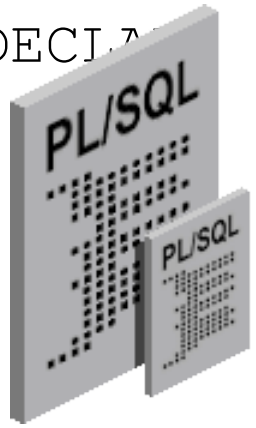
Creating Stored Procedures, Functions, Packages and Triggers

Procedures and Functions

- Are named PL/SQL blocks
- Are called PL/SQL subprograms
- Have block structures similar to anonymous blocks:
  - Optional declarative section (without DECLA keyword)
  - Mandatory executable section
  - Optional section to handle exceptions



Differences Between Anonymous Blocks and Subprograms

Anonymous Blocks	Subprograms
Unnamed PL/SQL blocks	Named PL/SQL blocks
Compiled every time	Compiled only once
Not stored in the database	Stored in the database
Cannot be invoked by other applications	Named and therefore can be invoked by other applications
Do not return values	Subprograms called functions must return values.
Cannot take parameters	Can take parameters

Procedure: Syntax

```
CREATE [OR REPLACE] PROCEDURE procedure_name
 [(argument1 [mode1] datatype1,
  argument2 [mode2] datatype2,
  . . .)]
IS|AS
procedure_body;
```

Procedure: Example

```
...
CREATE TABLE dept AS SELECT * FROM departments;
CREATE PROCEDURE add_dept IS
 dept_id dept.department_id%TYPE;
 dept_name dept.department_name%TYPE;
BEGIN
 dept_id:=280;
 dept_name:='ST-Curriculum';
 INSERT INTO dept(department_id,department_name)
 VALUES(dept_id,dept_name);
 DBMS_OUTPUT.PUT_LINE(' Inserted '||
  SQL%ROWCOUNT ||' row ');
END;
/
```

Invoking the Procedure

```
BEGIN
 add_dept;
END;
/
SELECT department_id, department_name FROM
dept WHERE department_id=280;
```

Inserted 1 row
PL/SQL procedure successfully completed.

DEPARTMENT_ID	DEPARTMENT_NAME
280	ST-Curriculum

Function: Syntax

```
CREATE [OR REPLACE] FUNCTION function_name
 [(argument1 [mode1] datatype1,
  argument2 [mode2] datatype2,
  . . .)]
RETURN datatype
IS|AS
function_body;
```

Function: Example

```
CREATE FUNCTION check_sal RETURN Boolean IS
 dept_id employees.department_id%TYPE;
 empno   employees.employee_id%TYPE;
 sal     employees.salary%TYPE;
 avg_sal employees.salary%TYPE;
BEGIN
 empno:=205;
 SELECT salary,department_id INTO sal,dept_id
 FROM employees WHERE employee_id= empno;
 SELECT avg(salary) INTO avg_sal FROM employees
 WHERE department_id=dept_id;
 IF sal > avg_sal THEN
  RETURN TRUE;
 ELSE
  RETURN FALSE;
 END IF;
EXCEPTION
  WHEN NO_DATA_FOUND THEN
   RETURN NULL;
END;
/
```

What Are Parameters?

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

Invoking the Function

```
SET SERVEROUTPUT ON
BEGIN
 IF (check_sal IS NULL) THEN
 DBMS_OUTPUT.PUT_LINE('The function returned
  NULL due to exception');
 ELSIF (check_sal) THEN
 DBMS_OUTPUT.PUT_LINE('Salary > average');
 ELSE
 DBMS_OUTPUT.PUT_LINE('Salary < average');
 END IF;
END;
/
```

Salary > average
PL/SQL procedure successfully completed.

Formal and Actual Parameters

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

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

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

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

Passing a Parameter to the Function

```
DROP FUNCTION check_sal;
CREATE FUNCTION check_sal(empno employees.employee_id%TYPE)
RETURN Boolean IS
 dept_id employees.department_id%TYPE;
 sal     employees.salary%TYPE;
 avg_sal employees.salary%TYPE;
BEGIN
 SELECT salary,department_id INTO sal,dept_id
 FROM employees WHERE employee_id=empno;
 SELECT avg(salary) INTO avg_sal FROM employees
 WHERE department_id=dept_id;
 IF sal > avg_sal THEN
  RETURN TRUE;
 ELSE
  RETURN FALSE;
 END IF;
EXCEPTION ...
...
```

Invoking the Function with a Parameter

```
BEGIN
DBMS_OUTPUT.PUT_LINE('Checking for employee with id 205');
 IF (check_sal(205) IS NULL) THEN
 DBMS_OUTPUT.PUT_LINE('The function returned
  NULL due to exception');
 ELSIF (check_sal(205)) THEN
 DBMS_OUTPUT.PUT_LINE('Salary > average');
 ELSE
 DBMS_OUTPUT.PUT_LINE('Salary < average');
 END IF;
DBMS_OUTPUT.PUT_LINE('Checking for employee with id 70');
 IF (check_sal(70) IS NULL) THEN
 DBMS_OUTPUT.PUT_LINE('The function returned
  NULL due to exception');
 ELSIF (check_sal(70)) THEN
 ...
 END IF;
END;
/
```

Types of Triggers

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

Guidelines for Designing Triggers

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

Creating DML Triggers

- Create DML statement or row type triggers by using:

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

  - A statement trigger fires once for a DML statement.
  - A row trigger fires once for each row affected.
- Note: Trigger names must be unique with respect to other triggers in the same schema.

Types of DML Triggers

- The trigger type determines whether the body executes for each row or only once for the triggering statement.
  - A statement trigger:
    - Executes once for the triggering event
    - Is the default type of trigger
    - Fires once even if no rows are affected at all
  - A row trigger:
    - Executes once for each row affected by the triggering event
    - Is not executed if the triggering event does not affect any rows
    - Is indicated by specifying the `FOR EACH ROW` clause

Trigger Timing

- When should the trigger fire?
  - `BEFORE`: Execute the trigger body before the triggering DML event on a table.
  - `AFTER`: Execute the trigger body after the triggering DML event on a table.
  - `INSTEAD OF`: Execute the trigger body instead of the triggering statement. This is used for views that are not otherwise modifiable.
- Note: If multiple triggers are defined for the same object, then the order of firing triggers is arbitrary.

Trigger-Firing Sequence

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

DML statement

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

Triggering action → **BEFORE statement trigger**

DEPARTMENT_ID	DEPARTMENT_NAME	LOCATION_ID
10	Administration	1700
20	Marketing	1800
30	Purchasing	1700
...		
400	CONSULTING	2400

→ **BEFORE row trigger**

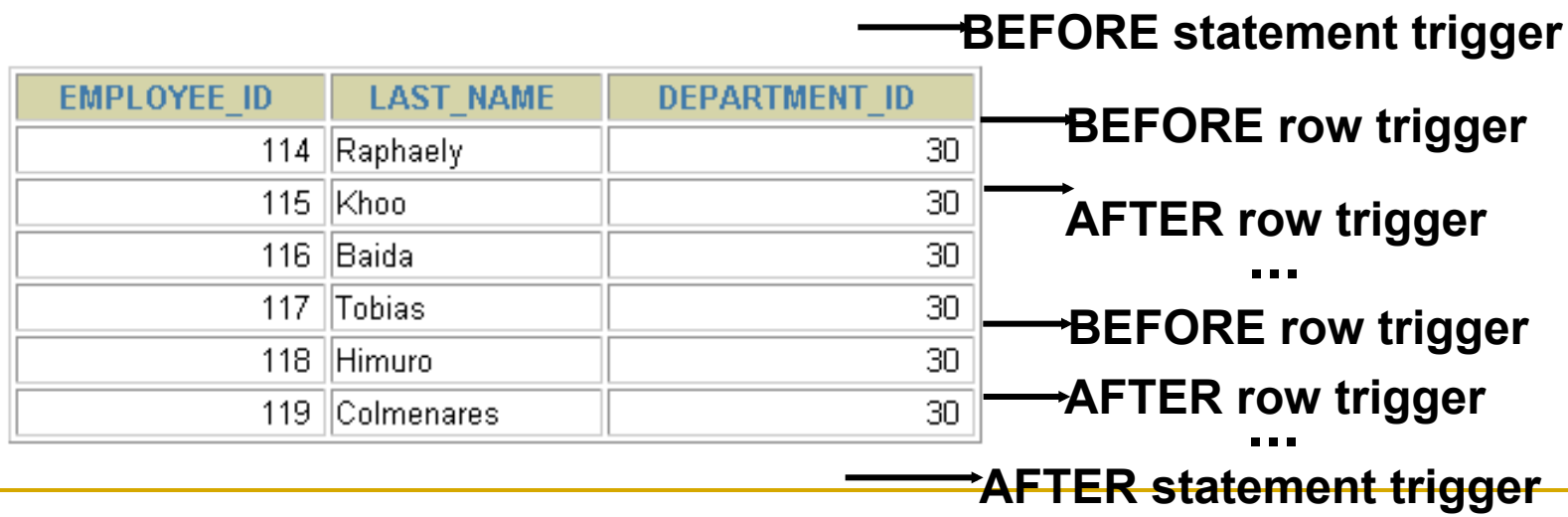
→ **AFTER row trigger**

→ **AFTER statement trigger**

Trigger-Firing Sequence

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

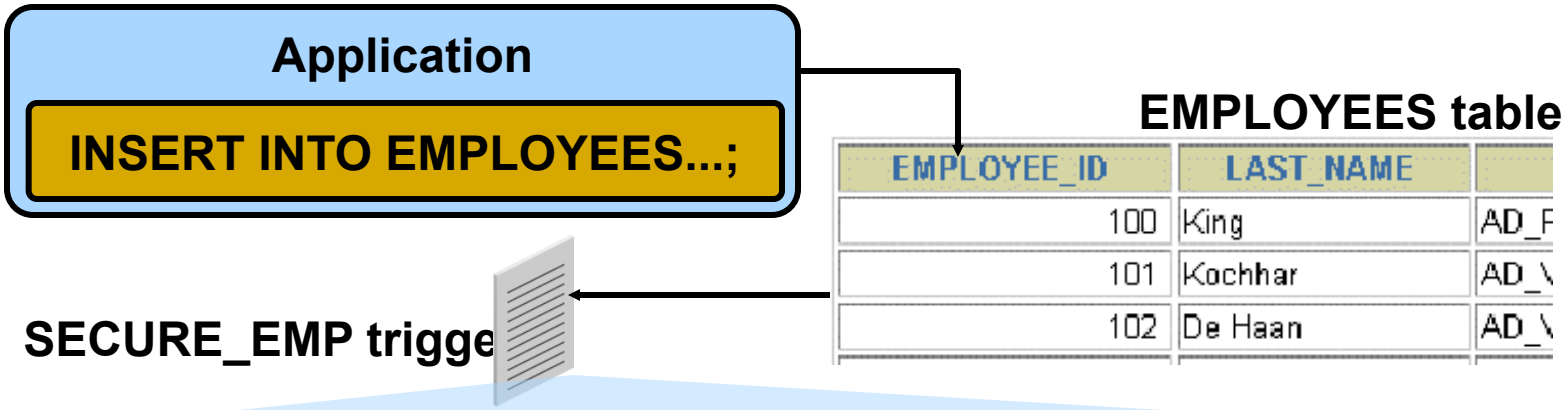
```
UPDATE employees
  SET salary = salary * 1.1
  WHERE department_id = 30;
```



Trigger Event Types and Body

- A trigger event:
  - Determines which DML statement causes the trigger to execute
  - Types are:
    - `INSERT`
    - `UPDATE [OF column]`
    - `DELETE`
- A trigger body:
  - Determines what action is performed
  - Is a PL/SQL block or a `CALL` to a procedure

Creating a DML Statement Trigger




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

Testing SECURE_EMP

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

```
INSERT INTO employees (employee_id, last_name, first_name, email,
       *
ERROR at line 1:
ORA-20500: You may insert into EMPLOYEES table only during business hours.
ORA-06512: at "PLSQL.SECURE_EMP", line 4
ORA-04088: error during execution of trigger 'PLSQL.SECURE_EMP'
```

Using Conditional Predicates

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

Creating a DML Row Trigger

```
CREATE OR REPLACE TRIGGER restrict_salary
BEFORE INSERT OR UPDATE OF salary ON employees
FOR EACH ROW
BEGIN
  IF NOT (:NEW.job_id IN ('AD_PRES', 'AD_VP'))
     AND :NEW.salary > 15000 THEN
    RAISE_APPLICATION_ERROR (-20202,
      'Employee cannot earn more than $15,000.');
  END IF;
END;
/
```

Using OLD and NEW Qualifiers

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

Using OLD and NEW Qualifiers: Example Using AUDIT_EMP

```
INSERT INTO employees
 (employee_id, last_name, job_id, salary, ...)
VALUES (999, 'Temp emp', 'SA_REP', 6000,...);

UPDATE employees
 SET salary = 7000, last_name = 'Smith'
 WHERE employee_id = 999;
```

```
SELECT user_name, timestamp, ...
FROM audit_emp;
```

USER_NAME	TIME_STAMP	ID	OLD_LAST_NAME	NEW_LAST_NAME	OLD_TITLE	NEW_TITLE	OLD_SALARY	NEW_SALARY
ORA25	31-MAR-06			Temp emp		SA_REP		6000
ORA25	31-MAR-06	999	Temp emp	Smith	SA_REP	SA_REP	6000	7000

Restricting a Row Trigger: Example

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

Summary of the Trigger Execution Model

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

- Note: Integrity checking can be deferred until the `COMMIT` operation is performed.