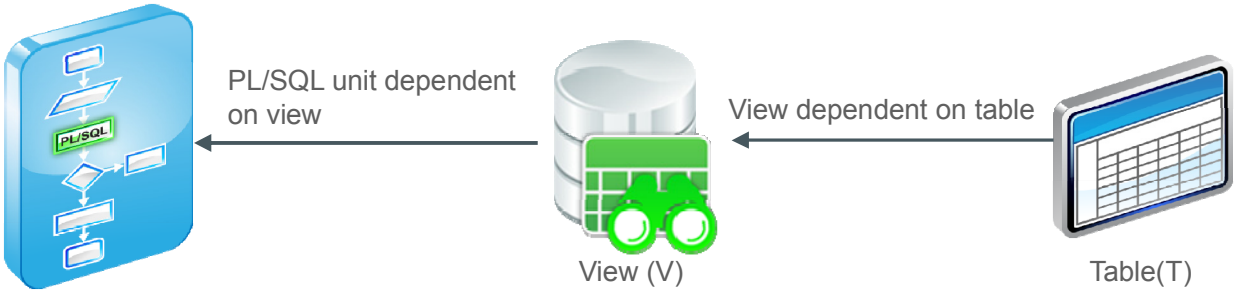





The slide shows a direct dependency between the table and the view defined on that table. A modification to the table structure might invalidate the view, as we have seen in the case of view earlier.

## Indirect Dependencies

- Consider a PL/SQL program unit dependent on the view V, which in turn is dependent on the table T. The PL/SQL program unit is indirectly dependent on the table T.
- Indirect dependents can be invalidated by changes to the referenced object that do not affect them.
- The PL/SQL unit may be invalidated if there is a modification to the table.






The slide shows an indirect dependency between the PL/SQL unit and the table. So, the PL/SQL unit is an indirect dependent on the table.

Indirect dependents can be invalidated by changes to the reference object that do not affect them. A modification to the table may invalidate the PL/SQL unit. This is called cascading invalidation.

## Displaying Direct and Indirect Dependencies

- Run the `utldtree.sql` script that creates the objects that enable you to display the direct and indirect dependencies.

```
@/home/oracle/labs/plpu/labs/utldtree.sql
```

- This script creates four objects, as given below:
  - A table `deptree_temptab` to hold dependency data
  - A procedure `deptree_fill` to populate the table
  - Two views – `deptree` and `ideptree` – to select and format dependency data from the populated table



### Displaying Direct and Indirect Dependencies by Using Views Provided by Oracle

You can display direct and indirect dependencies from additional user views, called `DEPTREE` and `IDEPTREE`; these views are provided by Oracle.

**Example**

1. Make sure that the `utldtree.sql` script has been executed. This script is located in the `$ORACLE_HOME/labs/plpu/labs` folder. You can run the script as follows:

   ```
   @?/labs/plpu/labs/utldtree.sql
   ```

   **Note:** In this class, this script is supplied in the `labs` folder of your class files. The code example above uses the student account `ORA61`. (This applies to a Linux environment. If the file is not found, locate the file in your labs subdirectory.)

2. Populate the `DEPTREE_TEMPTAB` table with information for a particular referenced object by invoking the `DEPTREE_FILL` procedure. There are three parameters for this procedure:

   | | |
   |---|---|
   | *`object_type`* | Type of the referenced object |
   | *`object_owner`* | Schema of the referenced object |
   | *`object_name`* | Name of the referenced object |

## Displaying Direct and Indirect Dependencies

- Execute the DEPTREE_FILL procedure.

```
EXECUTE deptree_fill('TABLE', 'ORA61', 'EMPLOYEES')
```

- Display the dependencies

```
SELECT   nested_level, type, name
FROM     deptree
ORDER BY seq#;
```

Script Output | Query Result | SQL | All Rows Fetched: 23 in 0.409 seconds

| | NESTED_LEVEL | TYPE | NAME |
|---|---|---|---|
| 1 | 0 | TABLE | EMPLOYEES |
| 2 | 1 | TRIGGER | SECURE_EMPLOYEES |
| 3 | 1 | TRIGGER | UPDATE_JOB_HISTORY |
| 4 | 1 | PROCEDURE | RAISE_SAL |
| 5 | 1 | PROCEDURE | DISPLAY_NEW_SAL |
| 6 | 1 | FUNCTION | GET_SAL |
| 7 | 1 | FUNCTION | TAX |
| 8 | 1 | FUNCTION | EMP_TAX |

. . .



You can display a tabular representation of all dependent objects by querying the DEPTREE view. You can display an indented representation of the same information by querying the IDEPTREE view, which consists of a single column named DEPENDENCIES as follows:

```
SELECT *
FROM   ideptree;
```

| | DEPENDENCIES |
|---|---|
| 1 | PROCEDURE ORA61.RAISE_SAL |
| 2 | FUNCTION ORA61.DML_CALL_SQL |
| 3 | PROCEDURE ORA61.SAL_STATUS |
| 4 | PROCEDURE ORA61.RAISE_SALARY |
| 5 | VIEW ORA61.COMMISSIONED |
| 6 | FUNCTION ORA61.TAX |
| 7 | FUNCTION ORA61.EMP_TAX |
| 8 | VIEW ORA61.EMP_MAILS |

. . .

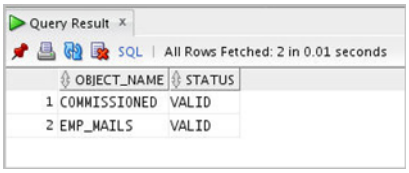
# Lesson Agenda

- Schema object dependencies
- Direct and indirect dependencies
- Fine-grained dependency management
- Managing remote dependencies
- Revalidating PL/SQL program units
- Package dependency management

## Fine-Grained Dependency Management

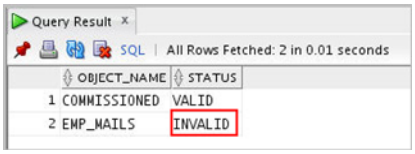
```
CREATE OR REPLACE VIEW commissioned AS SELECT first_name, last_name,
    commission_pct FROM employees WHERE commission_pct > 0.00;
CREATE OR REPLACE VIEW emp_mails AS SELECT first_name, last_name, email FROM
    employees;
```

```
SELECT object_name, status
FROM user_objects
WHERE object_type = 'VIEW'
ORDER BY object_name;
```




```
ALTER TABLE employees MODIFY email VARCHAR2(100);
```

```
SELECT object_name, status
FROM user_objects
WHERE object_type = 'VIEW'
ORDER BY object_name;
```






Let us reconsider the scenario that we discussed earlier. We created two views, `commissioned` and `emp_mails`, on the employees table.

The `commissioned` view has the `first_name`, `last_name`, and `commission_pct` columns of the `employees` table.

The `emp_mails` view has the `first_name`, `last_name`, and `email` columns of the `employees` table.

When we altered the definition of the `email` column of the `employees` table, only the `emp_mails` view is invalidated. The commissioned view is still valid.

This process of invalidating specific objects based on their definition is fine-grained dependency management. Whenever a referenced object is modified, only those dependent objects are invalidated that are effected by the modification, and not all the dependent objects.

# Fine-Grained Dependency Management

- Starting with Oracle Database 11*g*, dependencies are now tracked at the level of element within unit.
- Element-based dependency tracking covers the following:
  - Dependency of a single-table view on its base table
  - Dependency of a PL/SQL program unit (package specification, package body, or subprogram) on the following:
    - Other PL/SQL program units
    - Tables
    - Views

## Fine-Grained Dependency Management: Example 1

```
CREATE TABLE t2 (col_a NUMBER, col_b NUMBER, col_c NUMBER);
CREATE VIEW v AS SELECT col_a, col_b FROM t2;
```

```
SELECT ud.name, ud.type, ud.referenced_name,
       ud.referenced_type, uo.status
FROM user_dependencies ud, user_objects uo
WHERE ud.name = uo.object_name AND ud.name = 'V';
```

Results:

| | NAME | TYPE | REFERENCED_NAME | REFERENCED_TYPE | STATUS |
|---|---|---|---|---|---|
| 1 | V | VIEW | T2 | TABLE | VALID |

```
ALTER TABLE t2 ADD (col_d VARCHAR2(20));
```

```
SELECT ud.name, ud.type, ud.referenced_name,
       ud.referenced_type, uo.status
FROM user_dependencies ud, user_objects uo
WHERE ud.name = uo.object_name AND ud.name = 'V';
```

Results:

| | NAME | TYPE | REFERENCED_NAME | REFERENCED_TYPE | STATUS |
|---|---|---|---|---|---|
| 1 | V | VIEW | T2 | TABLE | VALID |

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### Example of Dependency of a Single-Table View on Its Base Table

In the first example in the slide, table `T2` is created with three columns: `COL_A`, `COL_B`, and `COL_C`. A view named `V` is created based on columns `COL_A` and `COL_B` of table `T2`. The dictionary views are queried and view `V` is dependent on table `T` and its status is valid.

In the third example, table `T2` is altered. A new column named `COL_D` is added. The dictionary views still report that view `V` is dependent because element-based dependency tracking grasps that columns `COL_A` and `COL_B` are not modified and, therefore, the view does not need to be invalidated.

# Fine-Grained Dependency Management: Example 1

```
ALTER TABLE t2 MODIFY (col_a VARCHAR2(20));
SELECT ud.name, ud.referenced_name, ud.referenced_type, uo.status
FROM user_dependencies ud, user_objects uo
WHERE ud.name = uo.object_name AND ud.name = 'V';
```

Results:

| | NAME | REFERENCED_NAME | REFERENCED_TYPE | STATUS |
|---|---|---|---|---|
| 1 | V | T2 | TABLE | INVALID |



In the example in the slide, the view is invalidated because its element (`COL_A`) is modified in the table on which the view is dependent.

## Fine-Grained Dependency Management: Example 2

```
CREATE OR REPLACE PACKAGE pkg IS
  PROCEDURE proc_1;
END pkg;
/
CREATE OR REPLACE PROCEDURE p IS
BEGIN
  pkg.proc_1();
END p;
/
CREATE OR REPLACE PACKAGE pkg
IS
  PROCEDURE proc_1;
  PROCEDURE unheard_of;
END pkg;
/
```

```
PACKAGE PKG compiled
PROCEDURE P compiled
PACKAGE PKG compiled
```



In the example in the slide, you create a package named `PKG` that has procedure `PROC_1` declared.

A procedure named `P` invokes `PKG.PROC_1`.

The definition of the `PKG` package is modified and another subroutine is added to the package declaration.

When you query the `USER_OBJECTS` dictionary view for the status of the `P` procedure, it is still valid as shown because the element you added to the definition of `PKG` is not referenced through procedure `P`.

```
SELECT status FROM user_objects
WHERE object_name = 'P';
```

Results:

| | STATUS |
|---|---|
| 1 | VALID |

## Guidelines for Reducing Invalidation

To reduce invalidation of dependent objects:

- Add new items to the end of the package
- Reference each table through a view





### Add New Items to the End of the Package

When adding new items to a package, add them to the end of the package. This preserves the slot numbers and entry-point numbers of existing top-level package items, thereby preventing their invalidation. For example, consider the following package:

```
CREATE OR REPLACE PACKAGE pkg1 IS
FUNCTION get_var RETURN VARCHAR2;
PROCEDURE set_var (v VARCHAR2);
END;
```

Adding an item to the end of `pkg1` does not invalidate dependents that reference `get_var`. Inserting an item between the `get_var` function and the `set_var` procedure invalidates dependents that reference the `set_var` function.

### Reference Each Table Through a View

Reference tables indirectly by using views. This allows you to do the following:

- Add columns to the table without invalidating dependent views or dependent PL/SQL objects
- Modify or delete columns not referenced by the view without invalidating dependent objects

## Object Revalidation

- An object that is not valid when it is referenced must be validated before it can be used.
- Validation occurs automatically when an object is referenced; it does not require explicit user action.
- Revalidation may not happen automatically if:
  - The object is compiled with errors
  - The object is an unauthorized object
  - The object is an invalid object



The compiler cannot automatically revalidate an object that compiled with errors. The compiler recompiles the object, and if it recompiles without errors, it is revalidated; otherwise, it remains invalid.

The compiler checks whether the unauthorized object has access privileges to all of its referenced objects. If so, the compiler revalidates the unauthorized object without recompiling it. If not, the compiler issues appropriate error messages.

The SQL compiler recompiles the invalid object. If the object recompiles without errors, it is revalidated; otherwise, it remains invalid.

For an invalid PL/SQL program unit (procedure, function, or package), the PL/SQL compiler checks whether any referenced object is an invalid object.

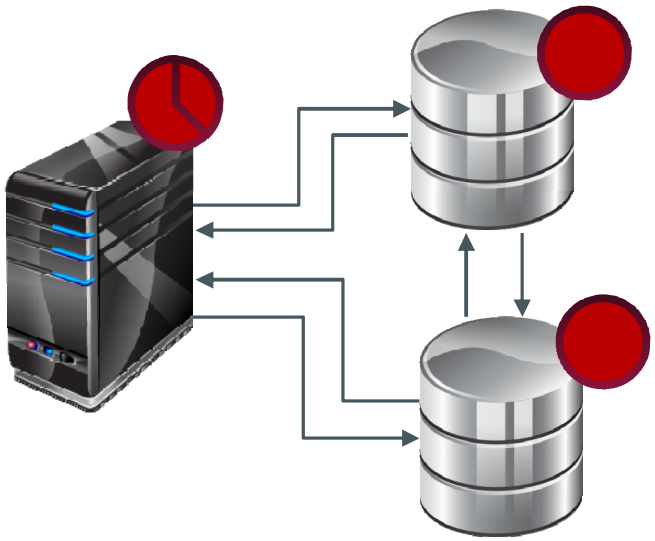
- If so, the compiler recompiles the invalid object. If the object recompiles without errors, it is revalidated; otherwise, it remains invalid.
- If not, the compiler revalidates the invalid object without recompiling it. Fast revalidation is usually performed on objects that were invalidated due to cascading invalidation.

# Lesson Agenda

- Schema object dependencies
- Direct and indirect dependencies
- Fine-grained dependency management
- Managing remote dependencies
- Revalidating PL/SQL program units
- Package dependency management

## Remote Dependencies

- The referenced and dependent objects are on different nodes across the network.
- Oracle Database does not manage dependencies among remote schema objects other than local-procedure-to-remote-procedure dependencies.





In the case of remote dependencies, the objects are on separate nodes. The local stored procedure and all its dependent objects are invalidated, but are automatically recompile when called for the first time. Oracle Database does not manage dependencies among remote schema objects other than local-procedure-to-remote-procedure dependencies.

For example, assume that a local view is created and defined by a query that references a remote table. Also assume that a local procedure includes a SQL statement that references the same remote table. Later, the definition of the table is altered.

As a result, the local view and procedure are never invalidated, even if the view or procedure is used after the table is altered and even if the view or procedure now returns errors when used. In this case, the view or procedure must be altered manually so that errors are not returned. In such cases, lack of dependency management is preferable to unnecessary recompilations of dependent objects.

**Recompilation of Dependent Objects: Local and Remote**

- Verify successful explicit recompilation of the dependent remote procedures and implicit recompilation of the dependent local procedures by checking the status of these procedures within the `USER_OBJECTS` view.
- If an automatic implicit recompilation of the dependent local procedures fails, the status remains invalid and the Oracle server issues a runtime error. Therefore, to avoid disrupting production, it is strongly recommended that you recompile local dependent objects manually, rather than rely on an automatic mechanism.

## Managing Remote Procedure Dependencies

Mechanisms used for managing remote procedure dependencies are:

- Timestamp checking

- Signature checking




### `TIMESTAMP` Checking

Each PL/SQL program unit carries a time stamp that is set when it is created or recompiled. Whenever you alter a PL/SQL program unit or a relevant schema object, all its dependent program units are marked as invalid and must be recompiled before they can execute. The actual time stamp comparison occurs when a statement in the body of a local procedure calls a remote procedure.

### `SIGNATURE` Checking

For each PL/SQL program unit, both the time stamp and the signature are recorded. The signature of a PL/SQL construct contains information about the following:

- The name of the construct (procedure, function, or package)
- The base types of the parameters of the construct
- The modes of the parameters (`IN`, `OUT`, or `IN OUT`)
- The number of the parameters

The recorded time stamp in the calling program unit is compared with the current time stamp in the called remote program unit. If the time stamps match, the call proceeds. If they do not match, the remote procedure call layer performs a simple comparison of the signature to determine whether the call is safe or not. If the signature has not been changed in an incompatible manner, execution continues; otherwise, an error is returned.

# Setting the REMOTE_DEPENDENCIES_MODE Parameter

- You can define whether a remote procedure call should undergo Timestamp checking or Signature checking by setting the REMOTE_DEPENDENCIES_MODE parameter.
  - At the system level:
    `ALTER SYSTEM SET REMOTE_DEPENDENCIES_MODE = TIMESTAMP | SIGNATURE`
  - At the session level:
    `ALTER SESSION SET REMOTE_DEPENDENCIES_MODE = TIMESTAMP | SIGNATURE`
  - As an `init.ora` parameter:
    `REMOTE_DEPENDENCIES_MODE = TIMESTAMP | SIGNATURE`
- If the `REMOTE_DEPENDENCIES_MODE` parameter is not specified, either in the `init.ora` parameter file or by using the `ALTER SESSION` or `ALTER SYSTEM` DDL statements, `TIMESTAMP` is the default value.

## Timestamp Checking


Remote procedure B:
compiles and is `VALID`
at 8:00 AM



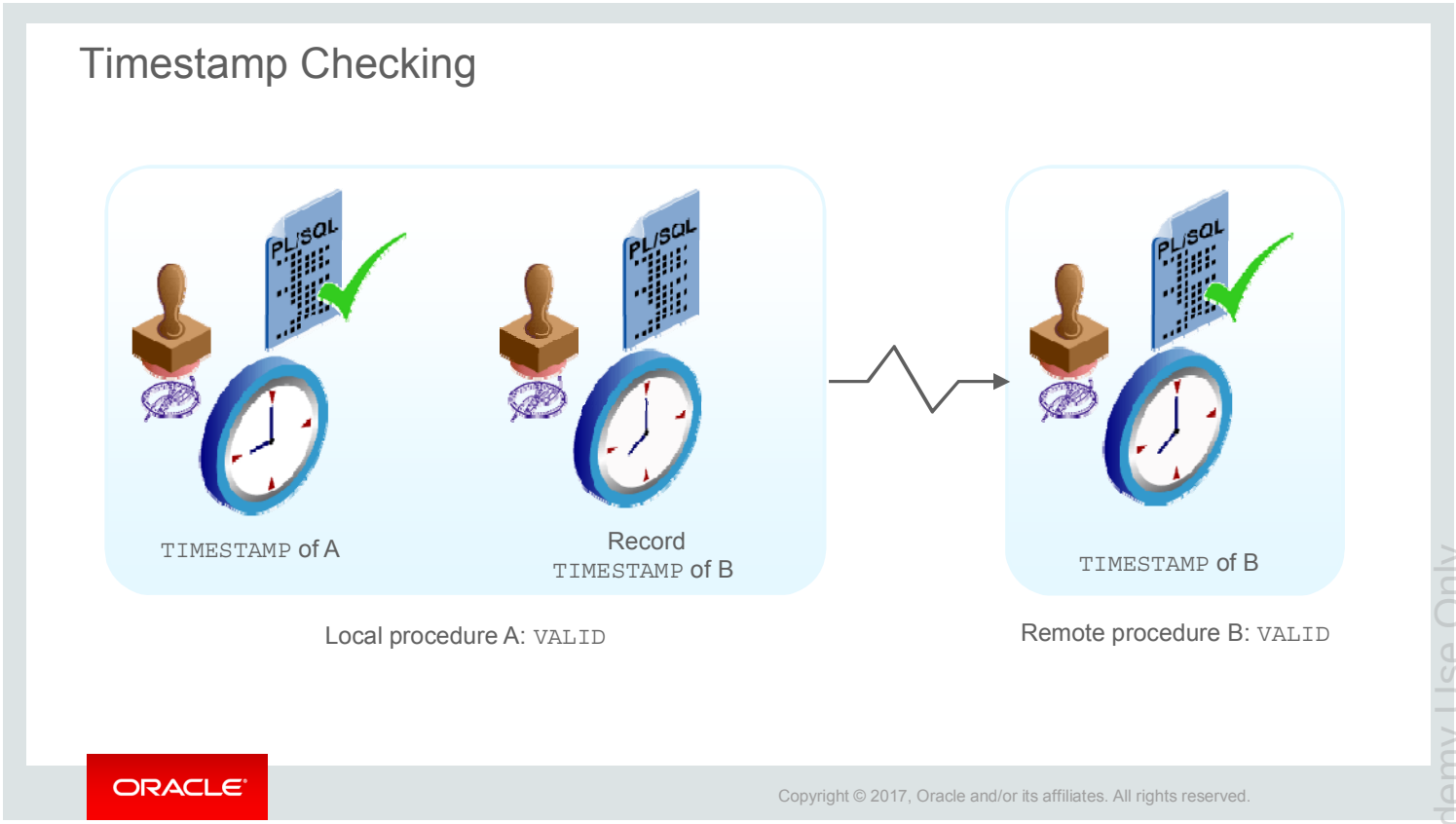
### Local Procedures Referencing Remote Procedures

A local procedure that references a remote procedure is invalidated by the Oracle server if the remote procedure is recompiled after the local procedure is compiled.

#### Automatic Remote Dependency Mechanism

When a procedure compiles, the Oracle server records the time stamp of that compilation within the `P` code of the procedure.

In the slide, when the remote procedure B is successfully compiled at 8:00 AM, this time is recorded as its time stamp.



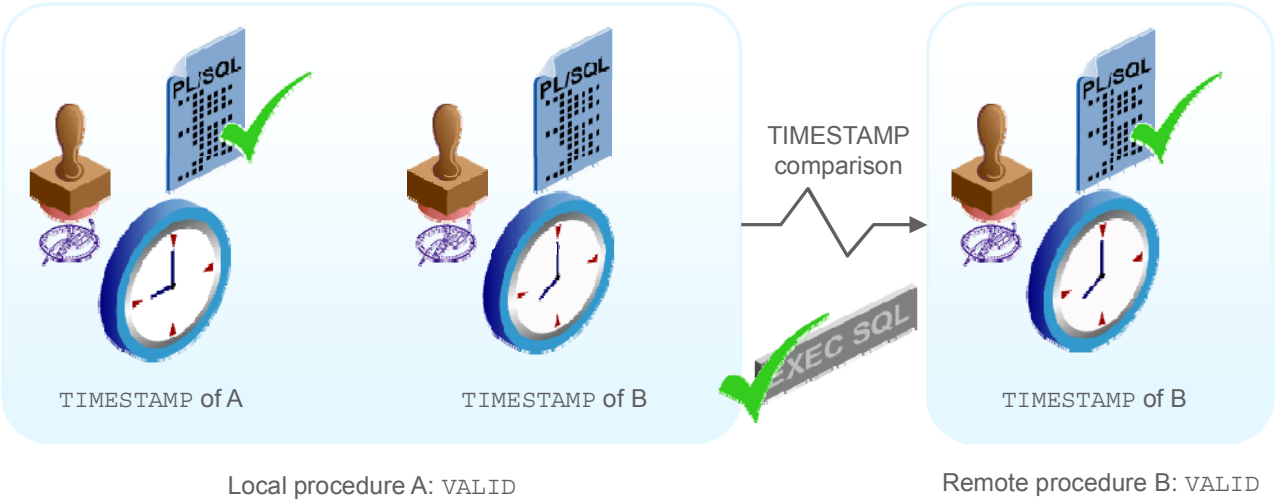

## Local Procedures Referencing Remote Procedures

### Automatic Remote Dependency Mechanism

When a local procedure referencing a remote procedure compiles, the Oracle server also records the time stamp of the remote procedure in the P code of the local procedure.

In the slide, local procedure A (which is dependent on remote procedure B) is compiled at 9:00 AM. The time stamps of both procedure A and remote procedure B are recorded in the P code of procedure A.

## Timestamp Checking






### Automatic Remote Dependency

When the local procedure is invoked at run time, the Oracle server compares the two time stamps of the referenced remote procedure.

If the time stamps are equal (indicating that the remote procedure has not recompiled), then the Oracle server executes the local procedure.

In the example in the slide, the time stamp recorded with the `P` code of remote procedure B is the same as that recorded with local procedure A. Therefore, local procedure A is valid.

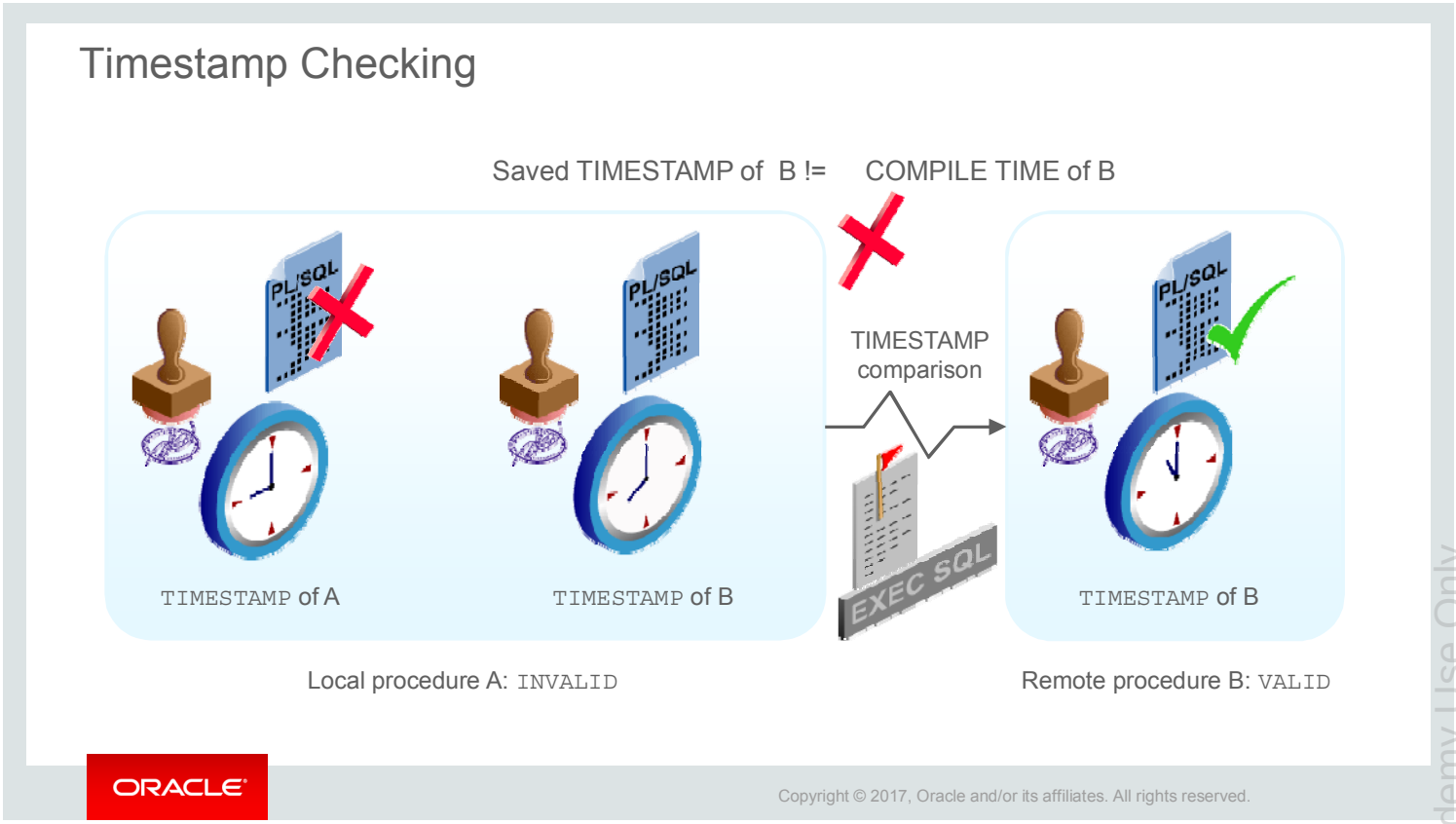
## Timestamp Checking


Remote procedure B:
Recompiles and is `VALID`
at 11:00 AM



### Local Procedures Referencing Remote Procedures

Assume that remote procedure B is successfully recompiled at 11:00 AM. The new time stamp is recorded along with its `P` code.




## Automatic Remote Dependency

If the time stamps are not equal (indicating that the remote procedure has recompiled), then the Oracle server invalidates the local procedure and returns a runtime error. If the local procedure (which is now tagged as invalid) is invoked a second time, then the Oracle server recompiles it before executing, in accordance with the automatic local dependency mechanism.

**Note:** If a local procedure returns a runtime error the first time it is invoked (indicating that the remote procedure's time stamp has changed), then you should develop a strategy to reinvoke the local procedure.

In the example in the slide, the remote procedure is recompiled at 11:00 AM and this time is recorded as its time stamp in the `P` code. The `P` code of local procedure A still has 8:00 AM as the time stamp for remote procedure B. Because the time stamp recorded with the `P` code of local procedure A is different from that recorded with the remote procedure B, the local procedure is marked invalid. When the local procedure is invoked for the second time, it can be successfully compiled and marked valid.

A disadvantage of the time stamp mode is that it is unnecessarily restrictive. Recompilation of dependent objects across the network is often performed when not strictly necessary, leading to performance degradation.

## Signature Checking

- The signature of a procedure is:
  - The name of the procedure
  - The data types of the parameters
  - The modes of the parameters
- The signature of the remote procedure is saved in the local procedure.
- When executing a dependent procedure, the signature of the referenced remote procedure is compared.



To alleviate some of the problems with the time stamp-only dependency model, you can use the signature model. This allows the remote procedure to be recompiled without affecting the local procedures. This is important if the database is distributed.

The signature of a subprogram contains the following information:

- The name of the subprogram
- The data types of the parameters
- The modes of the parameters
- The number of parameters
- The data type of the return value for a function

If a remote program is changed and recompiled but the signature does not change, then the local procedure can execute the remote procedure. With the time stamp method, an error would have been raised because the time stamps would not have matched.

# Lesson Agenda

- Schema object dependencies
- Direct and indirect dependencies
- Fine-grained dependency management
- Managing remote dependencies
- Revalidating PL/SQL program units
- Package dependency management

## Revalidating PL/SQL Program Units

You revalidate a PL/SQL program unit by recompiling it. There are two ways of recompiling:

- Implicit runtime recompilation
  - Local dependencies are resolved implicitly
- Explicit recompilation with the `ALTER` statement
  - Here is the syntax for using the `ALTER` statement.

```
ALTER PROCEDURE|FUNCTION | TRIGGER|PACKAGE
    [SCHEMA.]object_name COMPILE;
```



### Recompiling PL/SQL Objects

If the recompilation is successful, the object becomes valid. If not, the Oracle server returns an error and the object remains invalid. When you recompile a PL/SQL object, the Oracle server first recompiles any invalid object on which it depends. This is implicit recompilation or revalidation of the objects. Local dependencies are generally resolved implicitly.

You explicitly resolve dependencies by using the ALTER statement. You may have to explicitly recompile the PL/SQL program units if the implicit recompilation is unsuccessful. You have to resolve such dependencies by using the ALTER statement.

## Unsuccessful Recompilation

Recompiling-dependent procedures and functions are unsuccessful when:

- The referenced objects are compiled with errors
- The referenced objects are 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



Sometimes, a recompilation of dependent procedures is unsuccessful (for example, when a referenced table is dropped or renamed).

The success of any recompilation is based on the exact dependency. If a referenced view is recreated, any object that is dependent on the view needs to be recompiled. The success of the recompilation depends on the columns that the view now contains, as well as the columns that the dependent objects require for their execution. If the required columns are not part of the new view, then the object remains invalid.

## Successful Recompilation

Recompiling-dependent procedures and functions are successful if:

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



The recompilation of dependent objects is successful if:

- New columns are added to a referenced table
- All `INSERT` statements include a column list
- No new column is defined as `NOT NULL`

When a private table is referenced by a dependent procedure and the private table is dropped, the status of the dependent procedure would become invalid. When the procedure is recompiled (either explicitly or implicitly) and a public table exists, the procedure can recompile successfully but is now dependent on the public table. The recompilation is successful only if the public table contains the columns that the procedure requires; otherwise, the status of the procedure remains invalid.

## Recompiling Procedures

Minimize dependency failures by:

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

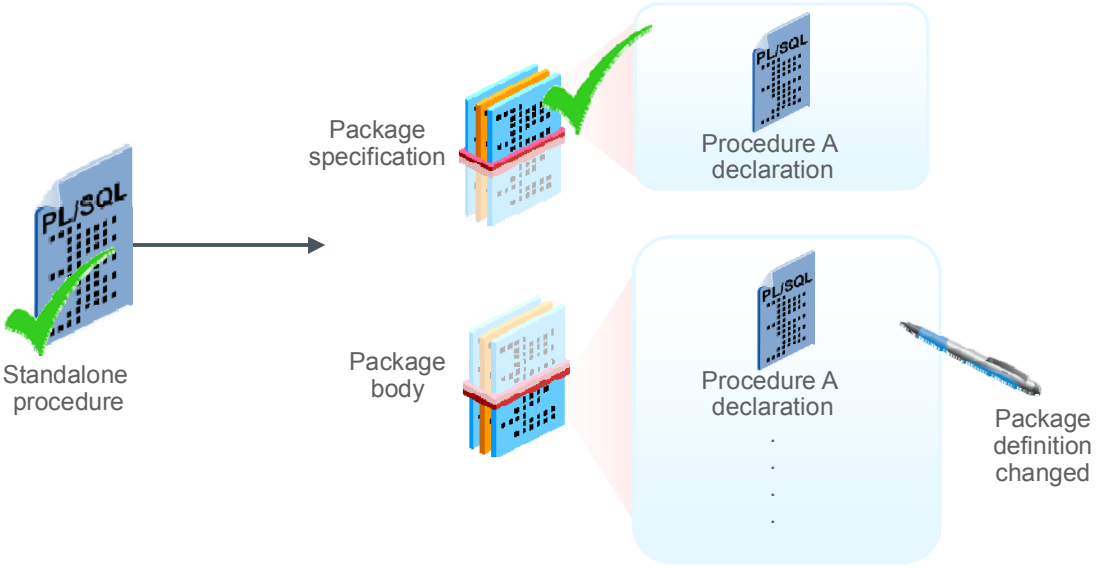


You can minimize recompilation failure by following the guidelines that are shown in the slide.

# Lesson Agenda

- Schema object dependencies
- Direct and indirect dependencies
- Fine-grained dependency management
- Managing remote dependencies
- Revalidating PL/SQL program units
- Package dependency management

## Packages and Dependencies: Subprogram References the Package

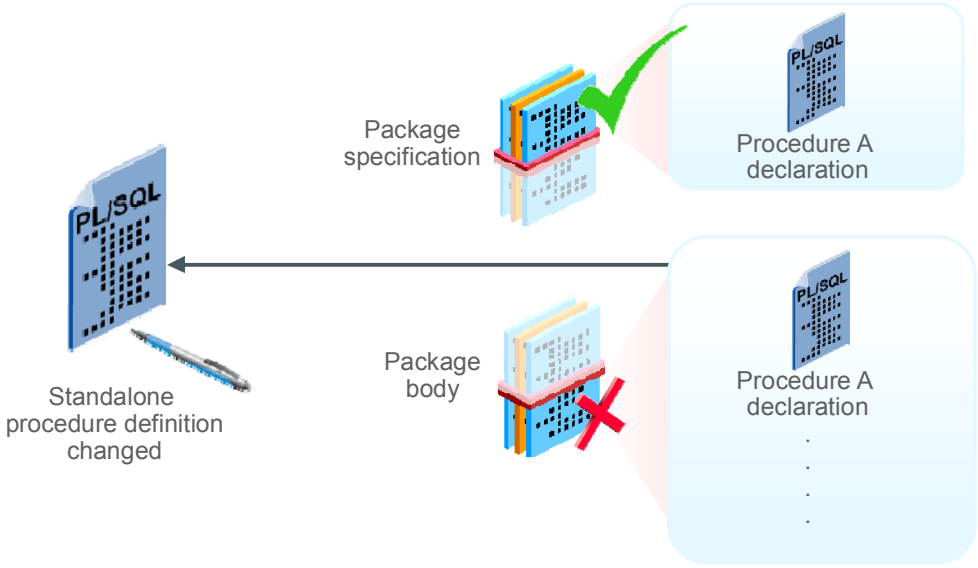





You can simplify dependency management with packages when referencing a package procedure or function from a standalone procedure or function.

- If the package body changes and the package specification does not change, then the standalone procedure that references a package construct remains valid.
- If the package specification changes, then the outside procedure referencing a package construct is invalidated.

## Packages and Dependencies: Package Subprogram References Procedure






If a standalone procedure that is referenced within the package changes, then the entire package body is invalidated, but the package specification remains valid. Therefore, it is recommended that all the procedures referenced by the procedures in a package body should be in the package body.

## Quiz

You can display direct and indirect dependencies by running the `utldtree.sql` script, populating the `DEPTREE_TEMPTAB` table with information for a particular referenced object, and querying the `DEPTREE` or `IDEPTREE` views.

a. True
b. False



**Answer: a**

### Displaying Direct and Indirect Dependencies

You can display direct and indirect dependencies as follows:

1. Run the `utldtree.sql` script, which creates the objects that enable you to display the direct and indirect dependencies.
2. Populate the `DEPTREE_TEMPTAB` table with information for a particular referenced object by executing the `DEPTREE_FILL` procedure.
3. Query the `DEPTREE` or `IDEPTREE` views.

## Summary

In this lesson, you should have learned how to:

- Track procedural dependencies
- Predict the effect of changing a database object on procedures and functions
- Manage procedural dependencies
- Manage local and remote dependencies

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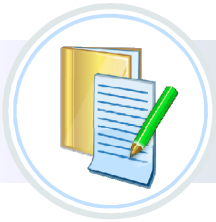
Avoid disrupting production by keeping a track of dependent procedures and recompiling them manually as soon as possible after the definition of a database object changes.

## Practice 13 Overview: Managing Dependencies in Your Schema

This practice covers the following topics:

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





In this practice, you use the `DEPTREE_FILL` procedure and the `IDEPTREE` view to investigate dependencies in your schema. In addition, you recompile invalid procedures, functions, packages, and views.

14

# Oracle Cloud Overview

# Lesson Objectives

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

- Describe the salient features of Oracle Cloud
- Discuss the features of Oracle Database Exadata Express Cloud Service

# Lesson Agenda

- Overview of Oracle Cloud
- Working with Oracle Database Exadata Express Cloud Service

## Introduction to Oracle Cloud

- Any business can now use the enterprise cloud provided by Oracle.
- You can access the Oracle Cloud from cloud.oracle.com.




The Oracle Cloud is an enterprise cloud for business. Oracle Cloud services are built on Oracle Exalogic Elastic Cloud and Oracle Exadata Database Machine, together offering a platform that delivers extreme performance and scalability.

The top two benefits of cloud computing are speed and cost.

As a result, the applications and databases deployed in the Oracle Cloud are portable and you can easily move them to or from a private cloud or on-premise environment.

- You can request and get the cloud services provisioned through a self-service interface.
- You can either use an integrated development and deployment platform to rapidly extend and create new services.

Using Oracle Cloud services, you can benefit from the following five essential characteristics:

- **On-demand self-service:** You can provision, monitor, and manage cloud on your own.
- **Resource pooling:** You can share resources and maintain a level of abstraction between consumers and services.
- **Rapid elasticity:** You can quickly scale up or down as needed.
- **Measured service:** You pay for what you use with either internal chargeback (private cloud) or external billing (public cloud).
- **Broad network access:** You can access the cloud services through a browser on any networked device.

## Oracle Cloud Services

Oracle Cloud provides three types of services:

- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)



**SaaS** generally refers to applications that are delivered to end users over the Internet. Oracle CRM On Demand is an example of a SaaS offering that provides both multitenant as well as single-tenant options, depending on the customer's preferences.

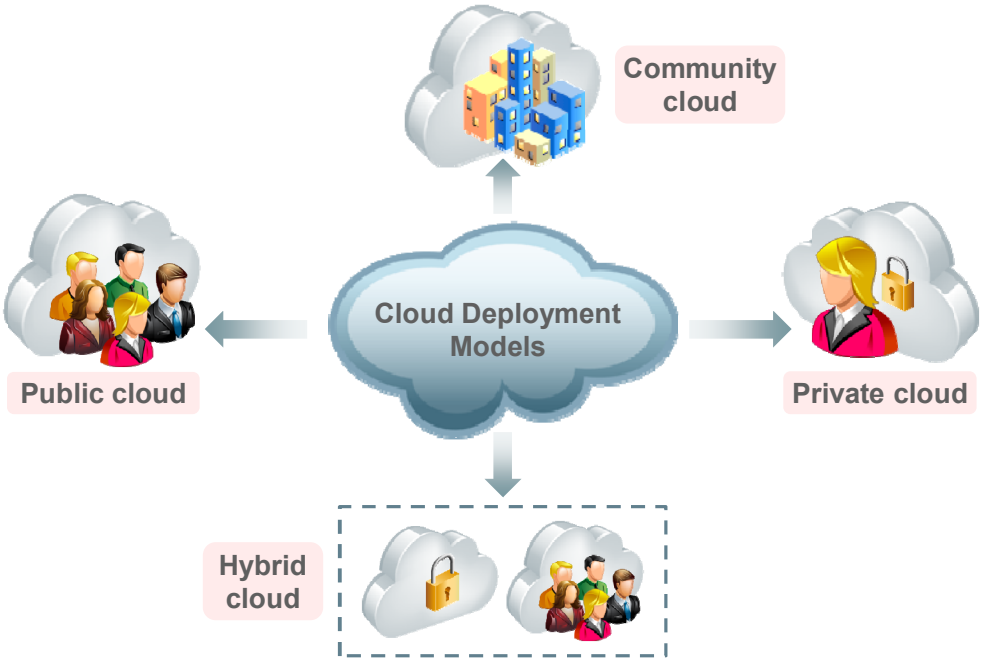
**PaaS** generally refers to an application development and deployment platform that is delivered as a service to developers, enabling them to quickly build and deploy a SaaS application to end users. The platform typically includes databases, middleware, and development tools, all delivered as a service via the Internet.

**IaaS** refers to computing hardware (servers, storage, and network) delivered as a service. This service typically includes the associated software as well as operating systems, virtualization, clustering, and so on. Examples of IaaS in the public cloud include Amazon's Elastic Compute Cloud (EC2) and Simple Storage Service (S3).

The Oracle Cloud Database is built as a PaaS model. It provides on-demand access to database services in a self-service, scalable, and metered manner. You can deploy a database within a virtual machine in an IaaS platform.

You can rapidly deploy Oracle Cloud Database on Oracle Exadata, which is a pre-integrated and optimized hardware platform that supports both online transaction processing (OLTP) and Data Warehouse workloads.

## Cloud Deployment Models






- **Private cloud:** A single organization uses a private cloud, which it typically controls, manages, and hosts in private data centers. However, the organization can also outsource hosting and operation to a third-party service provider. Amazon's Virtual Private Cloud is an example of a private cloud in an external provider setting.
- **Public cloud:** Multiple organizations (tenants) use a private cloud on a shared basis. This private cloud is hosted and managed by a third-party service provider. For example: Amazon's Elastic Compute Cloud (EC2), IBM's Blue Cloud, Sun Cloud, and Google AppEngine
- **Community cloud:** A group of related organizations, who want to make use of a common cloud computing environment, uses the community cloud. It is managed by the participating organizations or by a third-party managed service provider. It is hosted internally or externally. For example, a community might consist of the different branches of the military, all the universities in a given region, or all the suppliers to a large manufacturer.
- **Hybrid cloud:** A single organization that wants to adopt both private and public clouds for a single application uses the hybrid cloud. A third model, the hybrid cloud, is maintained by both internal and external providers. For example, an organization might use a public cloud service, such as Amazon Simple Storage Service (Amazon S3), for archived data but continue to maintain in-house (private cloud) storage for operational customer data.

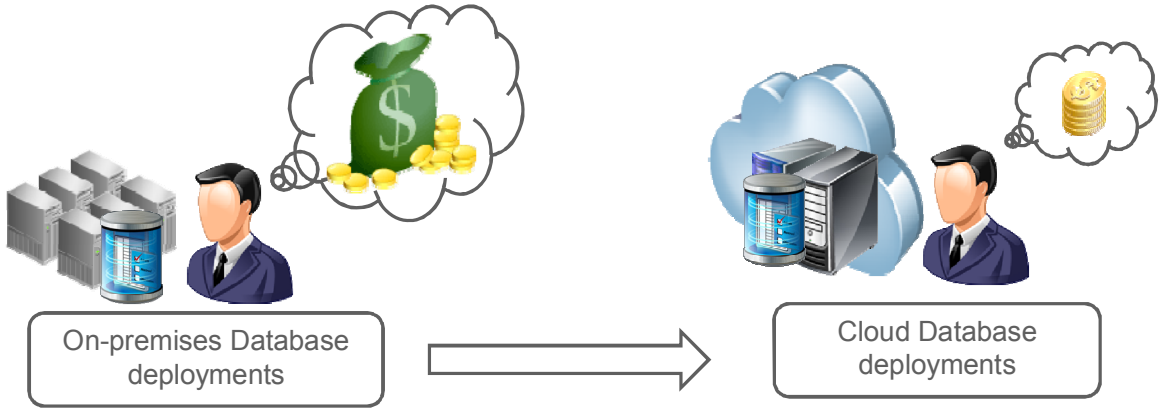
## Lesson Agenda

- Overview of Oracle Cloud
- Working with Oracle Database Exadata Express Cloud Service



In this topic, you gain an introduction to Oracle Exadata Express Cloud Service and its features. You will take a tour of its service console and also learn about the different database clients such as Oracle SQL Developer, SQL CL, SQL Workshop and SQL * Plus that can be used to connect to Oracle Exadata Express Cloud Service.

## Evolving from On-premises to Exadata Express






Cloud deployments provide end users and enterprises with different capabilities to store and process data. They enable users to have high performance and huge computing resources at a lower price as compared to traditional on-premises deployments.

Exadata Express is a powerful database machine, extended as a cloud service. End users can use it for Oracle 12*c* database deployments. It delivers a complete database experience for developers and enterprises.

Exadata express being a cloud deployment provides high scalability, performance and availability to its users.

It is fully managed database, therefore you need not worry about patching, upgrading or other DBA tasks.

## What is in Exadata Express?

- A fully managed database service
- Provides powerful yet elastic database cloud service for developers
- Provides on-demand access to a shared pool of database resources
- Comes with built-in tools for rapid application development
  - APEX for  web application development
  - Compatibility with clients such as SQL Developer, SQLcl



Exadata Express is a fully managed database service where end users need not worry about upgrades to the database and other components of the service. All enhancements are automatically managed by the cloud service.

Being a cloud deployment, Exadata Express, allows end users to scale their data virtually to unlimited size.

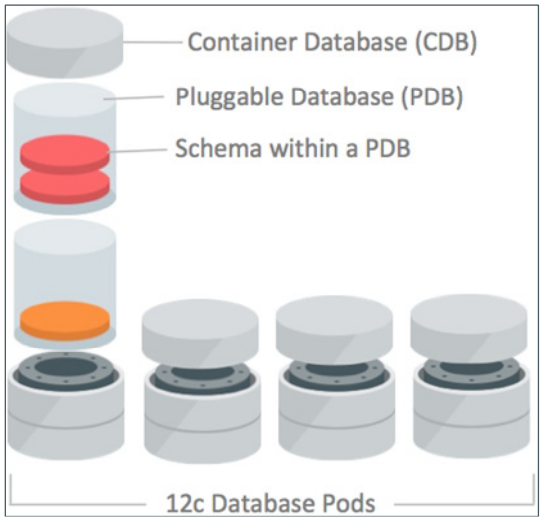
Dynamic provisioning of resources allows users to access huge amount of compute and storage resources in no time.

For developers, it provides built-in application development tool – APEX. APEX(Application Express) is a rapid web application development tool for Oracle database. Developers with minimal development experience can develop and deploy professional applications through web browser using APEX.

Oracle makes a variety of database client drivers and tools available for use with Oracle Database Exadata Express Cloud Service. You can use Exadata Express with Oracle SQL Developer, an IDE used for SQL, PL/SQL development and Oracle SQLcl, an enhanced command line interface.

## Exadata Express for Users

- Oracle manages the service as multiple Container databases(CDBs), also known as database pods
- Each CDB can accommodate upto 1000 Pluggable databases(PDBs).
- Each user is provisioned with a PDB on subscribing to the service, where the user can create several schemas.






Exadata Express is ideal for production applications that consist of small to medium sized data as well as developers, testers, evaluators and other users who are looking for a full Oracle Database experience at an affordable entry-level price. It is a fully managed database service, is organized into Container databases(CDBs). These container databases are also known as database pods.

Each container database in turn can contain several Pluggable databases(PDBs). When a user subscribes to the Exadata Service, a pluggable database is provisioned. Within the PDB, the user can create several schemas. However, PDB Services are constrained by CPU, storage and memory.

## Exadata Express for Developers

- Developers can connect with a wide range of data sources for their applications
  - JSON Document Storage
  - Document Style data access
  - Oracle Rest Data Services




**JSON Document Storage -** Oracle Database in Exadata Express provides direct storage, access and management of JSON documents. See JSON Support in Oracle Database New Features Guide 12*c* Release 2 (12.2).

**Document-Style Data Access -** Oracle Database in Exadata Express gives you the ability to store and access data as schema-less documents and collections using the Simple Oracle Document Access (SODA) API. See Working with JSON and Other Data Using SODA in Using Oracle Database Exadata Express Cloud Service.

**Oracle REST Data Services 3 -** Exadata Express includes the newest Oracle REST Data Services (ORDS). With ORDS 3, it's easy to develop modern RESTful interfaces for relational data and now JSON documents stored in Oracle Database.

## Getting Started with Exadata Express

1. Purchase a subscription.
2. Activate and verify the service.
3. Verify activation.
4. Learn about users and roles.
5. Create accounts for your users and assign them appropriate privileges and roles.
6. Set the password for the database user authorized to perform administrative tasks for your service (PDB_ADMIN).

**Note:** You can refer to Using Oracle Database Exadata Express Cloud Service (https://docs.oracle.com/cloud/latest/exadataexpress-cloud/CSDBP/toc.htm) for details on the subscription process.



The steps in the slide provide you a brief overview of how to get started with Exadata Express. In the following slides, you will learn in detail how to perform the aforementioned steps.

## Oracle Exadata Express Cloud Service

You can refer to Working with Oracle Database Exadata Express Cloud Service (http://oukc.oracle.com/public/redir.html?type=player&offid=1984115860) to gain an introduction to the service and its features.

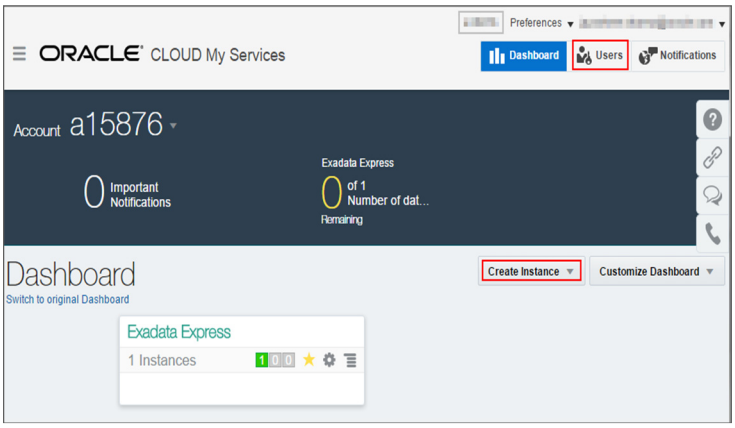


In this video, you gain an introduction to Oracle Exadata Express Cloud Service and its features. You will take a tour of its service console and also learn about the different database clients such as Oracle SQL Developer, SQL CL, SQL Workshop and SQL * Plus that can be used to connect to Oracle Exadata Express Cloud Service.

**Note:** This demonstration has audio, which cannot be played inside OU Classroom. However participants can access this link on open internet and review at their convenience.

## Getting Started with Exadata Express

- On signing into the service, you get access to the dashboard.
- Dashboard allows you to create database instances and users.
- The number of instances you create is limited by the amount of resources you have access to.

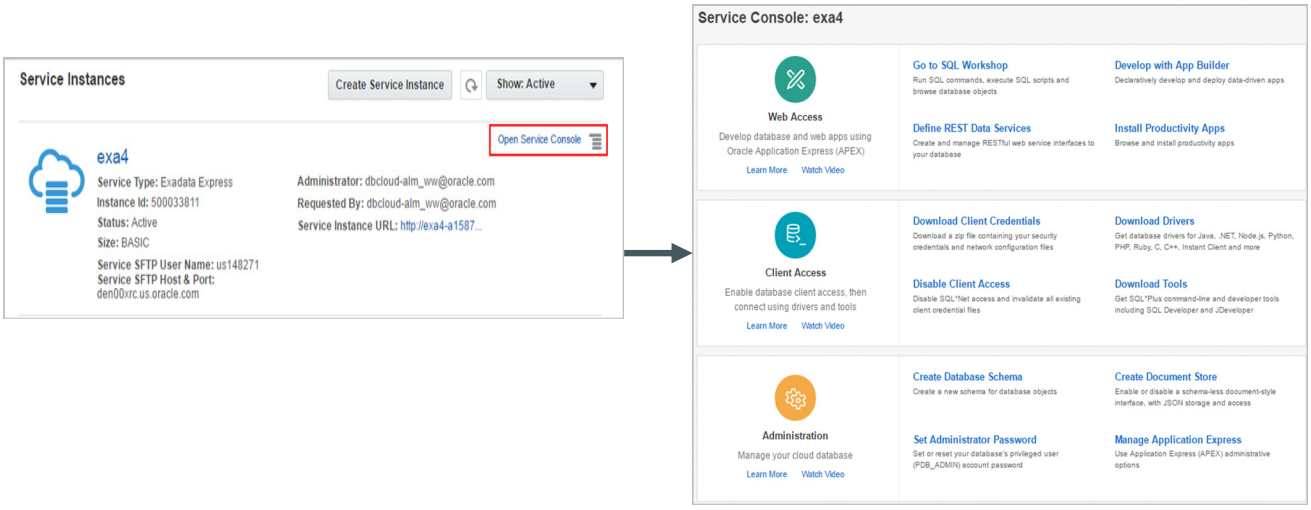





After successful subscription to the service, you can login to your account and access the dashboard. Based on the type of subscription you can create instances.

The instances would appear on the dashboard. You can see an instance created in the image . To manage the instance, click on the instance.

# Managing Exadata



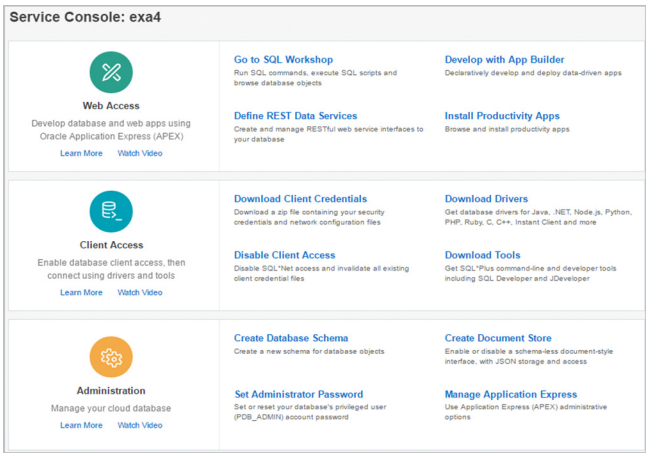



On clicking the instance on the dashboard, you see various details about the dashboard. You can access the services by clicking on ‘Open Service Console’.

The service console provides you access to tools for Web Access, Client Access and Administration.

## Service Console

- Service Console is the interface to use and manage the Exadata service
- It provides three different perspectives of the instance
  - Web Access
  - Client Access
  - Administration



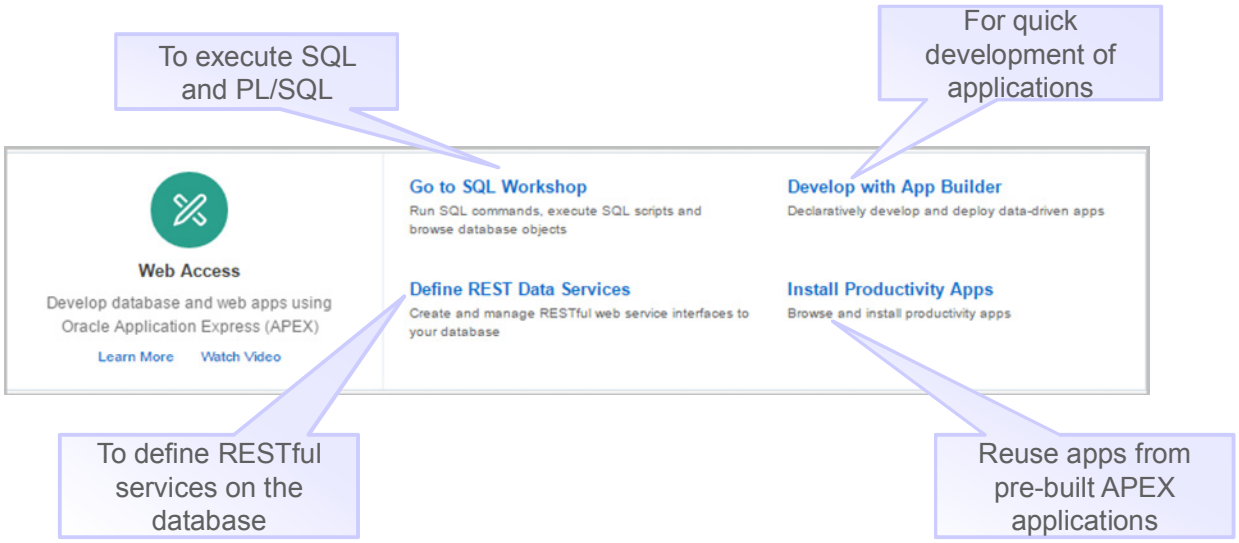



Web access provides utilities which enable you to develop database and web applications using Oracle Application Express(APEX).

Database clients can connect to Exadata Express service using SQL *Net Access. Some examples of supported database clients are SQLcl, SQL Developer, SQL *Plus, JDBC Thin client,ODP.NET, OCI and Instant Client. Client Access in the Service Console allows you to configure with the client you use.

Administration in the Service Console provides for performing administration tasks such as create new database schemas for database objects, set or reset administration password, create a schema-less documents and collections interface, and use administrative options to manage Oracle Application Express.

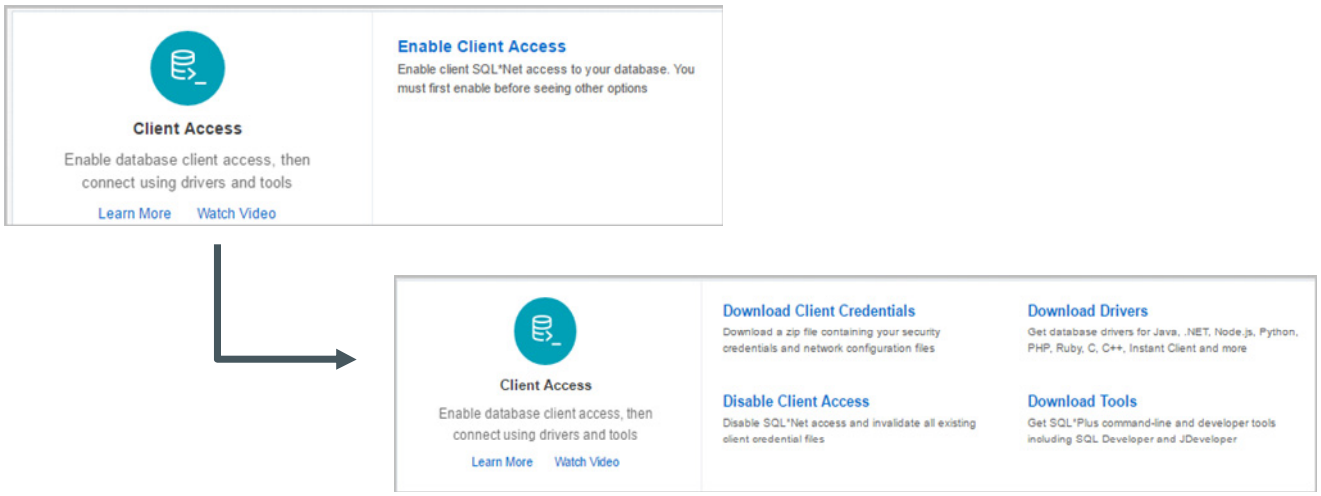
## Web Access through Service Console






| Option | Desription |
|---|---|
| Go to SQL Workshop | Allows you go directly to browser-based SQL Workshop, where you can run SQL statements, execute scripts and explore database objects. |
| Develop with App Builder | Quickly declaratively develop database and websheet applications. You can import files such as database applications and plug-ins. There is a dashboard showing metrics about your applications and workspace utilities to manage defaults, themes, metadata, exports, and more. |
| Define REST Data Services | Directly access the page to define and manage RESTful web services that view and manipulate data objects within your database. |
| Install Productivity Apps | Install from a gallery of pre-built Oracle Application Express Productivity Apps. |

## Client Access Configuration through Service Console



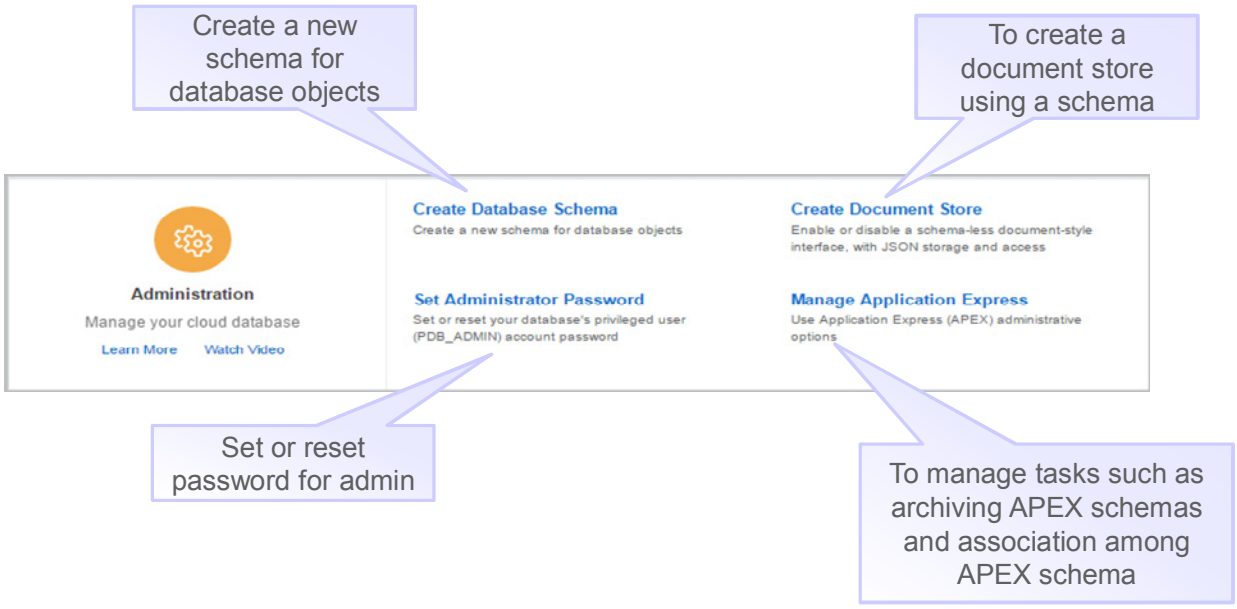





You have to enable client access to allow SQL*Net Access to your service. Using SQL *Net Access software you can connect the Exadata instance to different clients. This option is only available when client access has not yet been enabled. Once you enable the client access, four options appear in the console:

| Option | Desription |
|---|---|
| Download Client Credentials | Download client credentials needed for clients to access your service. |
| Download Drivers | Go directly to the Oracle Technology Network page to download and install database drivers including for Java, Instant Client, C, C++, Microsoft .NET, Node.js, Python, PHP, Ruby, and more. |
| Disable Client Access | Use this option to disallow SQL*Net access to your service. This option is only available when client access has been enabled. |
| Download tools | Go directly to the Oracle Technology Network page to download and install tools such as SQL*Plus, SQLcl, command-line and integrated development environments such as Oracle SQL Developer, JDeveloper, Oracle JET, and more |

## Database Administration through Service Console

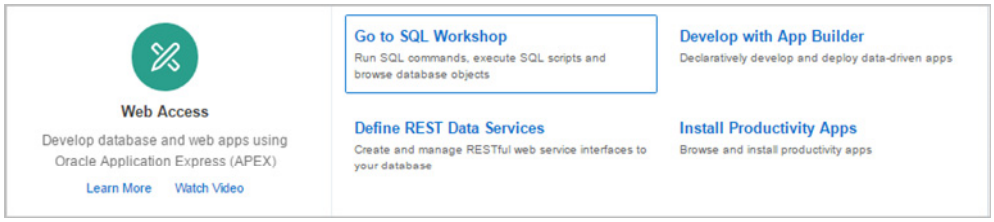




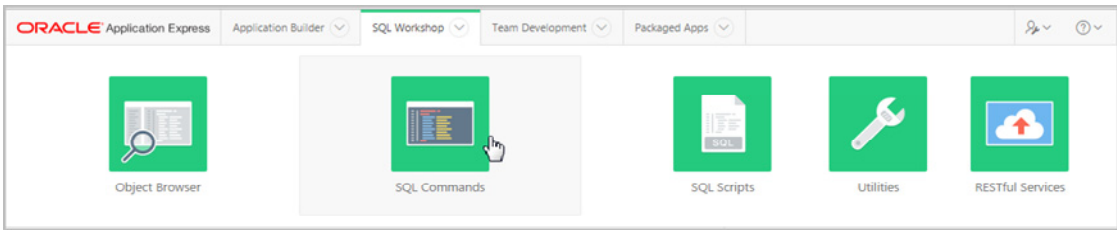

You can perform various administration tasks through 'Administration' in the service console.

| Option | Desription |
|---|---|
| Create Database Schema | Create a new schema for database objects. Schema is the set of database objects, such as tables and views that belong to that user account. |
| Create Document Store | This option enables you to create a document store, using either an existing schema or new schema, and to enable SODA for REST, which enables REST-based operations on the schema using Oracle's SODA for REST API. It also enables SODA for Java, which is Oracle's SODA for Java API for use with Java programs. |
| Set Administrator Password | Use this option to set the password for the PDB_ADMIN database user that is authorized to perform administrative tasks. |
| Manage Application Express | Options here allow you to enable application archiving to archive your Oracle Application Express applications to database tables, manage the association between schemas and Oracle Application Express, and manage messages and set preferences for the workspace. |

# SQL Workshop



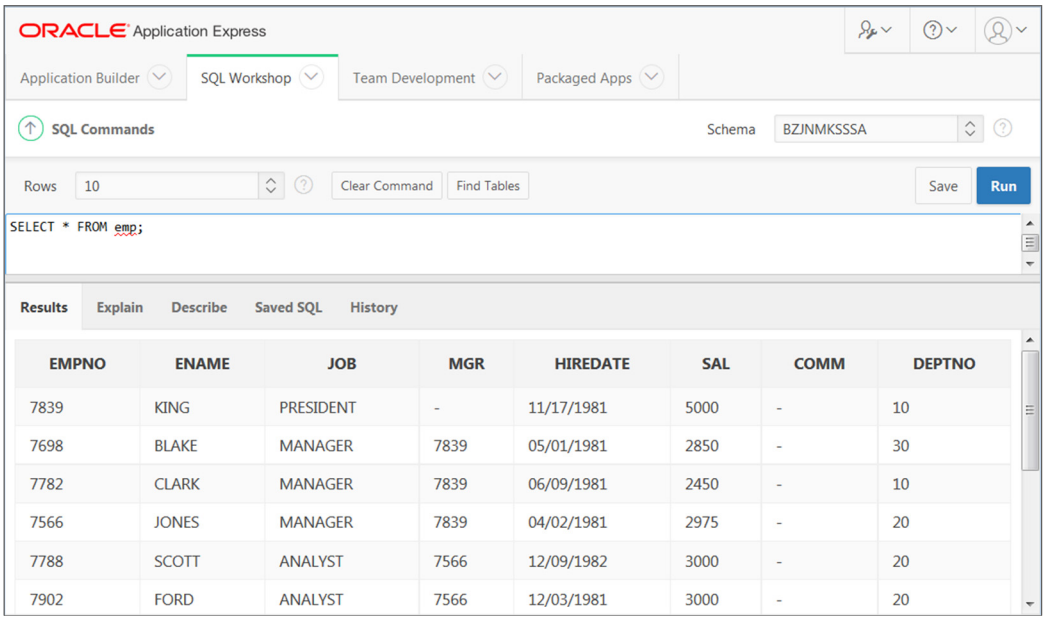

1 Clicking on SQL workshop will lead you to APEX interface




2 To run SQL or PL/SQL you can use the SQL commands utility

# SQL Workshop

You can run SQL statements in the editor.






SQL Workshop in APEX allows you to run SQL statements using SQL commands editor. The results of the SQL query entered will be displayed in the tab below.

## Connecting through Database Clients

You can connect to Exadata Express through various database clients.

Some of the database clients include:

- SQL*Plus
- SQLcl
- SQL Developer
- .Net and Visual Studio
- JDBC Thin Client



You must first configure database clients and Oracle Database Exadata Express Cloud Service to communicate with each other.

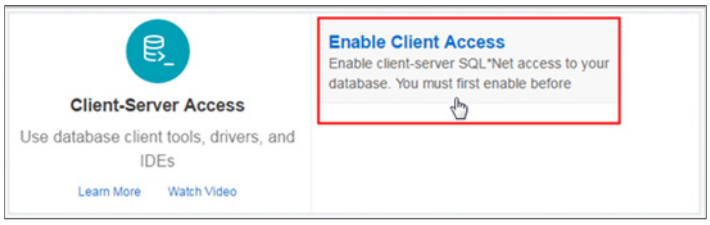
Prerequisite tasks for database client connectivity require you to:

- Enable SQL*Net access to your service.
- Download client credentials.
- Follow set-up instructions for the specific database client you want to connect with.

In the following topics, you will learn how to enable SQL*Net access, download client credentials and make connections using Oracle SQL Developer and SQLcl.

# Enabling SQL*Net Access for Client Applications

Enable SQL*Net Access in the Service Console to obtain the various Database Client options.





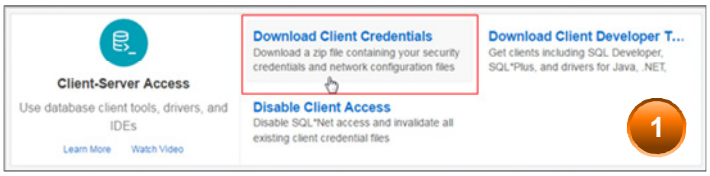

You can connect to your Exadata Express cloud service from diverse database clients over SQL*Net also called as Oracle Database Net Services. Some examples of supported clients include SQL*Plus, SQLcl, SQL Developer, JDBC Thin, ODP.NET, OCI, and Instant Client.

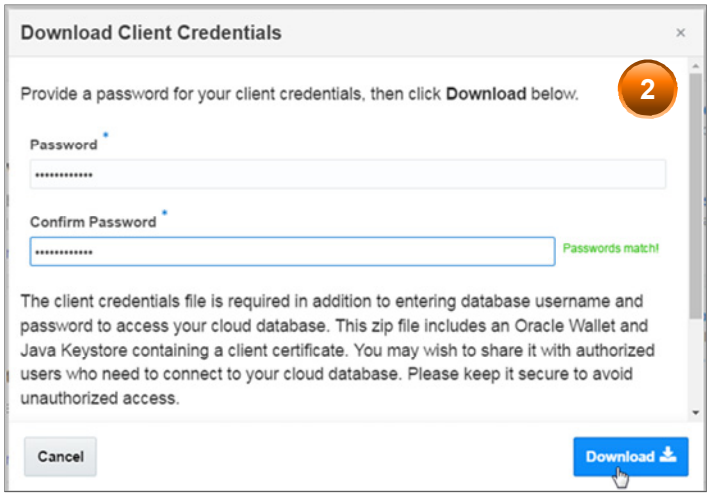
Database drivers for all popular programming and scripting languages such as Python, PHP, Node.js, C/C++, Ruby and Perl are supported. SQL*Net access has to be enabled as a prerequisite for all clients and drivers connecting over SQL*Net.

The Service Administrator must do the following to enable SQL*Net:

- Navigate to the Service Console for **Exadata Express** and open the service console.
- Click **Enable Client Access**.
- Download the client credentials.
- Now, depending on the client-side application and driver being used, you need to configure the application connection string for that application.

# Downloading Client Credentials






You can easily download the zip files for client credentials from service console. Its contents include Oracle Wallet and Java Keystore as well as essential client configuration files. While downloading the zip file, you are prompted to enter a password.

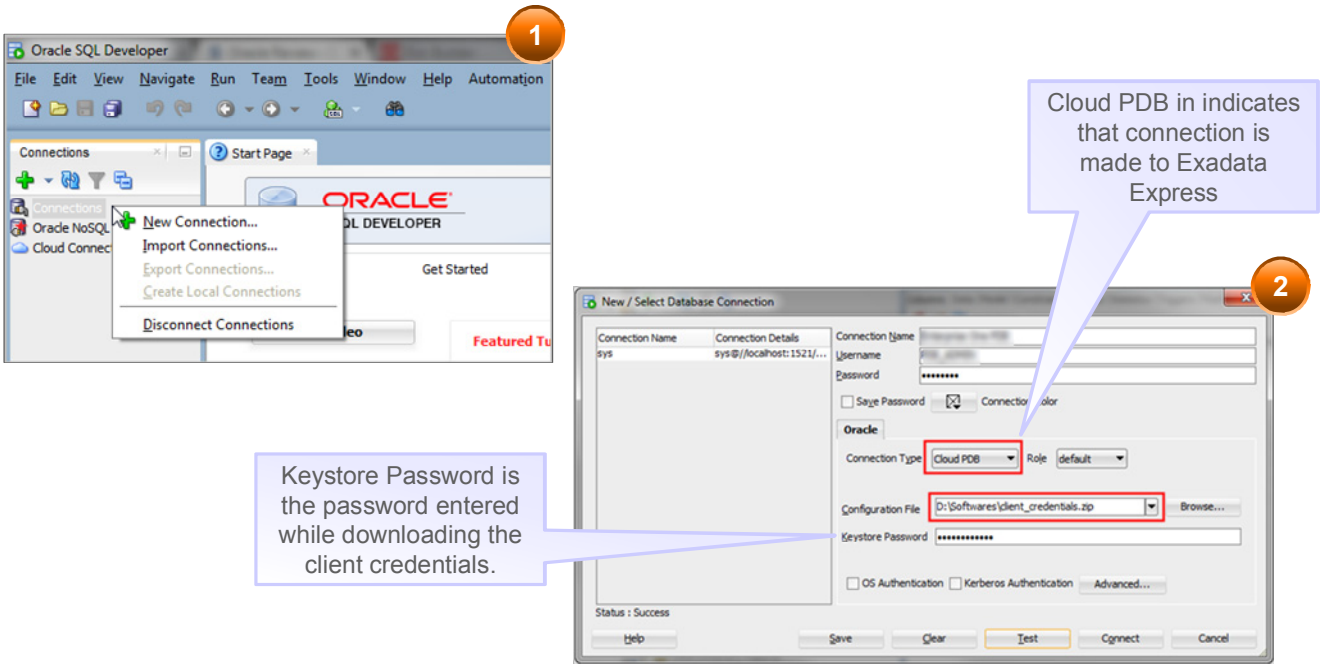
Note that client credential zip files should be carefully managed. Please remember to keep the file secure to avoid unauthorized database access. If you believe the security of this file has been compromised, then immediately disable client access using the cloud service console.

The steps to download the client credentials are as follows.

1. Navigate to Exadata Express and open the service console.
2. Click Download Client Credentials to download a zip file containing your security credentials and network configuration files.
3. Enter a password to create a password-protected Oracle Wallet and Java Keystore files for the service.
4. Click Download and save the downloaded zip file to a secure location that is accessible by your database client(s).

In the following topics, you will learn how to use these credentials to connect to the cloud database.

## Connecting Oracle SQL Developer






In order to connect to Oracle Database Exadata Express cloud service, you need to download and install Oracle SQL Developer Release 4.1.5 or later. You should have also downloaded the Client Credentials from Oracle Exadata Express service console. You should then configure an Oracle Cloud connection in the Oracle SQL Developer.

The connection can be created as follows:

1. Run Oracle SQL Developer locally.
2. Under Connections, right click Connections and select **New Connection**.
3. Enter the following details:
   - Connection Name – Enter a name for this cloud connection.
   - Username – Enter username required to sign into Exadata Express.
   - Password – Enter password required to sign into Exadata Express.
   - Connection type – Select **Cloud PDB**.
   - Configuration File - Click Browse and select the **Client Credentials** zip file that you previously downloaded from the Exadata Express service console.
   - Keystore Password – Enter the password provided while downloading the Client Credentials from the Exadata Express service console.
4. Click Test. If the status is Success, click Connect.

If you have connected successfully, the tables and other objects from Exadata Express display under the new connection.

## Connecting Oracle SQLcl

```
D:\PDB Service\SQL CL\sqlcl-no-jre-latest\sqlcl\bin>sql /nolog

SQLcl: Release 4.2.0.16.160.2007 RC on Thu Sep 08 12:18:07 2016

Copyright (c) 1982, 2016, Oracle. All rights reserved.
SQL>
```

1

```
SQL> set cloudconfig client_credentials.zip
Wallet Password: ************
Using temp directory:C:\Users\APOTHU~1.ORA\AppData\Local\Temp\
oracle_cloud_config6707346342028726502
```

2

```
SQL> conn pdb_admin/welcome1@dbaccess
Connected.
SQL>
```

3



You can use Oracle SQLcl which is a powerful command-line interface(CLI) to connect to the cloud database. In order to connect, you need to first download and setup Oracle SQLcl locally. You should have also downloaded the Client Credentials from Oracle Exadata Express service console.

To create an Oracle SQLcl cloud connection:

- Navigate to the `sqlcl/bin` directory from where you unzipped the SQLcl installation files, and run `sql /nolog`, to startup Oracle SQLcl. The Oracle SQLcl starts displaying the date and time, the SQLcl version and copyright information, before the SQLcl prompt appears.
- At the SQLcl prompt, type `set cloudconfig <name of your wallet zip file>`, and press the Enter key.
- Enter the Password provided for downloading the Client Credentials from the Exadata Express service console, and press the Enter key.
- To connect to the Exadata Express, type `conn <username>/<password>@<servicename>`, and press the Enter key. The `username` and `password` are the credentials of your database account.

You should now be connected to Exadata Express.

## Summary

In this lesson, you should have learned about:

- The salient features of Oracle Cloud
- Oracle Database Exadata Express Cloud Service

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Relational database management systems are composed of objects or relations. They are managed by operations and governed by data integrity constraints.

Oracle Corporation produces products and services to meet your RDBMS needs. The main products are the following:

- Oracle Database, which you use to store and manage information by using SQL
- Oracle Fusion Middleware, which you use to develop, deploy, and manage modular business services that can be integrated and reused
- Oracle Enterprise Manager Grid Control, which you use to manage and automate administrative tasks across sets of systems in a grid environment

**SQL**

The Oracle server supports ANSI-standard SQL and contains extensions. SQL is the language that is used to communicate with the server to access, manipulate, and control data.

# Commonly Used SQL Commands

## Objectives

After completing this appendix, you should be able to:

- Execute a basic `SELECT` statement
- Create, alter, and drop a table using the data definition language (DDL) statements
- Insert, update, and delete rows from one or more tables using data manipulation language (DML) statements
- Commit, roll back, and create save points using the transaction control statements
- Perform join operations on one or more tables



This lesson explains how to obtain data from one or more tables by using the `SELECT` statement, how to use DDL statements to alter the structure of data objects, how to manipulate data in the existing schema objects by using the DML statements, how to manage the changes made by DML statements, and how to use joins to display data from multiple tables using SQL:1999 join syntax.

## Basic SELECT Statement

- Use the SELECT statement to:
  - Identify the columns to be displayed
  - Retrieve data from one or more tables, object tables, views, object views, or materialized views
- A SELECT statement is also known as a query because it queries a database.
- Syntax:

```
SELECT {*|[DISTINCT] column|expression [alias],...}
FROM    table;
```



In its simplest form, a SELECT statement must include the following:

- A SELECT clause, which specifies the columns to be displayed
- A FROM clause, which identifies the table containing the columns that are listed in the SELECT clause

In the syntax:

| | |
|---|---|
| SELECT | Is a list of one or more columns |
| * | Selects all columns |
| DISTINCT | Suppresses duplicates |
| *column\|expression* | Selects the named column or the expression |
| *alias* | Gives different headings to the selected columns |
| FROM *table* | Specifies the table containing the columns |

**Note:** Throughout this course, the words *keyword*, *clause*, and *statement* are used as follows:

- A *keyword* refers to an individual SQL element (for example, SELECT and FROM are keywords).
- A *clause* is a part of a SQL statement (for example, SELECT employee_id, last_name).
- A *statement* is a combination of two or more clauses (for example, SELECT * FROM employees).

## SELECT Statement

- Select all columns:

```
SELECT *
FROM   job_history;
```

| | EMPLOYEE_ID | START_DATE | END_DATE | JOB_ID | DEPARTMENT_ID |
|---|---|---|---|---|---|
| 1 | 102 | 13-JAN-01 | 24-JUL-06 | IT_PROG | 60 |
| 2 | 101 | 21-SEP-97 | 27-OCT-01 | AC_ACCOUNT | 110 |
| 3 | 101 | 28-OCT-01 | 15-MAR-05 | AC_MGR | 110 |
| 4 | 201 | 17-FEB-04 | 19-DEC-07 | MK_REP | 20 |
| 5 | 114 | 24-MAR-06 | 31-DEC-07 | ST_CLERK | 50 |
| 6 | 122 | 01-JAN-07 | 31-DEC-07 | ST_CLERK | 50 |
| 7 | 200 | 17-SEP-95 | 17-JUN-01 | AD_ASST | 90 |
| 8 | 176 | 24-MAR-06 | 31-DEC-06 | SA_REP | 80 |
| 9 | 176 | 01-JAN-07 | 31-DEC-07 | SA_MAN | 80 |
| 10 | 200 | 01-JUL-02 | 31-DEC-06 | AC_ACCOUNT | 90 |

- Select specific columns:

```
SELECT manager_id, job_id
FROM   employees;
```

| | MANAGER_ID | JOB_ID |
|---|---|---|
| 1 | (null) | AD_PRES |
| 2 | 100 | AD_VP |
| 3 | 100 | AD_VP |
| 4 | 102 | IT_PROG |
| 5 | 103 | IT_PROG |
| 6 | 103 | IT_PROG |
| 7 | 100 | ST_MAN |
| 8 | 124 | ST_CLERK |
| 9 | 124 | ST_CLERK |
| 10 | 124 | ST_CLERK |

...

ORACLE



You can display all columns of data in a table by following the `SELECT` keyword with an asterisk (`*`) or by listing all the column names after the `SELECT` keyword. The first example in the slide displays all the rows from the `job_history` table. Specific columns of the table can be displayed by specifying the column names, separated by commas. The second example in the slide displays the `manager_id` and `job_id` columns from the `employees` table.

In the `SELECT` clause, specify the columns in the order in which you want them to appear in the output. For example, the following SQL statement displays the `location_id` column before displaying the `department_id` column:

```
SELECT location_id, department_id FROM departments;
```

**Note:** You can enter your SQL statement in a SQL Worksheet and click the Run Statement icon or press F9 to execute a statement in SQL Developer. The output displayed on the Results tabbed page appears as shown in the slide.

## WHERE Clause

- Use the optional WHERE clause to:
  - Filter rows in a query
  - Produce a subset of rows
- Syntax:

```
SELECT * FROM   table
[WHERE   condition];
```

- Example:

```
SELECT location_id from departments
WHERE department_name = 'Marketing';
```



The WHERE clause specifies a condition to filter rows, producing a subset of the rows in the table. A condition specifies a combination of one or more expressions and logical (Boolean) operators. It returns a value of TRUE, FALSE, or NULL. The example in the slide retrieves the location_id of the marketing department.

The WHERE clause can also be used to update or delete data from the database.

For example:

```
UPDATE departments
SET  department_name = 'Administration'
WHERE department_id = 20;
```

and

```
DELETE from departments
WHERE department_id =20;
```

## ORDER BY Clause

- Use the optional ORDER BY clause to specify the row order.
- Syntax:

```
SELECT * FROM   table
[WHERE   condition]
[ORDER BY {<column>|<position> } [ASC|DESC] [, ...] ];
```

- Example:

```
SELECT last_name, department_id, salary
FROM employees
ORDER BY department_id ASC, salary DESC;
```



The ORDER BY clause specifies the order in which the rows should be displayed. The rows can be sorted in ascending or descending order. By default, the rows are displayed in ascending order.

The example in the slide retrieves rows from the employees table ordered first by ascending order of department_id and then by descending order of salary.

## GROUP BY Clause

- Use the optional GROUP BY clause to group columns that have matching values into subsets.
- No group has two rows having the same value for the grouping column or columns.
- Syntax:

```
SELECT <column1, column2, ... column_n>
FROM  table
[WHERE   condition]
[GROUP BY <column> [, ...] ]
[ORDER BY <column> [, ...] ] ;
```

- Example:

```
SELECT department_id, MIN(salary), MAX (salary)
FROM employees
GROUP BY department_id ;
```



The GROUP BY clause is used to group selected rows based on the value of expr(s) for each row. The clause groups rows but does not guarantee the order of the result set. To order the groupings, use the ORDER BY clause.

Any SELECT list elements that are not included in aggregation functions must be included in the GROUP BY list of elements. This includes both columns and expressions. The database returns a single row of summary information for each group.

The example in the slide returns the minimum and maximum salaries for each department in the employees table.

## Data Definition Language

- DDL statements are used to define, structurally change, and drop schema objects.
- The commonly used DDL statements are:
  - `CREATE TABLE`, `ALTER TABLE`, and `DROP TABLE`
  - `GRANT`, `REVOKE`
  - `TRUNCATE`



Data definition language (DDL) statements enable you to alter the attributes of an object without altering the applications that access the object. You can also use DDL statements to alter the structure of objects while database users are performing work in the database. These statements are most frequently used to:

- Create, alter, and drop schema objects and other database structures, including the database itself and database users
- Delete all the data in schema objects without removing the structure of these objects
- Grant and revoke privileges and roles

Oracle Database implicitly commits the current transaction before and after every DDL statement.

## CREATE TABLE Statement

- Use the CREATE TABLE statement to create a table in the database.
- Syntax:

```
CREATE TABLE tablename (
{column-definition | Table-level constraint}
[ , {column-definition | Table-level constraint} ] * )
```

- Example:

```
CREATE TABLE teach_dept (
department_id  NUMBER(3) PRIMARY KEY,
department_name VARCHAR2(10));
```



Use the CREATE TABLE statement to create a table in the database. To create a table, you must have the CREATE TABLE privilege and a storage area in which to create objects.

The table owner and the database owner automatically gain the following privileges on the table after it is created:

- INSERT
- SELECT
- REFERENCES
- ALTER
- UPDATE

The table owner and the database owner can grant the preceding privileges to other users.

## ALTER TABLE Statement

- Use the ALTER TABLE statement to modify the definition of an existing table in the database.
- Example 1:

```
ALTER TABLE  teach_dept
ADD  location_id  NUMBER  NOT NULL;
```

- Example 2:

```
ALTER TABLE teach_dept
MODIFY department_name  VARCHAR2(30) NOT NULL;
```



The ALTER TABLE statement allows you to make changes to an existing table.

You can:

- Add a column to a table
- Add a constraint to a table
- Modify an existing column definition
- Drop a column from a table
- Drop an existing constraint from a table
- Increase the width of the VARCHAR and CHAR columns
- Change a table to have read-only status

Example 1 in the slide adds a new column called location_id to the teach_dept table.

Example 2 updates the existing department_name column from VARCHAR2(10) to VARCHAR2(30), and adds a NOT NULL constraint to it.

## DROP TABLE Statement

- The DROP TABLE statement removes the table and all its data from the database.
- Example:

```
DROP TABLE teach_dept;
```

- DROP TABLE with the PURGE clause drops the table and releases the space that is associated with it.

```
DROP TABLE teach_dept PURGE;
```

- The CASCADE CONSTRAINTS clause drops all referential integrity constraints from the table.

```
DROP TABLE teach_dept CASCADE CONSTRAINTS;
```



The DROP TABLE statement allows you to remove a table and its contents from the database, and pushes it to the recycle bin. Dropping a table invalidates dependent objects and removes object privileges on the table.

Use the PURGE clause along with the DROP TABLE statement to release back to the tablespace the space allocated for the table. You cannot roll back a DROP TABLE statement with the PURGE clause, nor can you recover the table if you have dropped it with the PURGE clause.

The CASCADE CONSTRAINTS clause allows you to drop the reference to the primary key and unique keys in the dropped table.

## GRANT Statement

- The GRANT statement assigns privileges to perform the following operations:
  - Insert or delete data
  - Create a foreign key reference to the named table or to a subset of columns from a table
  - Select data, a view, or a subset of columns from a table
  - Create a trigger on a table
  - Execute a specified function or procedure
- Example:

```
GRANT SELECT any table to PUBLIC;
```



You can use the GRANT statement to:

- Assign privileges to a specific user or role, or to all users, to perform actions on database objects
- Grant a role to a user, to PUBLIC, or to another role

Before you issue a GRANT statement, check that the derby.database.sql Authorization property is set to True. This property enables the SQL Authorization mode. You can grant privileges on an object if you are the owner of the database.

You can grant privileges to all users by using the PUBLIC keyword. When PUBLIC is specified, the privileges or roles affect all current and future users.

## Privilege Types

Assign the following privileges by using the GRANT statement:

- ALL PRIVILEGES
- DELETE
- INSERT
- REFERENCES
- SELECT
- UPDATE



Oracle Database provides a variety of privilege types to grant privileges to a user or role:

- Use the ALL PRIVILEGES privilege type to grant all privileges to the user or role for the specified table.
- Use the DELETE privilege type to grant permission to delete rows from the specified table.
- Use the INSERT privilege type to grant permission to insert rows into the specified table.
- Use the REFERENCES privilege type to grant permission to create a foreign key reference to the specified table.
- Use the SELECT privilege type to grant permission to perform SELECT statements on a table or view.
- Use the UPDATE privilege type to grant permission to use the UPDATE statement on the specified table.

## REVOKE Statement

- Use the REVOKE statement to remove privileges from a user to perform actions on database objects.
- Revoke a *system privilege* from a user:

```
REVOKE DROP ANY TABLE
FROM hr;
```

- Revoke a *role* from a user:

```
REVOKE dw_manager
FROM sh;
```



The REVOKE statement removes privileges from a specific user (or users) or role to perform actions on database objects. It performs the following operations:

- Revokes a role from a user, from PUBLIC, or from another role
- Revokes privileges for an object if you are the owner of the object or the database owner

**Note:** To revoke a role or system privilege, you must have been granted the privilege with the ADMIN OPTION.

## TRUNCATE TABLE Statement

- Use the TRUNCATE TABLE statement to remove all the rows from a table.
- Example:

```
TRUNCATE TABLE employees_demo;
```

- By default, Oracle Database performs the following tasks:
  - Deallocates space used by the removed rows
  - Sets the NEXT storage parameter to the size of the last extent removed from the segment by the truncation process



The TRUNCATE TABLE statement deletes all the rows from a specific table. Removing rows with the TRUNCATE TABLE statement can be more efficient than dropping and re-creating a table. Dropping and re-creating a table:

- Invalidates the dependent objects of the table
- Requires you to:
  - Regrant object privileges
  - Re-create indexes, integrity constraints, and triggers.
  - Respecify its storage parameters

The TRUNCATE TABLE statement spares you from these efforts.

**Note:** You cannot roll back a TRUNCATE TABLE statement.

## Data Manipulation Language

- DML statements query or manipulate data in existing schema objects.
- A DML statement is executed when:
  - New rows are added to a table by using the `INSERT` statement
  - Existing rows in a table are modified using the `UPDATE` statement
  - Existing rows are deleted from a table by using the `DELETE` statement
- A *transaction* consists of a collection of DML statements that form a logical unit of work.



Data manipulation language (DML) statements enable you to query or change the contents of an existing schema object. These statements are most frequently used to:

- Add new rows of data to a table or view by specifying a list of column values or by using a subquery to select and manipulate existing data
- Change column values in the existing rows of a table or view
- Remove rows from tables or views

A collection of DML statements that forms a logical unit of work is called a transaction. Unlike DDL statements, DML statements do not implicitly commit the current transaction.

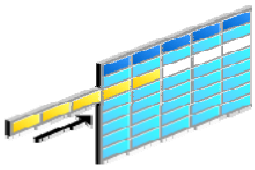
## INSERT Statement

- Use the INSERT statement to add new rows to a table.
- Syntax:

```
INSERT INTO   table [(column [, column...])]
VALUES     (value [, value...]);
```

- Example:

```
INSERT INTO   departments
VALUES     (200,'Development',104,1400);
1 rows inserted.
```





The INSERT statement adds rows to a table. Be sure to insert a new row containing values for each column and to list the values in the default order of the columns in the table. Optionally, you can also list the columns in the INSERT statement.

For example:

```
INSERT INTO job_history (employee_id, start_date,  end_date,
    job_id)
VALUES (120,'25-JUL-06','12-FEB_08','AC_ACCOUNT');
```

The syntax discussed in the slide allows you to insert a single row at a time. The VALUES keyword assigns the values of expressions to the corresponding columns in the column list.

## UPDATE Statement Syntax

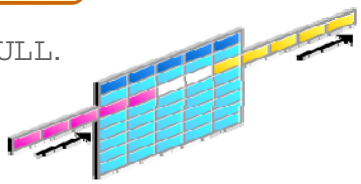
- Use the UPDATE statement to modify the existing rows in a table.
- Update more than one row at a time (if required).

```
UPDATE     table
SET        column = value [, column = value, ...]
[WHERE     condition];
```

- Example:

```
UPDATE     copy_emp
SET
22 rows updated
```

- Specify SET *column_name*= NULL to update a column value to NULL.





The UPDATE statement modifies the existing values in a table. Confirm the update operation by querying the table to display the updated rows. You can modify a specific row or rows by specifying the WHERE clause.

For example:

```
UPDATE employees
SET    salary = 17500
WHERE  employee_id = 102;
```

In general, use the primary key column in the WHERE clause to identify the row to update. For example, to update a specific row in the employees table, use employee_id instead of employee_name, to identify the row, because more than one employee may have the same name.

**Note:** Typically, the condition keyword is composed of column names, expressions, constants, subqueries, and comparison operators.

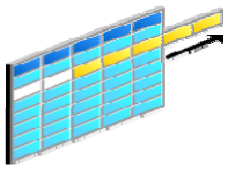
## DELETE Statement

- Use the DELETE statement to delete the existing rows from a table.
- Syntax:

```
DELETE    [FROM]      table
[WHERE        condition];
```

- Write the DELETE statement using the WHERE clause to delete specific rows from a table.

```
DELETE FROM departments
WHERE  department_name = 'Finance';
1 rows deleted
```





The DELETE statement removes existing rows from a table. You must use the WHERE clause to delete a specific row or rows from a table based on a condition. The condition identifies the rows to be deleted. It may contain column names, expressions, constants, subqueries, and comparison operators.

The first example in the slide deletes the finance department from the departments table. You can confirm the delete operation by using the SELECT statement to query the table.

```
SELECT  *
FROM    departments
WHERE   department_name = 'Finance';
```

If you omit the WHERE clause, all rows in the table are deleted. For example:

```
DELETE FROM  copy_emp;
```

The preceding example deletes all the rows from the copy_emp table.

## Transaction Control Statements

- Transaction control statements are used to manage the changes made by DML statements.
- The DML statements are grouped into transactions.
- Transaction control statements include:
  - `COMMIT`
  - `ROLLBACK`
  - `SAVEPOINT`



A transaction is a sequence of SQL statements that Oracle Database treats as a single unit. Transaction control statements are used in a database to manage the changes made by DML statements and to group these statements into transactions.

Each transaction is assigned a unique `transaction_id` and it groups SQL statements so that they are either all committed, which means they are applied to the database, or all rolled back, which means they are undone from the database.

## COMMIT Statement

- Use the COMMIT statement to:
  - Permanently save the changes made to the database during the current transaction
  - Erase all savepoints in the transaction
  - Release transaction locks
- Example:

```
INSERT INTO  departments
VALUES     (201, 'Engineering', 106, 1400);
COMMIT;
```

```
1 rows inserted.
commited.
```



The COMMIT statement ends the current transaction by making all the pending data changes permanent. It releases all row and table locks, and erases any savepoints that you may have marked since the last commit or rollback. The changes made using the COMMIT statement are visible to all users.

Oracle recommends that you explicitly end every transaction in your application programs with a COMMIT or ROLLBACK statement, including the last transaction, before disconnecting from Oracle Database. If you do not explicitly commit the transaction and the program terminates abnormally, the last uncommitted transaction is automatically rolled back.

**Note:** Oracle Database issues an implicit COMMIT before and after any data definition language (DDL) statement.

## ROLLBACK Statement

- Use the ROLLBACK statement to undo changes made to the database during the current transaction.
- Use the TO SAVEPOINT clause to undo a part of the transaction after the savepoint.
- Example:

```
UPDATE          employees
SET             salary = 7000
WHERE           last_name = 'Ernst';
SAVEPOINT       Ernst_sal;

UPDATE          employees
SET             salary = 12000
WHERE           last_name = 'Mourgos';

ROLLBACK TO SAVEPOINT Ersnt_sal;
```



The ROLLBACK statement undoes work done in the current transaction. To roll back the current transaction, no privileges are necessary.

Using ROLLBACK with the TO SAVEPOINT clause performs the following operations:

- Rolls back only the portion of the transaction after the savepoint
- Erases all savepoints created after that savepoint. The named savepoint is retained, so you can roll back to the same savepoint multiple times.

Using ROLLBACK without the TO SAVEPOINT clause performs the following operations:

- Ends the transaction
- Undoes all the changes in the current transaction
- Erases all savepoints in the transaction

## SAVEPOINT Statement

- Use the SAVEPOINT statement to name and mark the current point in the processing of a transaction.
- Specify a name to each savepoint.
- Use distinct savepoint names within a transaction to avoid overriding.
- Syntax:

```
SAVEPOINT savepoint;
```



The SAVEPOINT statement identifies a point in a transaction to which you can later roll back. You must specify a distinct name for each savepoint. If you create a second savepoint with the same identifier as an earlier savepoint, the earlier savepoint is erased.

After a savepoint has been created, you can either continue processing, commit your work, roll back the entire transaction, or roll back to the savepoint.

A simple rollback or commit erases all savepoints. When you roll back to a savepoint, any savepoints marked after that savepoint are erased. The savepoint to which you have rolled back is retained.

When savepoint names are reused within a transaction, the Oracle Database moves (overrides) the save point from its old position to the current point in the transaction.

## Joins

Use a join to query data from more than one table:

```
SELECT   table1.column, table2.column
FROM     table1, table2
WHERE    table1.column1 = table2.column2;
```

- Write the join condition in the `WHERE` clause.
- Prefix the column name with the table name when the same column name appears in more than one table.



When data from more than one table in the database is required, a *join* condition is used. Rows in one table can be joined to rows in another table according to common values that exist in the corresponding columns (usually primary and foreign key columns).

To display data from two or more related tables, write a simple join condition in the `WHERE` clause.

In the syntax:

| | |
|---|---|
| *table1.column* | Denotes the table and column from which data is retrieved |
| *table1.column1 = table2.column2* | Is the condition that joins (or relates) the tables together |

**Guidelines**

- When writing a `SELECT` statement that joins tables, precede the column name with the table name for clarity and to enhance database access.
- If the same column name appears in more than one table, the column name must be prefixed with the table name.
- To join *n* tables together, you need a minimum of `n-1` join conditions. For example, to join four tables, a minimum of three joins is required. This rule may not apply if your table has a concatenated primary key, in which case more than one column is required to uniquely identify each row.

## Types of Joins

- Natural join
- Equijoin
- Nonequijoin
- Outer join
- Self-join
- Cross join



To join tables, you can use Oracle's join syntax.

**Note:** Before the Oracle9*i* release, the join syntax was proprietary. The SQL:1999–compliant join syntax does not offer any performance benefits over the Oracle-proprietary join syntax.

## Qualifying Ambiguous Column Names

- Use table prefixes to qualify column names that are in multiple tables.
- Use table prefixes to improve performance.
- Use table aliases, instead of full table name prefixes.
- Table aliases give a table a shorter name.
  - This keeps SQL code smaller and uses less memory.
- Use column aliases to distinguish columns that have identical names, but reside in different tables.



When joining two or more tables, you need to qualify the names of the columns with the table name to avoid ambiguity. Without the table prefixes, the `DEPARTMENT_ID` column in the `SELECT` list could be from either the `DEPARTMENTS` table or the `EMPLOYEES` table. Therefore, it is necessary to add the table prefix to execute your query. If there are no common column names between the two tables, there is no need to qualify the columns. However, using a table prefix improves performance, because you tell the Oracle server exactly where to find the columns.

Qualifying column names with table names can be very time consuming, particularly if table names are lengthy. Therefore, you can use *table aliases*, instead of table names. Just as a column alias gives a column another name, a table alias gives a table another name. Table aliases help to keep SQL code smaller, thereby using less memory.

The table name is specified in full, followed by a space, and then the table alias. For example, the `EMPLOYEES` table can be given an alias of `e`, and the `DEPARTMENTS` table an alias of `d`.

**Guidelines**

- Table aliases can be up to 30 characters in length, but shorter aliases are better than longer ones.
- If a table alias is used for a particular table name in the `FROM` clause, that table alias must be substituted for the table name throughout the `SELECT` statement.
- Table aliases should be meaningful.
- A table alias is valid only for the current `SELECT` statement.

## Natural Join

- The NATURAL JOIN clause is based on all the columns in the two tables that have the same name.
- It selects rows from tables that have the same names and data values of columns.
- Example:

```
SELECT country_id, location_id, country_name,city
FROM countries NATURAL JOIN locations;
```

| | COUNTRY_ID | LOCATION_ID | COUNTRY_NAME | CITY |
|---|---|---|---|---|
| 1 | US | 1400 | United States of America | Southlake |
| 2 | US | 1500 | United States of America | South San Francisco |
| 3 | US | 1700 | United States of America | Seattle |
| 4 | CA | 1800 | Canada | Toronto |
| 5 | UK | 2500 | United Kingdom | Oxford |

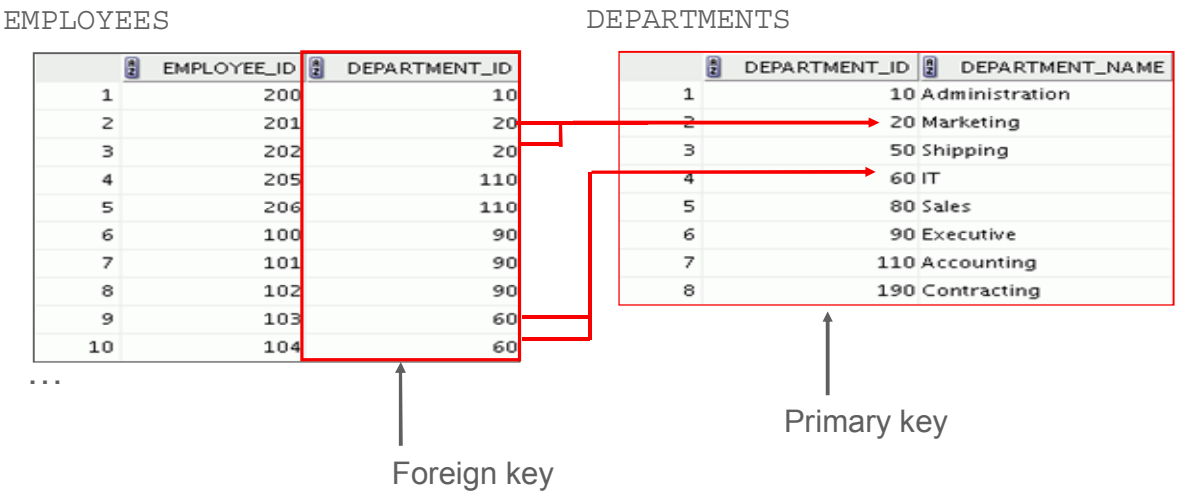


You can join tables automatically based on the columns in the two tables that have matching data types and names. You do this by using the NATURAL JOIN keywords.

**Note:** The join can happen only on those columns that have the same names and data types in both tables. If the columns have the same name but different data types, the NATURAL JOIN syntax causes an error.

In the example in the slide, the COUNTRIES table is joined to the LOCATIONS table by the COUNTRY_ID column, which is the only column of the same name in both tables. If other common columns were present, the join would have used them all.

## Equijoin






An **equijoin** is a join with a join condition containing an equality operator. An equijoin combines rows that have equivalent values for the specified columns. To determine an employee's department name, you compare the values in the `DEPARTMENT_ID` column in the `EMPLOYEES` table with the `DEPARTMENT_ID` values in the `DEPARTMENTS` table. The relationship between the `EMPLOYEES` and `DEPARTMENTS` tables is an *equijoin*; that is, values in the `DEPARTMENT_ID` column in both tables must be equal. Often, this type of join involves primary and foreign key complements.

**Note:** Equijoins are also called *simple joins.*

## Retrieving Records by Using Equijoins

```
SELECT e.employee_id, e.last_name, e.department_id,
       d.department_id, d.location_id
FROM   employees e JOIN departments d
ON e.department_id = d.department_id;
```

| | EMPLOYEE_ID | LAST_NAME | DEPARTMENT_ID | DEPARTMENT_ID_1 | LOCATION_ID |
|---|---|---|---|---|---|
| 1 | 200 | Whalen | 10 | 10 | 1700 |
| 2 | 201 | Hartstein | 20 | 20 | 1800 |
| 3 | 202 | Fay | 20 | 20 | 1800 |
| 4 | 144 | Vargas | 50 | 50 | 1500 |
| 5 | 143 | Matos | 50 | 50 | 1500 |
| 6 | 142 | Davies | 50 | 50 | 1500 |
| 7 | 141 | Rajs | 50 | 50 | 1500 |
| 8 | 124 | Mourgos | 50 | 50 | 1500 |
| 9 | 103 | Hunold | 60 | 60 | 1400 |
| 10 | 104 | Ernst | 60 | 60 | 1400 |
| 11 | 107 | Lorentz | 60 | 60 | 1400 |

...



In the example in the slide:

- **The `SELECT` clause specifies the column names to retrieve:**
  - Employee last name, employee ID, and department ID, which are columns in the `EMPLOYEES` table
  - Department ID and location ID, which are columns in the `DEPARTMENTS` table
- **The `FROM` clause specifies the two tables that the database must access:**
  - `EMPLOYEES` table
  - `DEPARTMENTS` table
- **The `WHERE` clause specifies how the tables are to be joined:**

`e.department_id = d.department_id`

Because the `DEPARTMENT_ID` column is common to both tables, it must be prefixed with the table alias to avoid ambiguity. Other columns that are not present in both the tables need not be qualified by a table alias, but it is recommended for better performance.

**Note:** When you use the Execute Statement icon to run the query, SQL Developer suffixes a "_1" to differentiate between the two `DEPARTMENT_ID`s.

## Adding Search Conditions by Using the AND and WHERE Operators

```
SELECT  d.department_id, d.department_name, l.city
FROM    departments d JOIN locations l
ON  d.location_id = l.location_id
AND d.department_id IN (20, 50);
```

| | DEPARTMENT_ID | DEPARTMENT_NAME | CITY |
|---|---|---|---|
| 1 | 20 | Marketing | Toronto |
| 2 | 50 | Shipping | South San Francisco |

```
SELECT  d.department_id, d.department_name, l.city
FROM    departments d JOIN locations l
ON  d.location_id = l.location_id
WHERE d.department_id IN (20, 50);
```



In addition to the join, you may have criteria for your WHERE clause to restrict the rows in consideration for one or more tables in the join. The example in the slide performs a join on the DEPARTMENTS and LOCATIONS tables and, in addition, displays only those departments with ID equal to 20 or 50. To add more conditions to the ON clause, you can add AND clauses. Alternatively, you can use a WHERE clause to apply additional conditions.

Both queries produce the same output.

| | LAST_NAME | DEPARTMENT_ID | DEPARTMENT_NAME |
|---|---|---|---|
| 1 | Matos | 50 | Shipping |

## Retrieving Records with Nonequijoins

```
SELECT e.last_name, e.salary, j.grade_level
FROM   employees e JOIN job_grades j
ON  e.salary
       BETWEEN j.lowest_sal AND j.highest_sal;
```

| | LAST_NAME | SALARY | GRADE_LEVEL |
|---|---|---|---|
| 1 | Vargas | 2500 | A |
| 2 | Matos | 2600 | A |
| 3 | Davies | 3100 | B |
| 4 | Rajs | 3500 | B |
| 5 | Lorentz | 4200 | B |
| 6 | Whalen | 4400 | B |
| 7 | Fay | 6000 | C |

...



The example in the slide creates a nonequijoin to evaluate an employee's salary grade. The salary must be *between* any pair of the low and high salary ranges.

It is important to note that all employees appear exactly once when this query is executed. No employee is repeated in the list. There are two reasons for this:

- None of the rows in the job grade table contain grades that overlap. That is, the salary value for an employee can lie only between the low salary and high salary values of one of the rows in the salary grade table.
- All of the employees' salaries lie within the limits that are provided by the job grade table. That is, no employee earns less than the lowest value contained in the `LOWEST_SAL` column or more than the highest value contained in the `HIGHEST_SAL` column.

**Note:** Other conditions (such as `<=` and `>=`) can be used, but `BETWEEN` is the simplest. Remember to specify the low value first and the high value last when using the `BETWEEN` condition. The Oracle server translates the `BETWEEN` condition to a pair of `AND` conditions. Therefore, using `BETWEEN` has no performance benefits, but should be used only for logical simplicity.

Table aliases have been specified in the example in the slide for performance reasons, not because of possible ambiguity.

## Retrieving Records by Using the USING Clause

- You can use the USING clause to match only one column when more than one column matches.
- You cannot specify this clause with a NATURAL join.
- Do not qualify the column name with a table name or table alias.
- Example:

```
SELECT country_id, country_name, location_id, city
FROM   countries JOIN locations
USING (country_id) ;
```

| | COUNTRY_ID | COUNTRY_NAME | LOCATION_ID | CITY |
|---|---|---|---|---|
| 1 | US | United States of America | 1400 | Southlake |
| 2 | US | United States of America | 1500 | South San Francisco |
| 3 | US | United States of America | 1700 | Seattle |
| 4 | CA | Canada | 1800 | Toronto |
| 5 | UK | United Kingdom | 2500 | Oxford |



In the example in the slide, the COUNTRY_ID columns in the COUNTRIES and LOCATIONS tables are joined and thus the LOCATION_ID of the location where an employee works is shown.

## Retrieving Records by Using the ON Clause

- The join condition for the natural join is basically an equijoin of all columns with the same name.
- Use the ON clause to specify arbitrary conditions or specify columns to join.
- The ON clause makes code easy to understand.

```
SELECT e.employee_id, e.last_name, j.department_id,
FROM   employees e JOIN job_history j
ON     (e.employee_id = j.employee_id);
```

| | EMPLOYEE_ID | LAST_NAME | DEPARTMENT_ID |
|---|---|---|---|
| 1 | 101 | Kochhar | 110 |
| 2 | 101 | Kochhar | 110 |
| 3 | 102 | De Haan | 60 |
| 4 | 176 | Taylor | 80 |
| 5 | 176 | Taylor | 80 |
| 6 | 200 | Whalen | 90 |
| 7 | 200 | Whalen | 90 |
| 8 | 201 | Hartstein | 20 |



Use the ON clause to specify a join condition. With this, you can specify join conditions separate from any search or filter conditions in the WHERE clause.

In this example, the EMPLOYEE_ID columns in the EMPLOYEES and JOB_HISTORY tables are joined using the ON clause. Wherever an employee ID in the EMPLOYEES table equals an employee ID in the JOB_HISTORY table, the row is returned. The table alias is necessary to qualify the matching column names.

You can also use the ON clause to join columns that have different names. The parentheses around the joined columns, as in the example in the slide, (e.employee_id = j.employee_id), is optional. So, even ON e.employee_id = j.employee_id will work.

**Note:** When you use the Execute Statement icon to run the query, SQL Developer suffixes a '_1' to differentiate between the two employee_ids.

## Left Outer Join

- A join between two tables that returns all matched rows, as well as the unmatched rows from the left table is called a `LEFT OUTER JOIN`.
- Example:

```
SELECT c.country_id, c.country_name, l.location_id, l.city
FROM   countries c LEFT OUTER JOIN locations l
ON    (c.country_id = l.country_id) ;
```

| | COUNTRY_ID | COUNTRY_NAME | LOCATION_ID | CITY |
|---|---|---|---|---|
| 1 | CA | Canada | 1800 | Toronto |
| 2 | DE | Germany | (null) | (null) |
| 3 | UK | United Kingdom | 2500 | Oxford |
| 4 | US | United States of America | 1400 | Southlake |
| 5 | US | United States of America | 1500 | South San Francisco |
| 6 | US | United States of America | 1700 | Seattle |



This query retrieves all the rows in the `COUNTRIES` table, which is the left table, even if there is no match in the `LOCATIONS` table.

## Right Outer Join

- A join between two tables that returns all matched rows, as well as the unmatched rows from the right table is called a `RIGHT OUTER JOIN`.
- Example:

```
SELECT e.last_name, d.department_id, d.department_name
FROM   employees e RIGHT OUTER JOIN departments d
ON    (e.department_id = d.department_id) ;
```

| | LAST_NAME | DEPARTMENT_ID | DEPARTMENT_NAME |
|---|---|---|---|
| 1 | Whalen | 10 | Administration |
| 2 | Hartstein | 20 | Marketing |
| 3 | Fay | 20 | Marketing |
| 4 | Davies | 50 | Shipping |
| ... | | | |
| 18 | Higgins | 110 | Accounting |
| 19 | Gietz | 110 | Accounting |
| 20 | (null) | 190 | Contracting |



This query retrieves all the rows in the `DEPARTMENTS` table, which is the table at the right, even if there is no match in the `EMPLOYEES` table.

## Full Outer Join

- A join between two tables that returns all matched rows, as well as the unmatched rows from both tables is called a FULL OUTER JOIN.
- Example:

```
SELECT e.last_name, d.department_id, d.manager_id,
 d.department_name
FROM   employees e FULL OUTER JOIN departments d
ON    (e.manager_id = d.manager_id) ;
```

| | LAST_NAME | DEPARTMENT_ID | MANAGER_ID | DEPARTMENT_NAME |
|---|---|---|---|---|
| 1 | King | (null) | (null) | (null) |
| 2 | Kochhar | 90 | 100 | Executive |
| 3 | De Haan | 90 | 100 | Executive |
| 4 | Hunold | (null) | (null) | (null) |

...

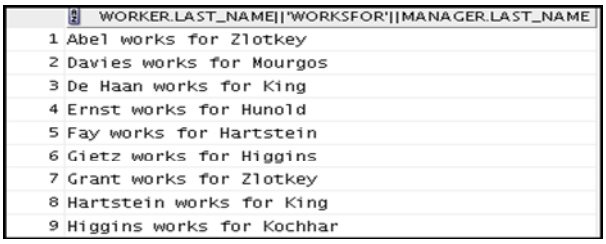
| | | | | |
|---|---|---|---|---|
| 19 | Higgins | (null) | (null) | (null) |
| 20 | Gietz | 110 | 205 | Accounting |
| 21 | (null) | 190 | (null) | Contracting |
| 22 | (null) | 10 | 200 | Administration |



This query retrieves all the rows in the EMPLOYEES table, even if there is no match in the DEPARTMENTS table. It also retrieves all the rows in the DEPARTMENTS table, even if there is no match in the EMPLOYEES table.

## Self-Join: Example

```
SELECT worker.last_name || ' works for '
       || manager.last_name
FROM   employees worker JOIN employees manager
ON worker.manager_id = manager.employee_id
ORDER BY worker.last_name;
```



| | WORKER.LAST_NAME\|\|'WORKSFOR'\|\|MANAGER.LAST_NAME |
|---|---|
| 1 | Abel works for Zlotkey |
| 2 | Davies works for Mourgos |
| 3 | De Haan works for King |
| 4 | Ernst works for Hunold |
| 5 | Fay works for Hartstein |
| 6 | Gietz works for Higgins |
| 7 | Grant works for Zlotkey |
| 8 | Hartstein works for King |
| 9 | Higgins works for Kochhar |

...



Sometimes you need to join a table to itself. To find the name of each employee's manager, you need to join the `EMPLOYEES` table to itself, or perform a self-join. The example in the slide joins the `EMPLOYEES` table to itself. To simulate two tables in the `FROM` clause, there are two aliases, namely worker and manager, for the same table, `EMPLOYEES`.

In this example, the `WHERE` clause contains the join that means "where a worker's manager ID matches the employee ID for the manager."

## Cross Join

- A `CROSS JOIN` is a `JOIN` operation that produces the Cartesian product of two tables.
- Example:

```
SELECT department_name, city
FROM department CROSS JOIN location;
```

| | DEPARTMENT_NAME | CITY |
|---|---|---|
| 1 | Administration | Oxford |
| 2 | Administration | Seattle |
| 3 | Administration | South San Francisco |
| 4 | Administration | Southlake |
| 5 | Administration | Toronto |
| 6 | Marketing | Oxford |
| 7 | Marketing | Seattle |
| 8 | Marketing | South San Francisco |
| 9 | Marketing | Southlake |
| 10 | Marketing | Toronto |

...



The `CROSS JOIN` syntax specifies the cross product. It is also known as a Cartesian product. A cross join produces the cross product of two relations, and is essentially the same as the comma-delimited Oracle Database notation.

You do not specify any `WHERE` condition between the two tables in the `CROSS JOIN`.

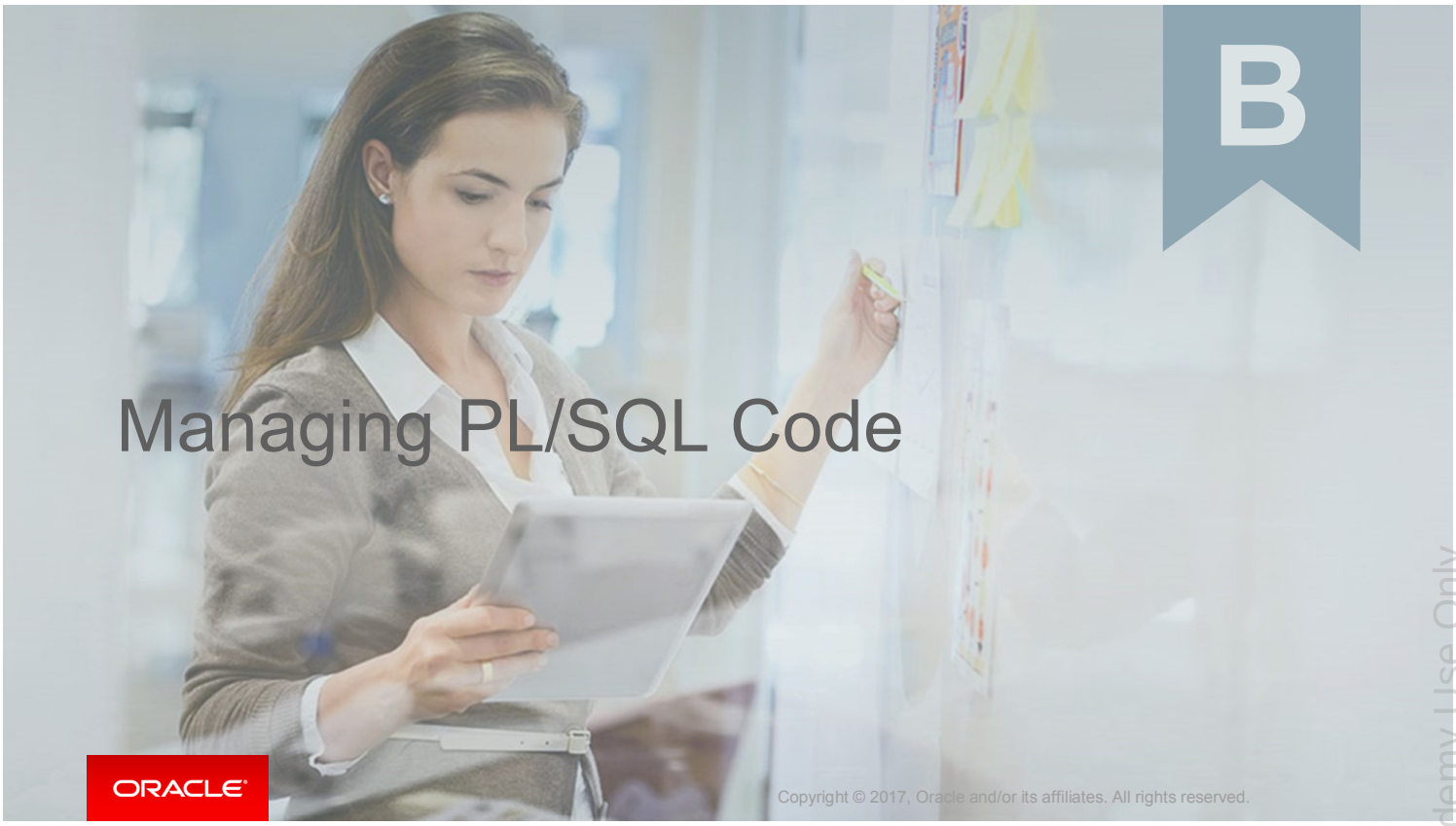
## Summary

In this appendix, you should have learned how to use:

- Execute a basic `SELECT` statement
- Create, alter, and drop a table using the data definition language (DDL) statements
- Insert, update, and delete rows from one or more tables using data manipulation language (DML) statements
- Commit, roll back, and create save points using the transaction control statements
- Perform join operations on one or more tables



This appendix covered commonly used SQL commands and statements, including DDL statements, DML statements, transaction control statements, and joins.



# Managing PL/SQL Code

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## Objectives

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

- Describe and use conditional compilation
- Hide PL/SQL source code by using dynamic obfuscation and the wrap utility



This appendix introduces the conditional compilation and obfuscating (or wrapping) PL/SQL code.

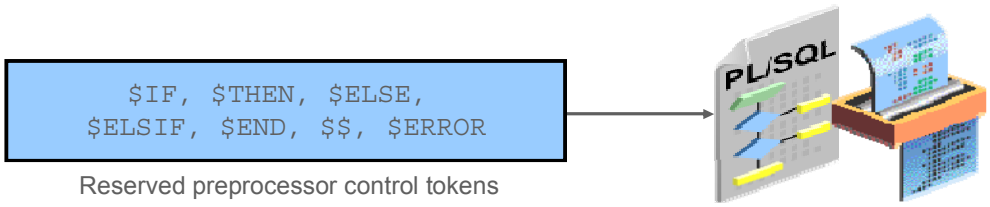
# Agenda

- Using conditional compilation
- Obfuscating PL/SQL code

## Conditional Compilation

Enables you to customize the functionality in a PL/SQL application without removing any source code:

- Use the latest functionality with the latest database release, or disable the new features to run the application against an older release of the database.
- Activate the debugging or tracing functionality in the development environment and hide that functionality in the application while it runs at a production site.




Reserved preprocessor control tokens

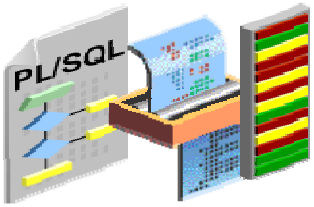


Conditional compilation enables you to selectively include code depending on the values of the conditions evaluated during compilation. For example, conditional compilation enables you to determine which PL/SQL features in a PL/SQL application are used for specific database releases. The latest PL/SQL features in an application can be run on a new database release; at the same time, those features can be conditional so that the same application is compatible with a previous database release. Conditional compilation is also useful when you want to execute debugging procedures in a development environment but want to turn off the debugging routines in a production environment.

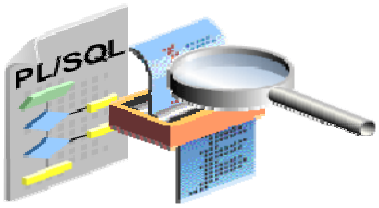
**Benefits of Conditional Compilation**

- Support for multiple versions of the same program in one source code
- Easy maintenance and debugging of code
- Easy migration of code to a different release of the database

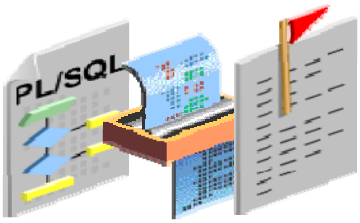
## How Does Conditional Compilation Work?




Selection directives:
Use the `$IF` token.

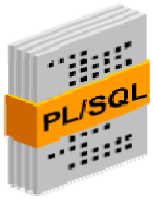



Inquiry directives:
Use the `$$` token.




Error directives:
Use the `$ERROR` token.


`DBMS_PREPROCESSOR`
package




`DBMS_DB_VERSION`
package

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You can use conditional compilation by embedding directives in your PL/SQL source programs. When the PL/SQL program is submitted for compilation, a preprocessor evaluates these directives and selects parts of the program to be compiled. The selected program source is then handed off to the compiler for compilation.

Inquiry directives use the `$$` token to make inquiries about the compilation environment, such as the value of the PL/SQL compiler `PLSQL_CCFLAGS` or `PLSQL_OPTIMIZE_LEVEL` initialization parameters for the unit being compiled. This directive can be used in conjunction with the conditional selection directive to select the parts of the program to compile.

Selection directives can test inquiry directives or static package constants by using the `$IF` construct to branch sections of code for possible compilation if a condition is satisfied.

Error directives issue a compilation error if an unexpected condition is encountered during conditional compilation done by using the $ERROR token.

The `DBMS_DB_VERSION` package provides database version and release constants that can be used for conditional compilation.

The `DBMS_PREPROCESSOR` package provides subprograms for accessing the post-processed source text that is selected by conditional compilation directives in a PL/SQL unit.

## Using Selection Directives

```
$IF <Boolean-expression> $THEN Text
$ELSIF <Boolean-expression> $THEN Text
. . .
$ELSE Text
$END
```

```
DECLARE
CURSOR cur IS SELECT employee_id FROM
employees WHERE
$IF myapp_tax_package.new_tax_code $THEN
   salary > 20000;
$ELSE
   salary > 50000;
$END
BEGIN
   OPEN cur;
. . .
END;
```

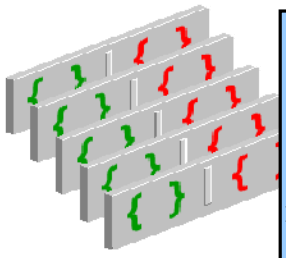


The conditional selection directive looks and operates like the `IF-THEN-ELSE` mechanism in PL/SQL proper. When the preprocessor encounters `$THEN`, it verifies that the text between `$IF` and `$THEN` is a static expression. If the check succeeds and the result of the evaluation is `TRUE`, the PL/SQL program text between `$THEN` and `$ELSE` (or `$ELSIF`) is selected for compilation.

The selection condition (the expression between `$IF` and `$THEN`) can be constructed by referring to constants defined in another package or an inquiry directive (or some combination of the two).

In the example in the slide, the conditional selection directive chooses between two versions of the cursor (`cur`) on the basis of the value of `MYAPP_TAX_PACKAGE.NEW_TAX_CODE`.
If the value is `TRUE`, employees with `salary > 20000` are selected; otherwise, employees with `salary > 50000` are selected.

## Using Predefined and User-Defined Inquiry Directives



```
PLSQL_CCFLAGS
PLSQL_CODE_TYPE
PLSQL_OPTIMIZE_LEVEL
PLSQL_WARNINGS
NLS_LENGTH_SEMANTICS
PLSQL_LINE
PLSQL_UNIT
```

Predefined inquiry directives

```
PLSQL_CCFLAGS = 'plsql_ccflags:true,debug:true,debug:0';
```

User-defined inquiry directives



An inquiry directive can be predefined or user-defined. Following is the order of the processing flow when conditional compilation attempts to resolve an inquiry directive:

1. The ID is used as an inquiry directive in the form `$$id` for the search key.
2. The two-pass algorithm proceeds as follows:
   a. The string in the `PLSQL_CCFLAGS` initialization parameter is scanned from right to left, searching by ID for a matching name (not case sensitive). Processing is done if an ID is found.
   b. The predefined inquiry directives are searched. Processing is done if an ID is found.
3. If the `$$ID` cannot be resolved to a value, the `PLW-6003` warning message is reported if the source text is not wrapped. The literal `NULL` is substituted as the value for undefined inquiry directives.
   **Note:** If the PL/SQL code is wrapped, the warning message is disabled so that the undefined inquiry directive is not revealed.

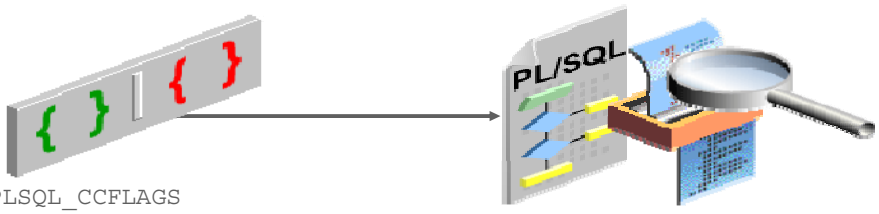
In the example in the slide, the value of `$$debug` is `0` and the value of `$$plsql_ccflags` is `TRUE`. Note that the value of `$$plsql_ccflags` resolves to the user-defined `plsql_ccflags` inside the value of the `PLSQL_CCFLAGS` compiler parameter. This occurs because a user-defined directive overrides the predefined one.

## The PLSQL_CCFLAGS Parameter and the Inquiry Directive

Use the PLSQL_CCFLAGS parameter to control conditional compilation of each PL/SQL library unit independently.

```
PLSQL_CCFLAGS = '<v1>:<c1>,<v2>:<c2>,...,<vn>:<cn>'
```

```
ALTER SESSION SET
PLSQL_CCFLAGS = 'plsql_ccflags:true, debug:true, debug:0';
```




PLSQL_CCFLAGS
initialization parameter

Inquiry directive



Oracle Database 10*g* Release 2 introduced a new Oracle initialization parameter PLSQL_CCFLAGS for use with conditional compilation. This dynamic parameter enables you to set up name-value pairs. The names (called "flag names") can then be referenced in inquiry directives. PLSQL_CCFLAGS provides a mechanism that enables PL/SQL programmers to control the conditional compilation of each PL/SQL library unit independently.

**Values**

- vi: Has the form of an unquoted PL/SQL identifier that is unrestricted and can be a reserved word or a keyword. The text is not case sensitive. Each is known as a flag or a flag name. Each vi can occur more than once in the string, each occurrence can have a different flag value, and the flag values can be of different kinds.
- ci: Can be any of the following:
  - A PL/SQL Boolean literal
  - A PLS_INTEGER literal
  - The literal NULL (default). The text is not case sensitive. Each is known as a flag value and corresponds to a flag name.

# Displaying the PLSQL_CCFLAGS Initialization Parameter Setting

```
SELECT name, type, plsql_ccflags
FROM  user_plsql_object_settings
```

Results:

| | NAME | TYPE | PLSQL_CCFLAGS |
|---|---|---|---|
| 1 | DEPT_PKG | PACKAGE | (null) |
| 2 | DEPT_PKG | PACKAGE BODY | (null) |
| 3 | TAXES_PKG | PACKAGE | (null) |
| 4 | TAXES_PKG | PACKAGE BODY | (null) |
| 5 | EMP_PKG | PACKAGE | (null) |
| 6 | EMP_PKG | PACKAGE BODY | (null) |
| 7 | SECURE_DML | PROCEDURE | (null) |
| 8 | SECURE_EMPLOYEES | TRIGGER | (null) |
| 9 | ADD_JOB_HISTORY | PROCEDURE | plsql_ccflags:true, debug:true, debug:0 |
| 10 | UPDATE_JOB_HISTORY | TRIGGER | (null) |

. . .



Use the USER | ALL | DBA_PLSQL_OBJECT_SETTINGS data dictionary views to display the settings of a PL/SQL object.

You can define any allowable value for PLSQL_CCFLAGS. However, Oracle recommends that this parameter be used for controlling the conditional compilation of debugging or tracing code.

The flag names can be set to any identifier, including reserved words and keywords. The values must be the literals TRUE, FALSE, or NULL, or a PLS_INTEGER literal. The flag names and values are not case sensitive. The PLSQL_CCFLAGS parameter is a PL/SQL compiler parameter (like other compiler parameters) and is stored with the PL/SQL program unit. Consequently, if the PL/SQL program is recompiled later with the REUSE SETTINGS clause (example, ALTER PACKAGE …REUSE SETTINGS), the same value of PLSQL_CCFLAGS is used for the recompilation. Because the PLSQL_CCFLAGS parameter can be set to a different value for each PL/SQL unit, it provides a convenient method for controlling conditional compilation on a per-unit basis.

## The PLSQL_CCFLAGS Parameter and the Inquiry Directive: Example

```
ALTER SESSION SET PLSQL_CCFLAGS = 'Tracing:true';
CREATE OR REPLACE PROCEDURE P IS
BEGIN
  $IF $$tracing $THEN
      DBMS_OUTPUT.PUT_LINE ('TRACING');
  $END
END P;
```

```
ALTER SESSION SET succeeded.
PROCEDURE P Compiled.
```

```
SELECT name, plsql_ccflags
FROM USER_PLSQL_OBJECT_SETTINGS
WHERE name = 'P';
```

Results:

| | NAME | PLSQL_CCFLAGS |
|---|---|---|
| 1 | P | Tracing:true |



In the example in the slide, the parameter is set and then the procedure is created. The setting is stored with each PL/SQL unit.

# Using Conditional Compilation Error Directives to Raise User-Defined Errors

```
$ERROR varchar2_static_expression $END
```

```
ALTER SESSION SET Plsql_CCFlags = ' Trace_Level:3 '
/
CREATE PROCEDURE P IS
BEGIN
  $IF    $$Trace_Level = 0 $THEN ...;
  $ELSIF $$Trace_Level = 1 $THEN ...;
  $ELSIF $$Trace_Level = 2 $THEN ...;
  $else $error 'Bad: '||$$Trace_Level $END -- error
                                            -- directive
  $END -- selection directive ends
END P;
```

```
SHOW ERRORS
Errors for PROCEDURE P:
LINE/COL ERROR
-------- -----------------------------------
6/9      PLS-00179: $ERROR: Bad: 3
```



The `$ERROR` error directive raises a user-defined error and is of the following form:

`$ERROR varchar2_static_expression $END`

**Note:** `varchar2_static_expression` must be a `VARCHAR2` static expression.

## Using Static Expressions with Conditional Compilation

- `Boolean` static expressions:
  - `TRUE, FALSE, NULL, IS NULL, IS NOT NULL`
  - `> , < , >= , <= , = , <>, NOT, AND, OR`
- `PLS_INTEGER` static expressions:
  - `-2147483648` to `2147483647, NULL`
- `VARCHAR2` static expressions include:
  - `||, NULL, TO_CHAR`
- Static constants:

```
static_constant CONSTANT datatype := static_expression;
```



As described earlier, a preprocessor processes conditional directives before proper compilation begins. Consequently, only those expressions that can be fully evaluated at compile time are permitted in conditional compilation directives. Expressions that contain references to variables or functions that require the execution of the PL/SQL are not available during compilation and cannot be evaluated.

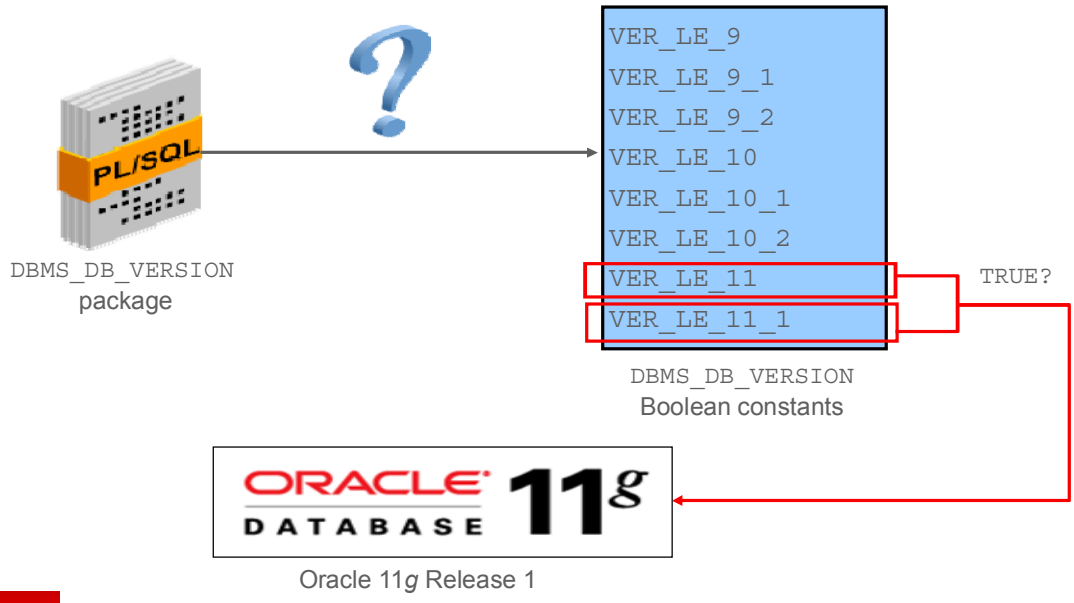
These PL/SQL expressions that are allowed in conditional compilation directives are referred to as “static expressions.” Static expressions are carefully defined to guarantee that if a unit is automatically recompiled without any changes to the values it depends on, the expressions evaluate in the same way and the same source is compiled.

Static expressions are typically composed of three sources:

- Inquiry directives marked with `$$`
- Constants defined in PL/SQL packages such as `DBMS_DB_VERSION`. These values can be combined and compared using the ordinary operations of PL/SQL.
- Literals such as `TRUE`, `FALSE`, 'CA', `123`, and `NULL`

Static expressions can also contain operations that include comparisons, logical Boolean operations (such as `OR` and `AND`), or concatenations of static character expression.

## DBMS_DB_VERSION Package: Boolean Constants






Oracle Database 10*g* Release 2 introduced the `DBMS_DB_VERSION` package. This package specifies the Oracle Database version and release numbers that are useful when making simple selections for conditional compilation.

The constants represent a Boolean condition that evaluates to less than or equal to the version and the release, if present.

**Example**

`VER_LE_11` indicates that the database version `<= 11`. The values of the constants are either `TRUE` or `FALSE`. For example, in an Oracle Database 11*g* Release 1 database, `VER_LE_11` and `VER_LE_11_1` are `TRUE` and all other constants are `FALSE`.

## DBMS_DB_VERSION Package Constants

| Name | Description |
|---|---|
| VER_LE_9 | Version <= 9. |
| VER_LE_9_1 | Version <= 9 and release <= 1. |
| VER_LE_9_2 | Version <= 9 and release <= 2. |
| VER_LE_10 | Version <= 10. |
| VER_LE_10_1 | Version <= 10 and release <= 1. |
| VER_LE_10_2 | Version <=10 and release <= 2. |
| VER_LE_11 | Version <= 11. |
| VER_LE_11_1 | Version <=11 and release <= 1. |





The package for the Oracle Database 11*g* Release 1 version is shown as follows:

```
PACKAGE DBMS_DB_VERSION IS
   VERSION CONSTANT PLS_INTEGER := 11; -- RDBMS version
                                       -- number
   RELEASE CONSTANT PLS_INTEGER := 1;  -- RDBMS release
                                       -- number
   ver_le_9_1    CONSTANT BOOLEAN := FALSE;
   ver_le_9_2    CONSTANT BOOLEAN := FALSE;
   ver_le_9      CONSTANT BOOLEAN := FALSE;
   ver_le_10_1   CONSTANT BOOLEAN := FALSE;
   ver_le_10_2   CONSTANT BOOLEAN := FALSE;
   ver_le_10     CONSTANT BOOLEAN := FALSE;
   ver_le_11_1   CONSTANT BOOLEAN := TRUE;
   ver_le_11     CONSTANT BOOLEAN := TRUE;
END DBMS_DB_VERSION;
```

The DBMS_DB_VERSION package contains different constants for different Oracle Database releases. The Oracle Database 11*g* Release 1 version of the DBMS_DB_VERSION package uses the constants shown in the slide.

## Using Conditional Compilation with Database Versions: Example

```
ALTER SESSION SET PLSQL_CCFLAGS = 'my_debug:FALSE, my_tracing:FALSE';
CREATE PACKAGE my_pkg AS
  SUBTYPE my_real IS
  -- Check the database version, if >= 10g, use BINARY_DOUBLE data type,
  -- else use NUMBER data type
    $IF DBMS_DB_VERSION.VERSION < 10 $THEN   NUMBER;
    $ELSE  BINARY_DOUBLE;
    $END
  my_pi my_real; my_e my_real;
END my_pkg;
/
CREATE PACKAGE BODY my_pkg AS
BEGIN
  $IF DBMS_DB_VERSION.VERSION < 10 $THEN
       my_pi := 3.14016408289008292431940027343666863227;
       my_e  := 2.71828182845904523536028747135266249775;
  $ELSE
       my_pi := 3.14016408289008292431940027343666863227d;
       my_e  := 2.71828182845904523536028747135266249775d;
  $END
END my_pkg;
/
```

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This example also shows the use of the `PLSQL_CCFLAGS` parameter. You first set the `PLSQL_CCFLAGS` parameter flag to display debugging code and tracing information.

In the example in the slide on this page and the next page, conditional compilation is used to specify code for database versions. Conditional compilation is used to determine whether the `BINARY_DOUBLE` data type can be used in the calculations for PL/SQL units in the database. The `BINARY_DOUBLE` data type can be used only in Oracle Database 10*g* or later. If you are using Oracle Database 10*g*, the data type for `my_real` is `BINARY_DOUBLE`; otherwise, the data type for `my_real` is `NUMBER`.

In the specification of the new package (`my_pkg`), conditional compilation is used to check for the database version. In the body definition of the package, conditional compilation is used again to set the values of `my_pi` and `my_e` for future calculations based on the database version.

The result of the example code in the slide is as follows:

```
PACKAGE my_pkg compiled
PACKAGE BODY my_pkg compiled
session SET altered.
```

## Using Conditional Compilation with Database Versions: Example

```
CREATE OR REPLACE PROCEDURE circle_area(p_radius my_pkg.my_real) IS
  v_my_area my_pkg.my_real;
  v_my_datatype VARCHAR2(30);
BEGIN
  v_my_area := my_pkg.my_pi * p_radius * p_radius;
  DBMS_OUTPUT.PUT_LINE('Radius: ' || TO_CHAR(p_radius)
                       || ' Area: ' || TO_CHAR(v_my_area) );
  $IF $$my_debug $THEN -- if my_debug is TRUE, run some debugging code
    SELECT DATA_TYPE INTO v_my_datatype FROM USER_ARGUMENTS
       WHERE OBJECT_NAME = 'CIRCLE_AREA' AND ARGUMENT_NAME = 'P_RADIUS';
     DBMS_OUTPUT.PUT_LINE('Datatype of the RADIUS argument is: ' ||
    v_my_datatype);
  $END
END; /
```

```
PROCEDURE circle_area compiled
```

```
CALL circle_area(50); -- Using Oracle Database 11g Release 2
```

```
CALL circle_area(50) succeeded.
Radius: 5.0E+001 Area: 7.8504102072252062E+003
```



In the example in the slide, a new procedure called `circle_area` is defined. This procedure calculates the area of a circle based on the values of the variables in the `my_pkg` package defined on the previous page. The procedure has one informal parameter: `radius`.

The procedure declares two variables:

- `my_area`, which is the same data type as `my_real` in `my_pkg`
- `my_datatype`, which is a `VARCHAR2(30)`

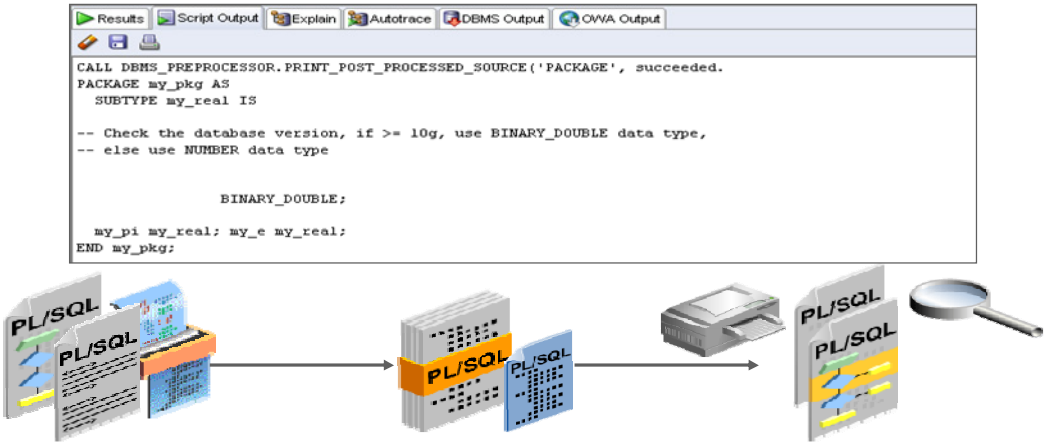
In the procedure's body, `my_area` becomes equal to the value of `my_pi` set in `my_pkg` multiplied by the value that is passed to the procedure as a radius. A message is printed displaying the radius and the area of the circle, as shown in the second code example in the slide.

**Note:** If you want to set `my_debug` to `TRUE`, you can make this change only for the `circle_area` procedure with the `REUSE SETTINGS` clause as follows:

```
ALTER PROCEDURE circle_area COMPILE PLSQL_CCFLAGS = 'my_debug:TRUE' REUSE
SETTINGS;
```

# Using DBMS_PREPROCESSOR Procedures to Print or Retrieve Source Text

```
CALL
    DBMS_PREPROCESSOR.PRINT_POST_PROCESSED_SOURCE('PACKAGE',
    'ORA61', 'MY_PKG');
```






`DBMS_PREPROCESSOR` subprograms print or retrieve the postprocessed source text of a PL/SQL unit after processing the conditional compilation directives. This postprocessed text is the actual source that is used to compile a valid PL/SQL unit. The example in the slide shows how to print the postprocessed form of `my_pkg` by using the `PRINT_POST_PROCESSED_SOURCE` procedure.

When `my_pkg` is compiled on an Oracle Database 10*g* release (or later) database using the HR account, the resulting output is shown in the slide.

The `PRINT_POST_PROCESSED_SOURCE` removes unselected text. The lines of code that are not included in the postprocessed text are removed. The arguments for the `PRINT_POST_PROCESSED_SOURCE` procedure are object type, schema name (using student account `ORA61`), and object name.

**Note:** For additional information about the `DBMS_PREPROCESSOR` package, refer to the *Oracle Database PL/SQL Packages and Types Reference*.

# Agenda

- Using conditional compilation
- Obfuscating PL/SQL code

## Obfuscation

- The obfuscation (or wrapping) of a PL/SQL unit is the process of hiding the PL/SQL source code.
- Wrapping can be done with the `wrap` utility and `DBMS_DDL` subprograms.
- The `wrap` utility is run from the command line. It processes an input SQL file, such as a SQL*Plus installation script.
- The `DBMS_DDL` subprograms wrap a single PL/SQL unit, such as a single `CREATE PROCEDURE` command, that has been generated dynamically.

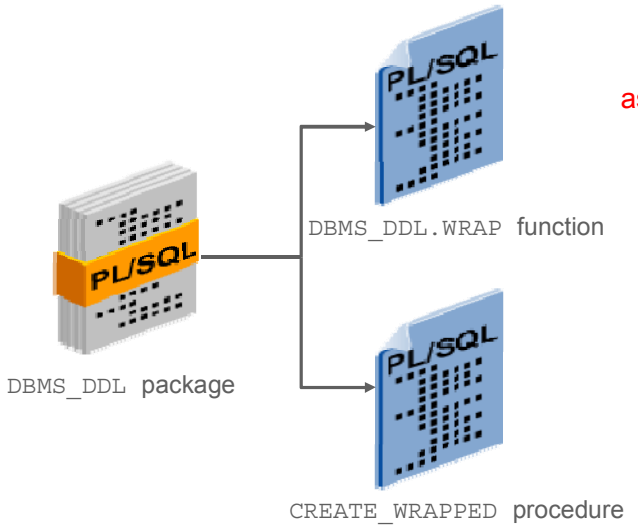


**Note:** For additional information about obfuscation, refer to the *Oracle Database PL/SQL Language Reference*.

# Benefits of Obfuscating

- It prevents others from seeing your source code.
- Your source code is not visible through the `USER_SOURCE`, `ALL_SOURCE`, or `DBA_SOURCE` data dictionary views.
- SQL*Plus can process the obfuscated source files.
- The `Import` and `Export` utilities accept wrapped files.

## What's New in Dynamic Obfuscating Since Oracle 10*g*?




Provides the same functionality as the `CREATE_WRAPPED` procedure but enables larger inputs

Wraps the text and creates the PL/SQL unit



### `CREATE_WRAPPED` Procedure

Does the following:

1. Takes as input a single `CREATE OR REPLACE` statement that specifies creation of a PL/SQL package specification, package body, function, procedure, type specification, or type body
2. Generates a `CREATE OR REPLACE` statement in which the PL/SQL source text has been obfuscated
3. Executes the generated statement

### `WRAP` Function

Does the following:

1. Takes as input a `CREATE OR REPLACE` statement that specifies the creation of a PL/SQL package specification, package body, function, procedure, type specification, or type body
2. Returns a `CREATE OR REPLACE` statement in which the text of the PL/SQL unit has been obfuscated

## Nonobfuscated PL/SQL Code: Example

```
SET SERVEROUTPUT ON
BEGIN -- The ALL_SOURCE view family shows source code
  EXECUTE IMMEDIATE '
    CREATE OR REPLACE PROCEDURE P1 IS
    BEGIN
      DBMS_OUTPUT.PUT_LINE (''I am not wrapped'');
    END P1;
  ';
END;
/
CALL p1();
```

```
anonymous block completed
CALL p1() succeeded.
I'm not wrapped
```

```
SELECT text FROM user_source
WHERE name = 'P1' ORDER BY line;
```

| | TEXT |
|---|---|
| 1 | PROCEDURE P1 IS |
| 2 | BEGIN |
| 3 | DBMS_OUTPUT.PUT_LINE ('I am not wrapped'); |
| 4 | END P1; |

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In the first example in the slide, the `EXECUTE IMMEDIATE` statement is used to create the `P1` procedure. The code in the created procedure is not wrapped. The code is not hidden when you use any of the views from the `ALL_SOURCE` view family to display the procedure's code as shown in the slide.

## Obfuscated PL/SQL Code: Example

```
BEGIN -- ALL_SOURCE view family obfuscates source code
  DBMS_DDL.CREATE_WRAPPED ( '
    CREATE OR REPLACE PROCEDURE P1 IS
    BEGIN
      DBMS_OUTPUT.PUT_LINE (''I am wrapped now'');
    END P1;
  ' );
END;
/
CALL p1();
```

```
anonymous block completed
p1 ) succeeded.
```

```
SELECT text FROM user_source
WHERE name = 'P1' ORDER BY line;
```

```
TEXT
--------------------------------------------------------------------------------
PROCEDURE P1 wrapped
a000000
b2
abcd
...
```



In the example in the slide, the `DBMS_DDL.CREATE_WRAPPED` package procedure is used to create the `P1` procedure. The code is obfuscated when you use any of the views from the `ALL_SOURCE` view family to display the procedure's code (as shown on the next page). When you check the `*_SOURCE` views, the source is wrapped, or hidden, so that others cannot view the code details shown in the output of the command in the slide.

## Dynamic Obfuscation: Example

```
SET SERVEROUTPUT ON

DECLARE
c_code CONSTANT VARCHAR2(32767) :=
' CREATE OR REPLACE PROCEDURE new_proc AS
  v_VDATE  DATE;
  BEGIN
    v_VDATE := SYSDATE;
    DBMS_OUTPUT.PUT_LINE(v_VDATE) ;
  END; ' ;
BEGIN
  DBMS_DDL.CREATE_WRAPPED (c_CODE);
END;
/
```



The example in the slide displays the creation of a dynamically obfuscated procedure called NEW_PROC. To verify that the code for NEW_PROC is obfuscated, you can query from the DBA|ALL|USER_SOURCE dictionary views:

```
SELECT text FROM user_source
WHERE name = 'NEW_PROC';
```

```
TEXT
--------------------------------------------------------------------------------
PROCEDURE new_proc wrapped
a000000
```

```
7
71 9e
hBWMpGeSsd58b4jCP3/0d04rof0wg5nnm7+fMr2ywFyFDGLQlhaXriu4dCuPCWnnx1J0Ulxp
pvc8nsr7Seq/riQvHRsXAQovdoh0K6ZvMlKbskr+KLK957KzHQYwLK4k6rJLCS5EyJ7qJB/2
RDmm3j79Uw==
```

## PL/SQL Wrapper Utility

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



Using the PL/SQL Wrapper utility, you can deliver PL/SQL applications without exposing your source code, which may contain proprietary algorithms and data structures. The Wrapper utility converts the readable source code into unreadable code. By hiding application internals, it prevents misuse of your application.

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

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

## Running the PL/SQL Wrapper Utility

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

- Do not use spaces around the equal signs.
- The INAME argument is required.
- The default extension for the input file is .sql, unless it is specified with the name.
- The ONAME argument is optional.
- The default extension for output file is .plb, unless specified with the ONAME argument.

Examples

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



The PL/SQL Wrapper utility is an operating system executable called WRAP.

**Note:** This is 11*g*-only code.

To run the wrapper, enter the following command at your operating system prompt:

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

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

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

**Note**

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

## Results of Wrapping

```
-- Original PL/SQL source code in input file:

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

```
-- Wrapped code in output file:
CREATE PACKAGE banking
    wrapped
012abc463e ...
/
```



When it is wrapped, an object type, package, or subprogram has the following form: header, followed by the word `wrapped`, followed by the encrypted body.

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

- `CREATE [OR REPLACE] TYPE`
- `CREATE [OR REPLACE] TYPE BODY`
- `CREATE [OR REPLACE] PACKAGE`
- `CREATE [OR REPLACE] PACKAGE BODY`
- `CREATE [OR REPLACE] FUNCTION`
- `CREATE [OR REPLACE] PROCEDURE`

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

## Guidelines for Wrapping

- You must wrap only the package body and not the package specification.
- The wrapper can detect syntactic errors but cannot detect semantic errors.
- The output file should not be edited. You maintain the original source code and wrap again as required.
- To ensure that all the important parts of your source code are obfuscated, view the wrapped file in a text editor before distributing it.





Guidelines include the following:

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

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

  However, the PL/SQL compiler resolves external references. Therefore, semantic errors are reported when the wrapper output file (`.plb` file) is compiled.
- Because its contents are not readable, the output file should not be edited. To change a wrapped object, you must modify the original source code and wrap the code again.

## DBMS_DDL Package Versus wrap Utility

| Functionality | DBMS_DDL Package | wrap Utility |
|---|---|---|
| Code obfuscation | Yes | Yes |
| Dynamic Obfuscation | Yes | No |
| Obfuscate multiple programs at a time | No | Yes |





Both the wrap utility and the DBMS_DDL package have distinct uses.

### wrap Utility

The wrap utility is useful for obfuscating multiple programs with one execution of the utility. In essence, a complete application can be wrapped. However, the wrap utility cannot be used to obfuscate dynamically generated code at run time. The wrap utility processes an input SQL file and obfuscates only the PL/SQL units in the file, such as:

- Package specification and body
- Function and procedure
- Type specification and body

The wrap utility does not obfuscate PL/SQL content in:

- Anonymous blocks
- Triggers
- Non-PL/SQL code

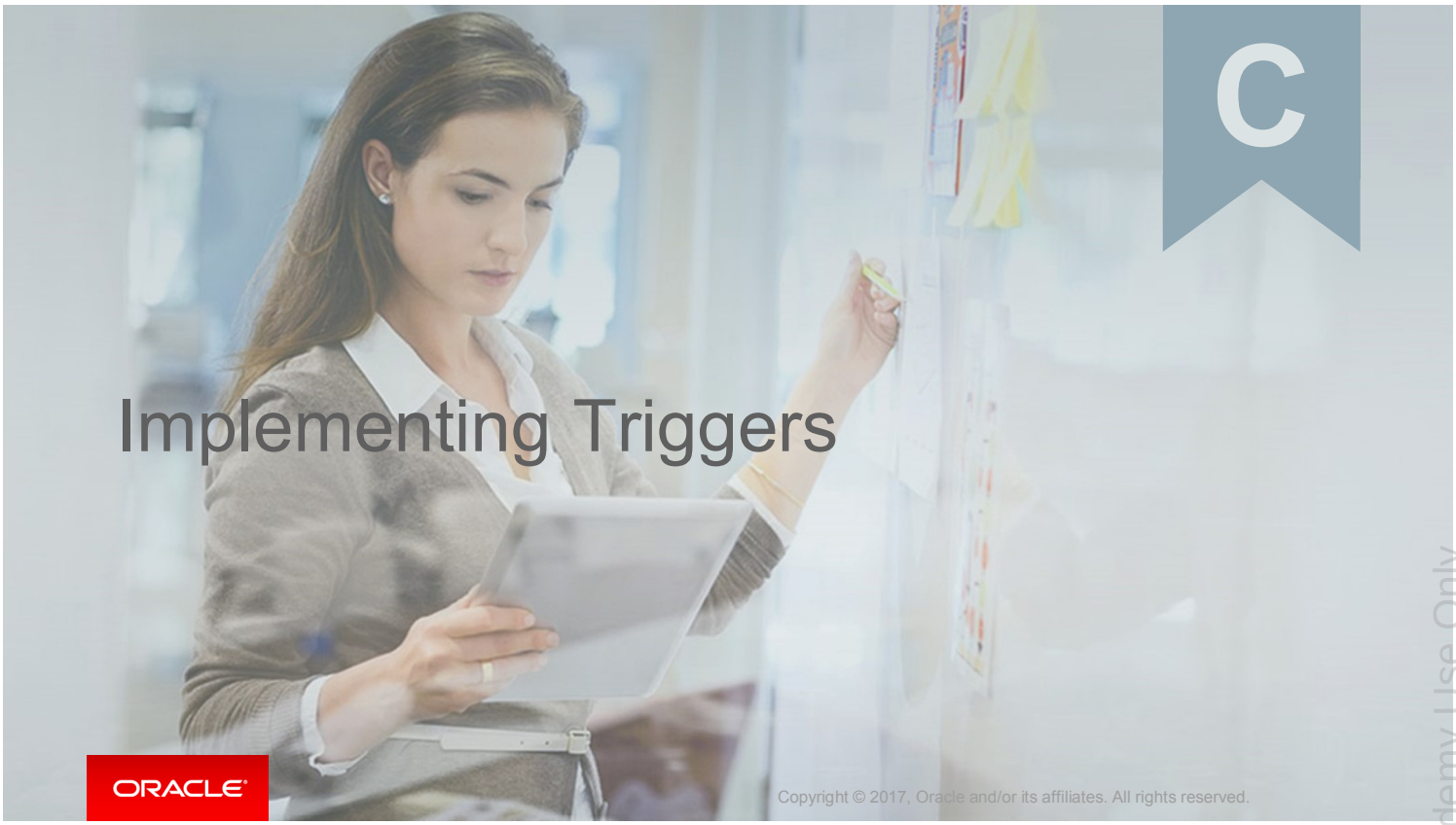
### DBMS_DDL Package

The DBMS_DDL package is intended to obfuscate a dynamically generated program unit from within another program unit. The DBMS_DDL package methods cannot obfuscate multiple program units at one execution. Each execution of these methods accepts only one CREATE OR REPLACE statement at a time as argument.

# Summary

In this appendix, you should have learned how to:

- Describe and use conditional compilation
- Hide PL/SQL source code by using dynamic obfuscation and the `wrap` utility



# Implementing Triggers

## Objectives

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

- Enhance database security with triggers
- Enforce data integrity with DML triggers
- Maintain referential integrity using triggers
- Use triggers to replicate data between tables
- Use triggers to automate computation of derived data
- Provide event-logging capabilities by using triggers



In this lesson, you learn to develop database triggers in order to enhance features that cannot otherwise be implemented by the Oracle server. In some cases, it may be sufficient to refrain from using triggers and accept the functionality provided by the Oracle server.

This lesson covers the following business application scenarios:

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

## Controlling Security Within the Server

Using database security with the `GRANT` statement

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



Develop schemas and roles within the Oracle server to control the security of data operations on tables according to the identity of the user.

- Base privileges upon the username supplied when the user connects to the database.
- Determine access to tables, views, synonyms, and sequences.
- Determine query, data-manipulation, and data-definition privileges.

## Controlling Security with a Database Trigger

```
CREATE OR REPLACE TRIGGER secure_emp
  BEFORE INSERT OR UPDATE OR DELETE ON employees
DECLARE
dummy PLS_INTEGER;
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 dummy FROM holiday
 WHERE holiday_date = TRUNC (SYSDATE);
 IF dummy > 0 THEN
   RAISE_APPLICATION_ERROR(-20507,
     'You may not change data on a holiday.');
 END IF;
END;
/
```



Develop triggers to handle more complex security requirements.

- Base privileges on any database values, such as the time of day, the day of the week, and so on.
- Determine access to tables only.
- Determine data-manipulation privileges only.

## Enforcing Data Integrity Within the Server

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



You can enforce data integrity within the Oracle server and develop triggers to handle more complex data integrity rules.

The standard data integrity rules are not null, unique, primary key, and foreign key.

Use these rules to:

- Provide constant default values
- Enforce static constraints
- Enable and disable dynamically

**Example**

The code sample in the slide ensures that the salary is at least $500.

## 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;
/
```



Protect data integrity with a trigger and enforce nonstandard data integrity checks.

- Provide variable default values.
- Enforce dynamic constraints.
- Enable and disable dynamically.
- Incorporate declarative constraints within the definition of a table to protect data integrity.

**Example**

The code sample in the slide ensures that the salary is never decreased.

## 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;
```



Incorporate referential integrity constraints within the definition of a table to prevent data inconsistency and enforce referential integrity within the server.

- Restrict updates and deletes.
- Cascade deletes.
- Enable and disable dynamically.

**Example**

When a department is removed from the `DEPARTMENTS` parent table, cascade the deletion to the corresponding rows in the `EMPLOYEES` child table.

## 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;
/
```



The following referential integrity rules are not supported by declarative constraints:

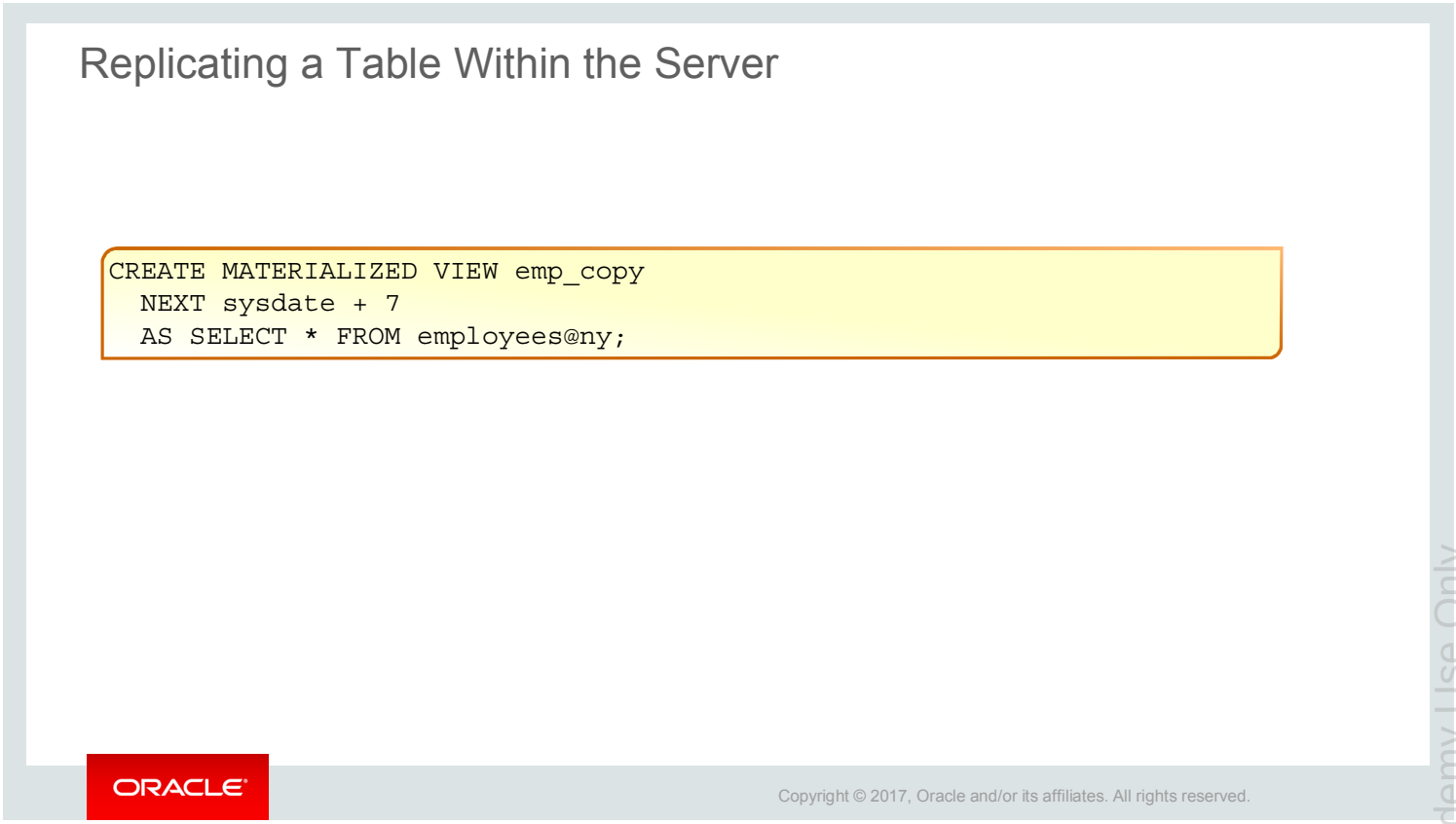
- Cascade updates.
- Set to `NULL` for updates and deletions.
- Set to a default value on updates and deletions.
- Enforce referential integrity in a distributed system.
- Enable and disable dynamically.

You can develop triggers to implement these integrity rules.

**Example**

Enforce referential integrity with a trigger. When the value of `DEPARTMENT_ID` changes in the `DEPARTMENTS` parent table, cascade the update to the corresponding rows in the `EMPLOYEES` child table.

For a complete referential integrity solution using triggers, a single trigger is not enough.




## Creating a Materialized View

Materialized views enable you to maintain copies of remote data on your local node for replication purposes. You can select data from a materialized view as you would from a normal database table or view. A materialized view is a database object that contains the results of a query, or a copy of some database on a query. The `FROM` clause of the query of a materialized view can name tables, views, and other materialized views.

When a materialized view is used, replication is performed implicitly by the Oracle server. This performs better than user-defined PL/SQL triggers for replication. Materialized views:

- Copy data from local and remote tables asynchronously, at user-defined intervals
- Can be based on multiple master tables
- Are read-only by default, unless using the Oracle Advanced Replication feature
- Improve the performance of data manipulation on the master table

Alternatively, you can replicate tables using triggers.

The example in the slide creates a copy of the remote `EMPLOYEES` table from New York. The `NEXT` clause specifies a date-time expression for the interval between automatic refreshes.

## Replicating a Table with a Trigger

```
CREATE OR REPLACE TRIGGER emp_replica
 BEFORE INSERT OR UPDATE ON employees FOR EACH ROW
BEGIN /* Proceed if user initiates data operation,
         NOT through the cascading trigger.*/
  IF INSERTING THEN
   IF :NEW.flag IS NULL THEN
     INSERT INTO employees@sf
     VALUES(:new.employee_id,...,'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;
```



You can replicate a table with a trigger. By replicating a table, you can:

- Copy tables synchronously, in real time
- Base replicas on a single master table
- Read from replicas as well as write to them

**Note:** Excessive use of triggers can impair the performance of data manipulation on the master table, particularly if the network fails.

**Example**

In New York, replicate the local `EMPLOYEES` table to San Francisco.

## Computing Derived Data Within the Server

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



By using the server, you can schedule batch jobs or use the database Scheduler for the following scenarios:

- Compute derived column values asynchronously, at user-defined intervals.
- Store derived values only within database tables.
- Modify data in one pass to the database and calculate derived data in a second pass.

Alternatively, you can use triggers to keep running computations of derived data.

**Example**

Keep the salary total for each department within a special `TOTAL_SALARY` column of the `DEPARTMENTS` table.

## Computing Derived Values with a Trigger

```
CREATE PROCEDURE increment_salary
  (id NUMBER, new_sal NUMBER) IS
BEGIN
   UPDATE departments
   SET    total_sal = NVL (total_sal, 0)+ new_sal
   WHERE  department_id = 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;
```



By using a trigger, you can perform the following tasks:

- Compute derived columns synchronously, in real time.
- Store derived values within database tables or within package global variables.
- Modify data and calculate derived data in a single pass to the database.

**Example**

Keep a running total of the salary for each department in the special `TOTAL_SALARY` column of the `DEPARTMENTS` table.

## 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
 dsc product_descriptions.product_description%TYPE;
 msg_text VARCHAR2(2000);
BEGIN
  IF :NEW.quantity_on_hand <=
     :NEW.reorder_point THEN
    SELECT product_description INTO dsc
    FROM product_descriptions
    WHERE product_id = :NEW.product_id;
  _ msg_text := 'ALERT: INVENTORY LOW ORDER:'||
       'Yours,' ||CHR(10) ||user || '.'|| CHR(10);
  ELSIF :OLD.quantity_on_hand >=
        :NEW.quantity_on_hand THEN
    msg_text := 'Product #'||... CHR(10);
  END IF;
  UTL_MAIL.SEND('inv@oracle.com','ord@oracle.com',
   message=>msg_text, subject=>'Inventory Notice');
END;
```



In the server, you can log events by querying data and performing operations manually. This sends an email message when the inventory for a particular product has fallen below the acceptable limit. This trigger uses the Oracle-supplied package `UTL_MAIL` to send the email message.

**Logging Events Within the Server**

1. Query data explicitly to determine whether an operation is necessary.
2. Perform the operation, such as sending a message.

**Using Triggers to Log Events**

1. Perform operations implicitly, such as firing off an automatic electronic memo.
2. Modify data and perform its dependent operation in a single step.
3. Log events automatically when data is changing.

### Logging Events Transparently

In the trigger code:

- `CHR(10)` is a carriage return
- `Reorder_point` is not `NULL`
- Another transaction can receive and read the message in the pipe

Example

```
CREATE OR REPLACE TRIGGER notify_reorder_rep
BEFORE UPDATE OF amount_in_stock, reorder_point
ON inventory  FOR EACH ROW
DECLARE
  dsc product.descrip%TYPE;
  msg_text VARCHAR2(2000);
BEGIN
  IF  :NEW.amount_in_stock <= :NEW.reorder_point THEN
    SELECT descrip INTO  dsc
    FROM PRODUCT WHERE prodid = :NEW.product_id;
    msg_text := 'ALERT: INVENTORY LOW ORDER:'||CHR(10)||
    'It has come to my personal attention that, due to recent'
    ||CHR(10)||'transactions, our inventory for product # '||
    TO_CHAR(:NEW.product_id)||'-- '|| dsc ||
    ' -- has fallen below acceptable levels.' || CHR(10) ||
    'Yours,' ||CHR(10) ||user || '.'|| CHR(10)|| CHR(10);
  ELSIF :OLD.amount_in_stock >= :NEW.amount_in_stock THEN
    msg_text := 'Product #'|| TO_CHAR(:NEW.product_id)
    ||' ordered. '|| CHR(10)|| CHR(10);
  END IF;
  UTL_MAIL.SEND('inv@oracle.com', 'ord@oracle.com',
     message => msg_text, subject => 'Inventory Notice');
END;
```

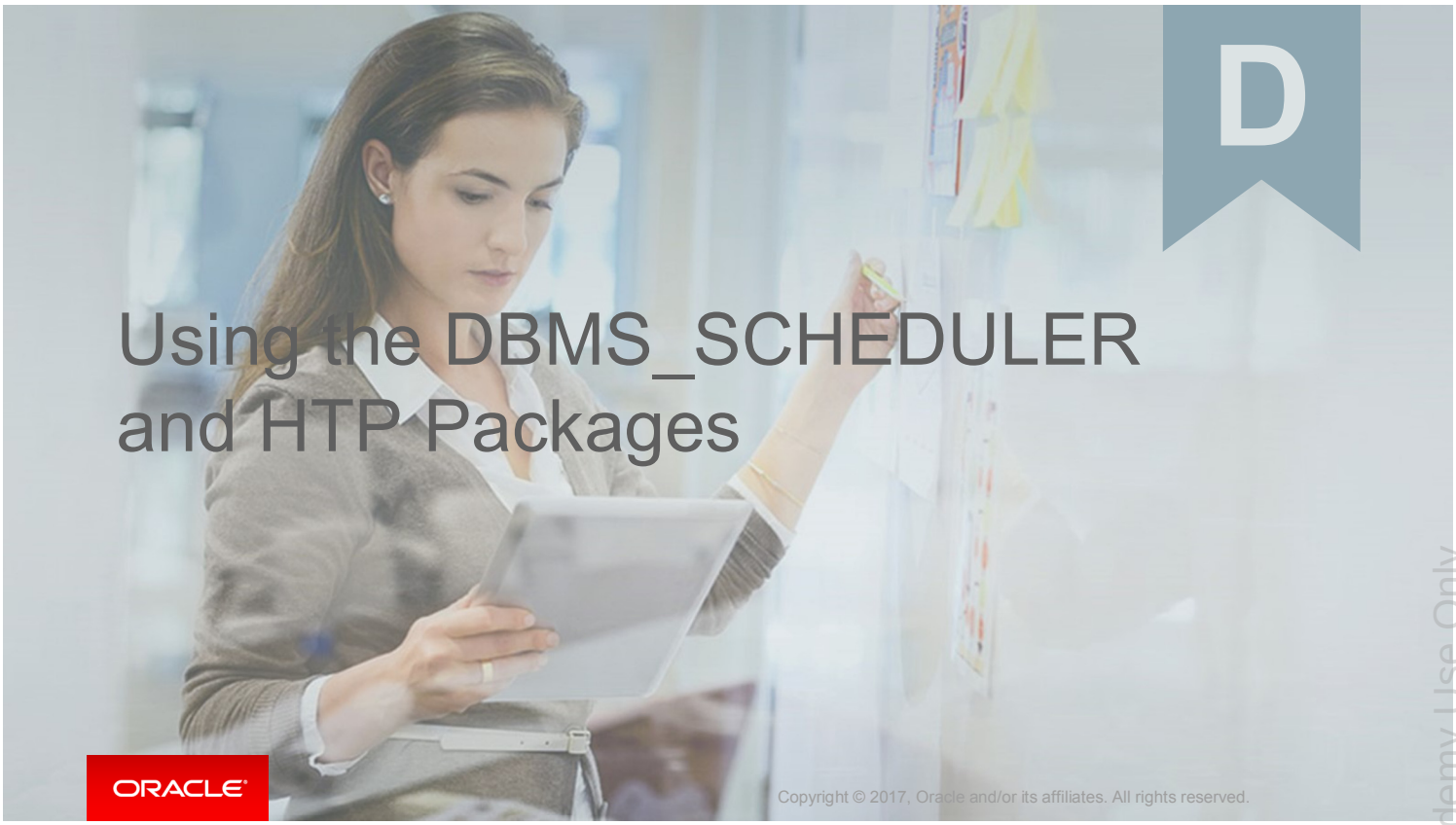
## Summary

In this appendix, you should have learned how to:

- Enhance database security with triggers
- Enforce data integrity with DML triggers
- Maintain referential integrity using triggers
- Use triggers to replicate data between tables
- Use triggers to automate computation of derived data
- Provide event-logging capabilities using triggers



This lesson provides some detailed comparison of using the Oracle database server functionality to implement security, auditing, data integrity, replication, and logging. The lesson also covers how database triggers can be used to implement the same features but go further to enhance the features that the database server provides. In some cases, you must use a trigger to perform some activities (such as computation of derived data) because the Oracle server cannot know how to implement this kind of business rule without some programming effort.



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# Using the DBMS_SCHEDULER and HTP Packages

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## Objectives

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

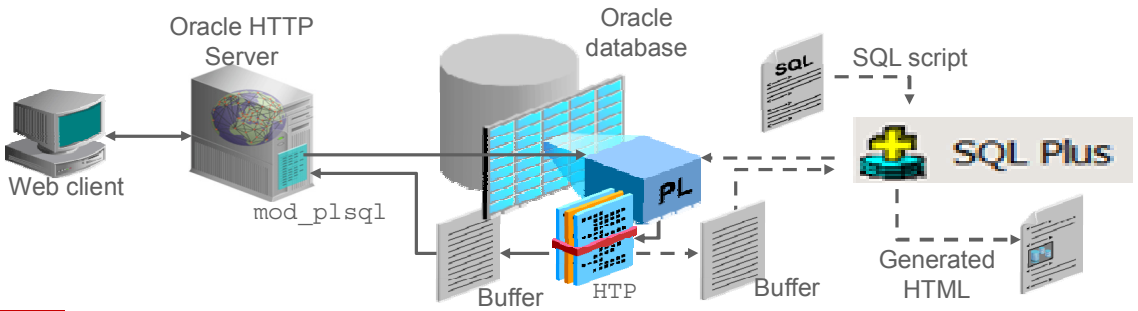
- Use the `HTP` package to generate a simple webpage
- Call the `DBMS_SCHEDULER` package to schedule PL/SQL code for execution



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

## Generating Webpages with the HTP Package

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

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

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

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

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

## Using the HTP Package Procedures

- Generate one or more HTML tags. For example:

```
htp.bold('Hello');              -- <B>Hello</B>
htp.print('Hi <B>World</B>');   -- Hi <B>World</B>
```

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

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



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

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

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

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

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

## Creating an HTML File with SQL*Plus

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

1. Create a SQL script with the following commands:

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

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



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

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

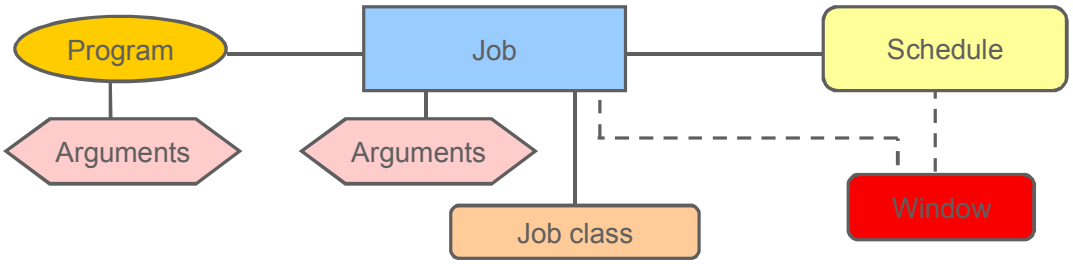
The `ACCEPT` command prompts for the name of the procedure to execute. The call to `OWA_UTIL.SHOWPAGE` displays the HTML tags in the browser window. You can then copy and paste the generated HTML tags from the browser window into an HTML file, typically with an `.htm` or `.html` extension.

**Note:** If you are using SQL*Plus, then you can use the `SPOOL` command to direct the HTML output directly to an HTML file.

## The DBMS_SCHEDULER Package

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

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






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

The diagram shows the following architectural components of the Scheduler:

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

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

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

For more information about the Scheduler, see the online course titled *Oracle Database: Configure and Manage Jobs with the Scheduler*.

## Creating a Job

- A job can be created in several ways by using a combination of inline parameters, named `Programs`, and named `Schedules`.
- You can create a job with the `CREATE_JOB` procedure by:
  - Using inline information with the "what" and the schedule specified as parameters
  - Using a named (saved) program and specifying the schedule inline
  - Specifying what should be done inline and using a named Schedule
  - Using named Program and Schedule components



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

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

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

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

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

## Creating a Job with Inline Parameters

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

```
-- Schedule a PL/SQL block every hour:

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



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

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

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

**Note:** String expressions that are specified for repeat_interval are discussed later. The example specifies that the job should run every hour.

## Creating a Job Using a Program

- Use CREATE_PROGRAM to create a program:

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

- Use overloaded CREATE_JOB procedure with its program_name parameter:

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



The DBMS_SCHEDULER.CREATE_PROGRAM procedure defines a program that must be assigned a unique name. Creating the program separately for a job enables you to:

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

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

- PLSQL_BLOCK to execute an anonymous block or SQL statement
- STORED_PROCEDURE to execute a stored procedure, such as PL/SQL, Java, or C
- EXECUTABLE to execute operating system command-line programs

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

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

To create a job with a program, specify the program name in the program_name argument in the call to the DBMS_SCHEDULER.CREATE_JOB procedure, as shown in the slide.

## Creating a Job for a Program with Arguments

- Create a program:

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

- Define an argument:

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

- Create a job specifying the number of arguments:

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

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

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

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

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

## Creating a Job Using a Schedule

- Use `CREATE_SCHEDULE` to create a schedule:

```
BEGIN
  DBMS_SCHEDULER.CREATE_SCHEDULE('SCHED_NAME',
   start_date => SYSTIMESTAMP,
   repeat_interval => 'FREQ=DAILY',
   end_date => SYSTIMESTAMP +15);
END;
```

- Use `CREATE_JOB` by referencing the schedule in the `schedule_name` parameter:

```
BEGIN
  DBMS_SCHEDULER.CREATE_JOB('JOB_NAME',
   schedule_name => 'SCHED_NAME',
   job_type => 'PLSQL_BLOCK',
   job_action => 'BEGIN ...; END;',
   enabled => TRUE);
END;
```



You can create a common schedule that can be applied to different jobs without having to specify the schedule details each time. The following are the benefits of creating a schedule:

- It is reusable and can be assigned to different jobs.
- Changing the schedule affects all the jobs that are using the schedule. The job schedules are changed once, not multiple times.

A schedule is precise to only the nearest second. Although the `TIMESTAMP` data type is more accurate, the Scheduler rounds off anything with a higher precision to the nearest second.

The start and end times for a schedule are specified by using the `TIMESTAMP` data type. The `end_date` for a saved schedule is the date after which the schedule is no longer valid. The schedule in the example is valid for 15 days after using it with a specified job.

The `repeat_interval` for a saved schedule must be created by using a calendaring expression. A `NULL` value for `repeat_interval` specifies that the job runs only once.

**Note:** You cannot use PL/SQL expressions to express the repeat interval for a saved schedule.

# Setting the Repeat Interval for a Job

- Using a calendaring expression:

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

- Using a PL/SQL expression:

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

## Creating a Job Using a Named Program and Schedule

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

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



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

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

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

For more information, refer to the online course titled *Oracle Database: Configure and Manage Jobs with the Scheduler*.

## Managing Jobs

- Run a job:

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

- Stop a job:

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

- Drop a job even if it is currently running:

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





After a job has been created, you can:

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

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

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

## Data Dictionary Views

- [DBA | ALL | USER]_SCHEDULER_JOBS
- [DBA | ALL | USER]_SCHEDULER_RUNNING_JOBS
- [DBA | ALL]_SCHEDULER_JOB_CLASSES
- [DBA | ALL | USER]_SCHEDULER_JOB_LOG
- [DBA | ALL | USER]_SCHEDULER_JOB_RUN_DETAILS
- [DBA | ALL | USER]_SCHEDULER_PROGRAMS



The DBA_SCHEDULER_JOB_LOG view shows all completed job instances, both successful and failed.

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

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

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

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

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

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

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

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

## Summary

In this appendix, you should have learned how to:

- Use the `HTP` package to generate a simple webpage
- Call the `DBMS_SCHEDULER` package to schedule PL/SQL code for execution



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

In this lesson, you should have learned how to schedule PL/SQL and external code for execution with the `DBMS_SCHEDULER` package.

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