16

Creating Database Triggers

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Objectives

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

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

Types of Triggers

A trigger:

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

Guidelines for Designing Triggers

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

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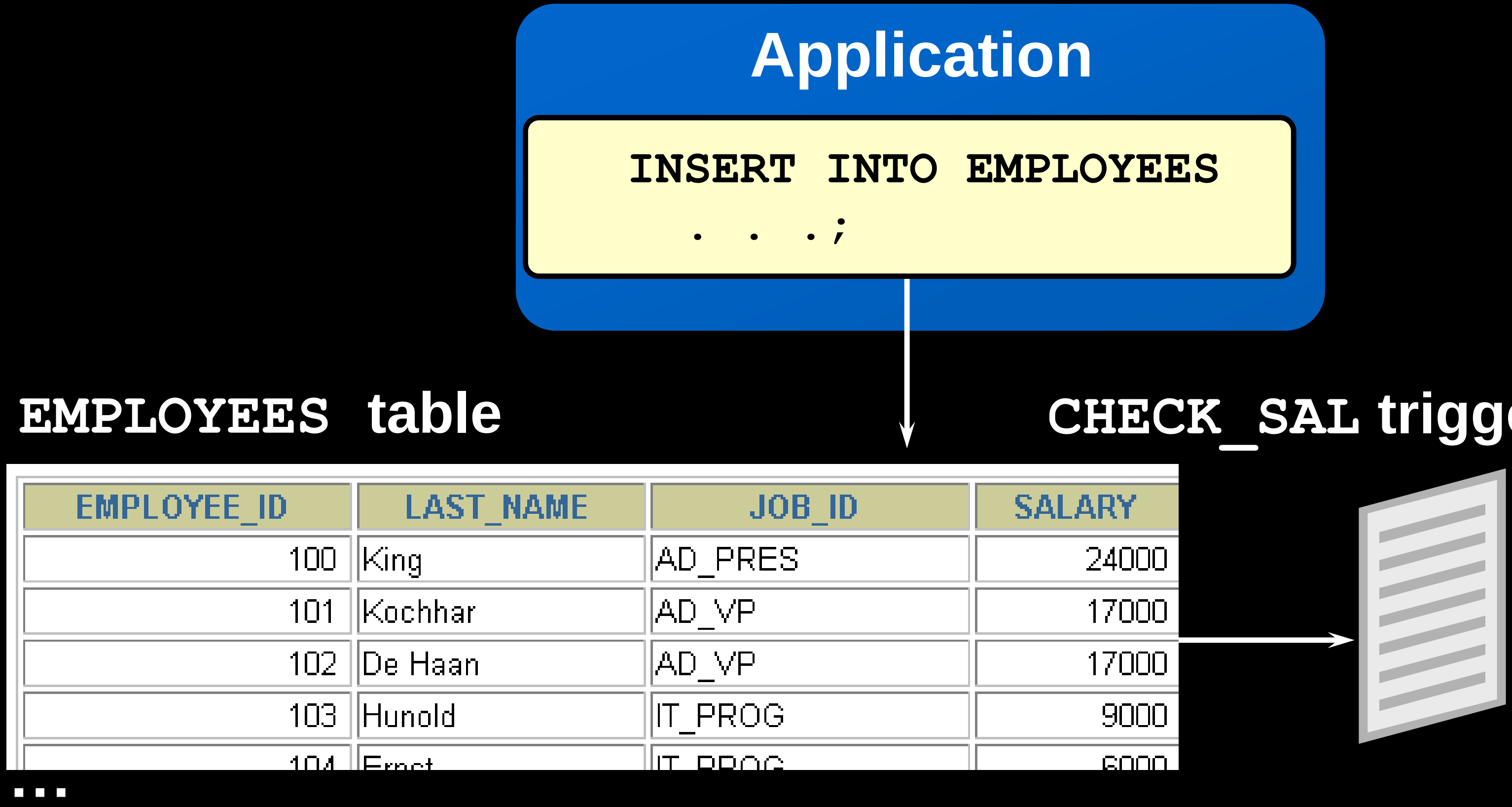
Database Trigger: Example



```
INSERT INTO EMPLOYEES
  . . .;
```

EMPLOYEE_ID	LAST_NAME	JOB_ID	SALARY
100	King	AD_PRES	24000
101	Kochhar	AD_VP	17000
102	De Haan	AD_VP	17000
103	Hunold	IT_PROG	9000
104	Ernst	IT_PROG	6000

...

Creating DML Triggers

A triggering statement contains:

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

DML Trigger Components

Trigger timing: When should the trigger fire?

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

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DML Trigger Components

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

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

DML Trigger Components

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

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

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DML Trigger Components

Trigger body: What action should the trigger perform?

The trigger body is a PL/SQL block or a call to a procedure.

Firing Sequence

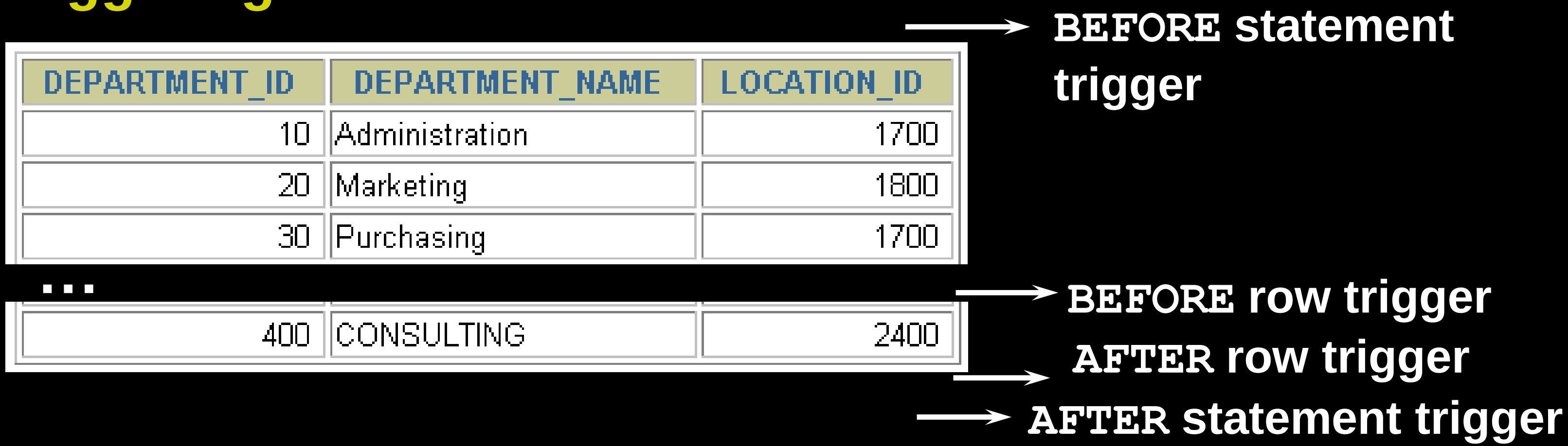
Use the following firing sequence for a trigger on a table, when a single row is manipulated:

DML statement

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

```
1 row created.
```

Triggering action



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

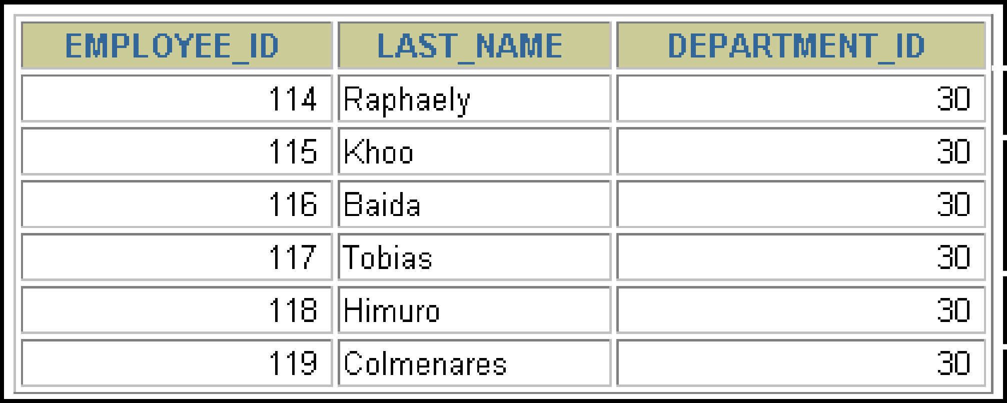
Firing Sequence

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

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

```
6 rows updated.
```

BEFORE statement trigger



EMPLOYEE_ID	LAST_NAME	DEPARTMENT_ID
114	Raphaely	30
115	Khoo	30
116	Baida	30
117	Tobias	30
118	Himuro	30
119	Colmenares	30

BEFORE row trigger
AFTER row trigger
. . .

BEFORE row trigger
AFTER row trigger
. . .

AFTER statement trigger

Syntax for Creating DML Statement Triggers

Syntax:

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

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

Creating DML Statement Triggers

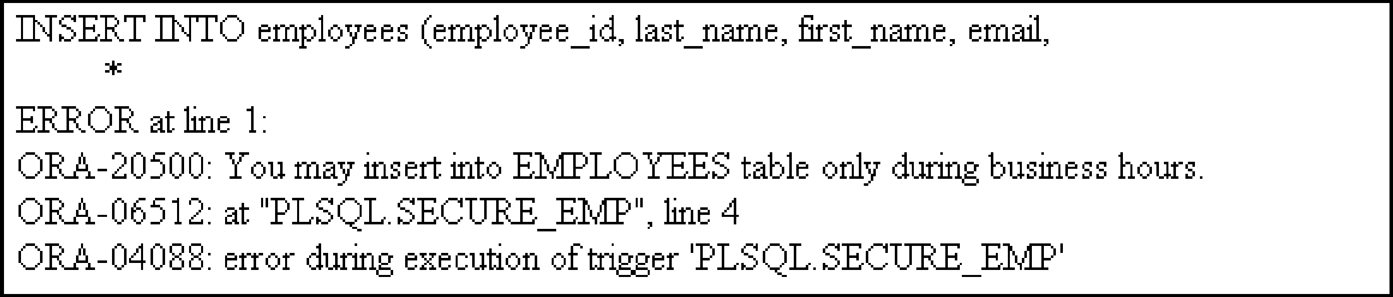
Example:

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

```
Trigger created.
```

Testing SECURE_EMP

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



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

Using Conditional Predicates

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

Creating a DML Row Trigger

Syntax:

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

Creating DML Row Triggers

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

```
Trigger created.
```

Using OLD and NEW Qualifiers

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

```
Trigger created.
```

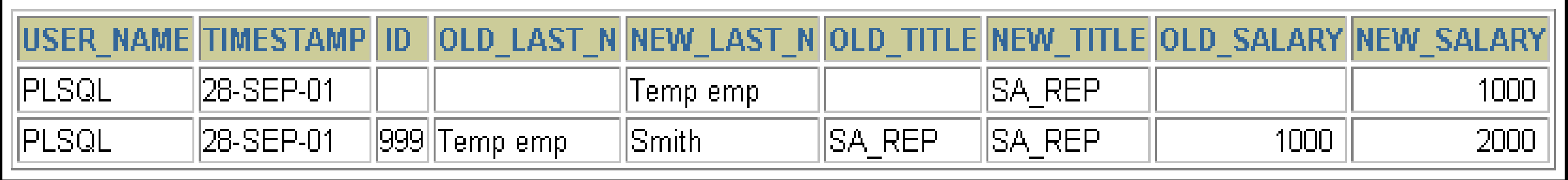
Using OLD and NEW Qualifiers: Example Using Audit_Emp_Table

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

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

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

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



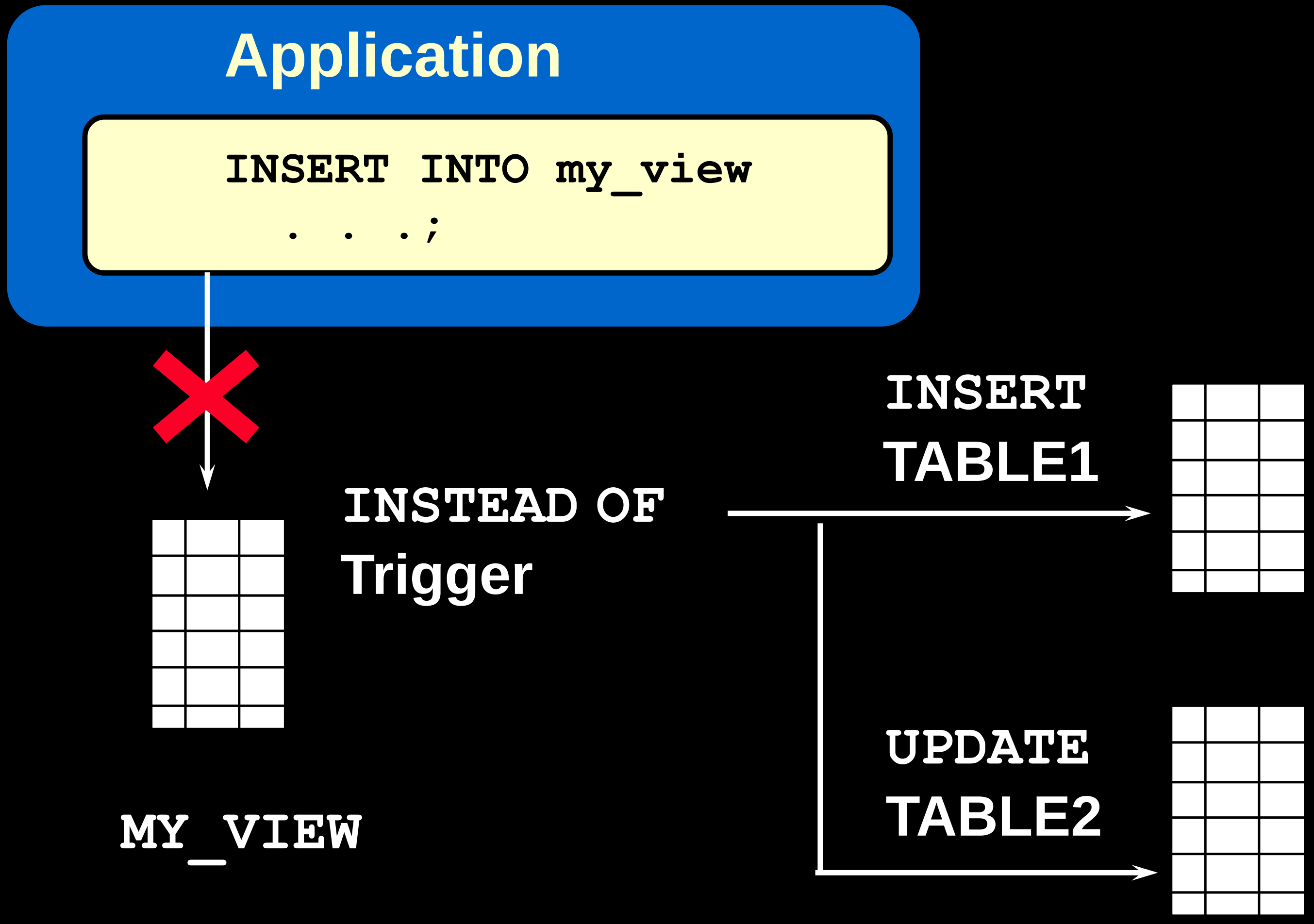
USER_NAME	TIMESTAMP	ID	OLD_LAST_N	NEW_LAST_N	OLD_TITLE	NEW_TITLE	OLD_SALARY	NEW_SALARY
PLSQL	28-SEP-01			Temp emp		SA_REP		1000
PLSQL	28-SEP-01	999	Temp emp	Smith	SA_REP	SA_REP	1000	2000

Restricting a Row Trigger

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

```
Trigger created.
```

INSTEAD OF Triggers



Creating an `INSTEAD OF` Trigger

Syntax:

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

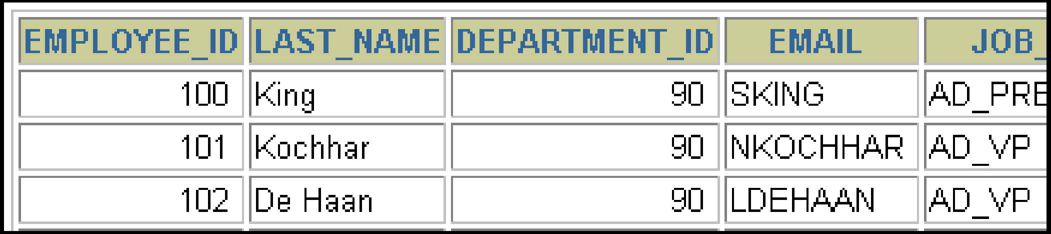
Creating an INSTEAD OF Trigger

INSERT into EMP_DETAILS that is based on EMPLOYEES and DEPARTMENTS tables

1

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

INSTEAD OF INSERT into EMP_DETAILS



EMPLOYEE_ID	LAST_NAME	DEPARTMENT_ID	EMAIL	JOB_
100	King	90	SKING	AD_PRE
101	Kochhar	90	NKOCHHAR	AD_VP
102	De Haan	90	LDEHAAN	AD_VP

...

Creating an INSTEAD OF Trigger

INSERT into EMP_DETAILS that is based on EMPLOYEES and DEPARTMENTS tables

1

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

INSTEAD OF INSERT into EMP_DETAILS

EMPLOYEE_ID	LAST_NAME	DEPARTMENT_ID	EMAIL	JOB_
100	King	90	SKING	AD_PRE
101	Kochhar	90	NKOCHHAR	AD_VP
102	De Haan	90	LDEHAAN	AD_VP

...

2 **INSERT into NEW_EMPS**

EMPLOYEE_ID	LAST_NAME	SALARY	DEPARTMENT_ID	EMA
100	King	24000	90	SKING
101	Kochhar	17000	90	NKOCHH
102	De Haan	17000	90	LDEHAA
...				
9001	ABBOTT	3000	10	abbott.m

3 **UPDATE NEW_DEPTS**

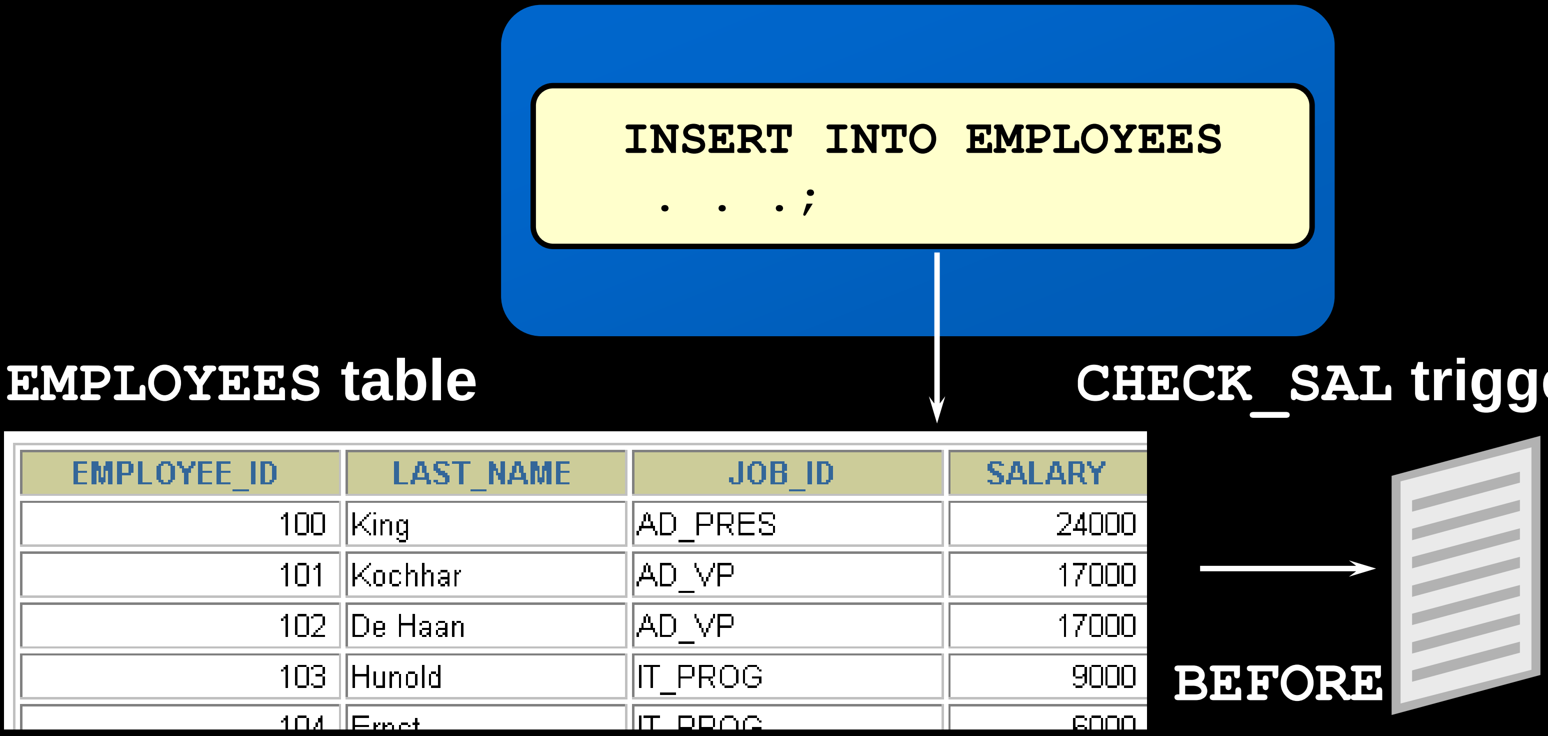
DEPARTMENT_ID	DEPARTMENT_NAME	TOT_DEPT_SA
10	Administration	940
20	Marketing	1900
30	Purchasing	3012
40	Human Resources	650

...

Differentiating Between Database Triggers and Stored Procedures

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

Differentiating Between Database Triggers and Form Builder Triggers



EMPLOYEE_ID	LAST_NAME	JOB_ID	SALARY
100	King	AD_PRES	24000
101	Kochhar	AD_VP	17000
102	De Haan	AD_VP	17000
103	Hunold	IT_PROG	9000
104	Ernst	IT_PROG	6000

...

BEFORE INSERT row

Managing Triggers

Disable or reenable a database trigger:

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

Disable or reenable all triggers for a table:

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

Recompile a trigger for a table:

```
ALTER TRIGGER trigger_name COMPILE
```

`DROP TRIGGER` Syntax

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

```
DROP TRIGGER trigger_name;
```

Example:

```
DROP TRIGGER secure_emp;
```

```
Trigger dropped.
```

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

Trigger Test Cases

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

Trigger Execution Model and Constraint Checking

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

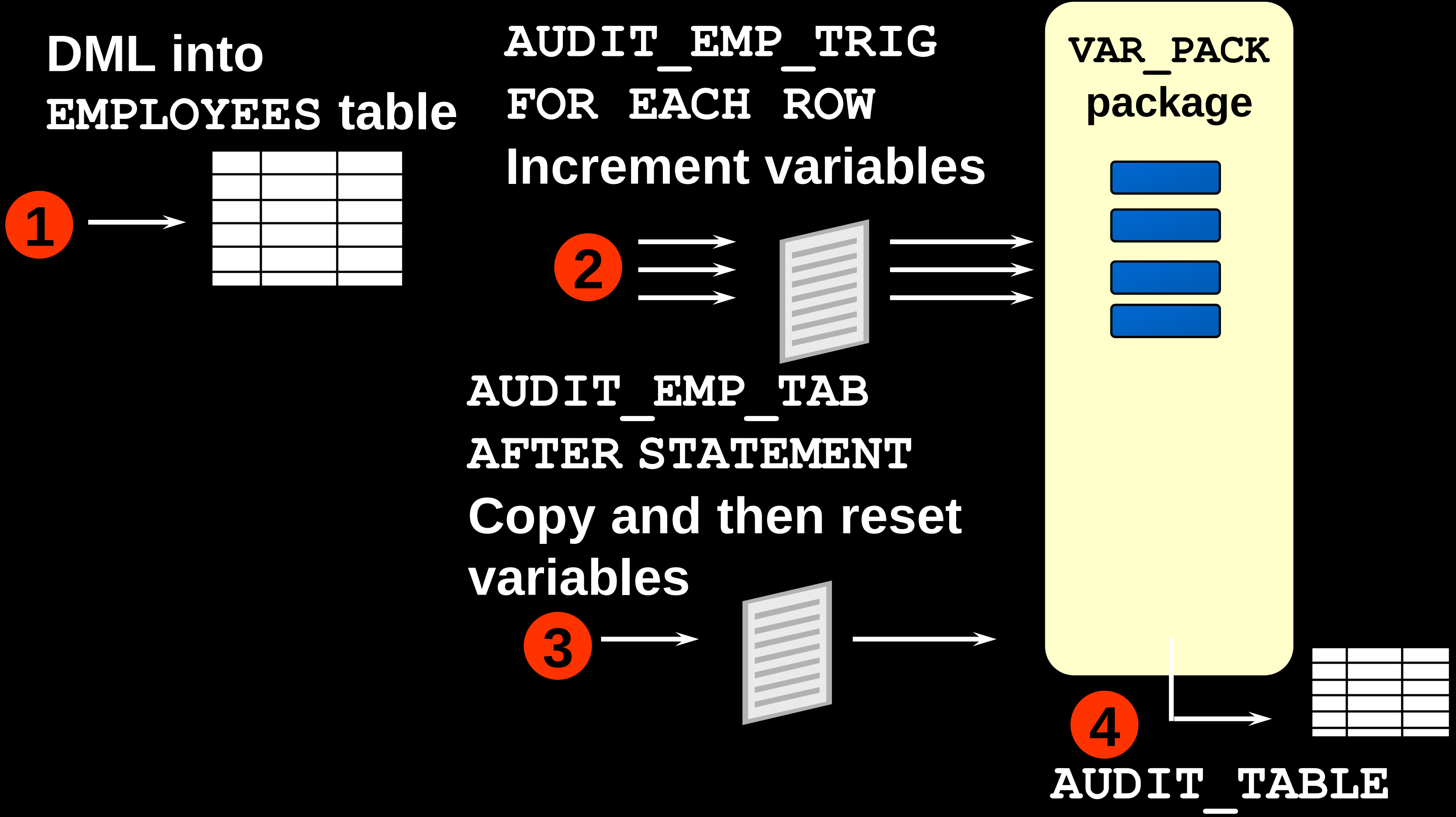
Trigger Execution Model and Constraint Checking: Example

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

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

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

A Sample Demonstration for Triggers Using Package Constructs



After Row and After Statement Triggers

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

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

Demonstration: VAR_PACK Package Specification

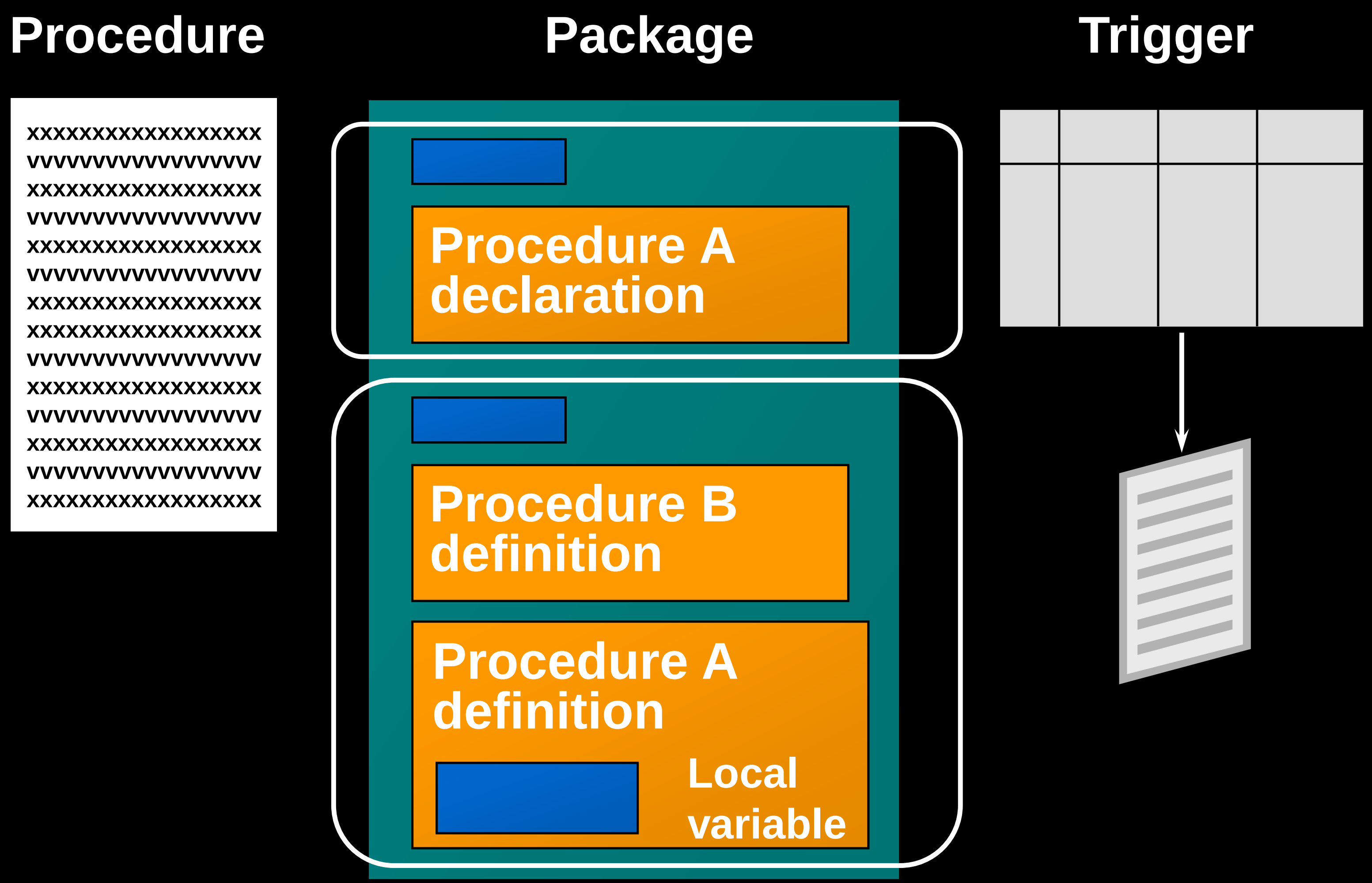
var_pack.sql

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

Demonstration: Using the `AUDIT_EMP` Procedure

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

Summary


Procedure
Package
Trigger
Procedure A declaration
Procedure B definition
Procedure A definition
Local variable

Practice 16 Overview

This practice covers the following topics:

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