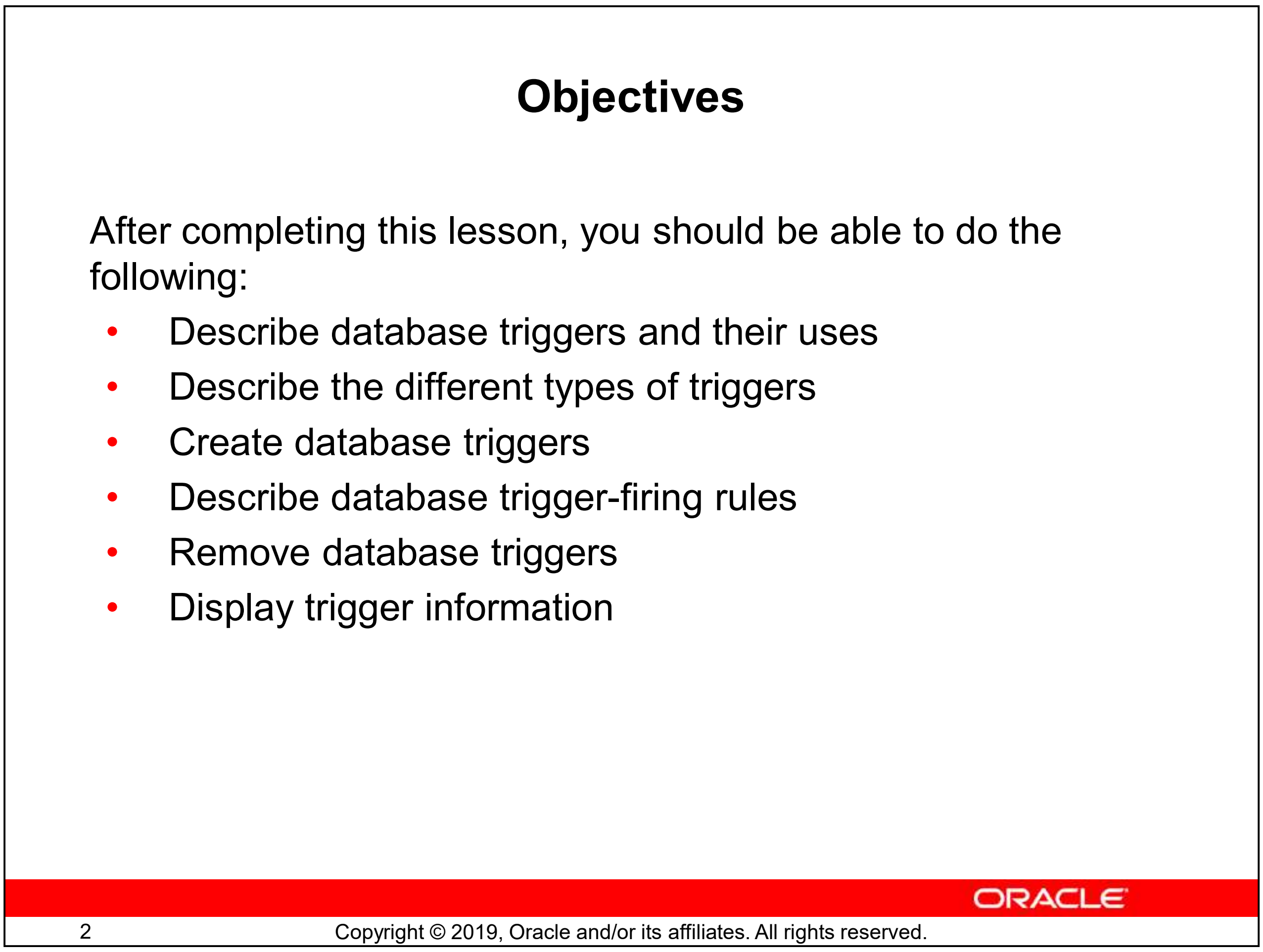
Creating Triggers



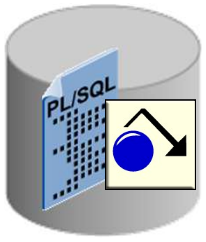
Objectives

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

- Describe database triggers and their uses
- Describe the different types of triggers
- Create database triggers
- Describe database trigger-firing rules
- Remove database triggers
- Display trigger information

In this lesson, you learn how to create and use database triggers.

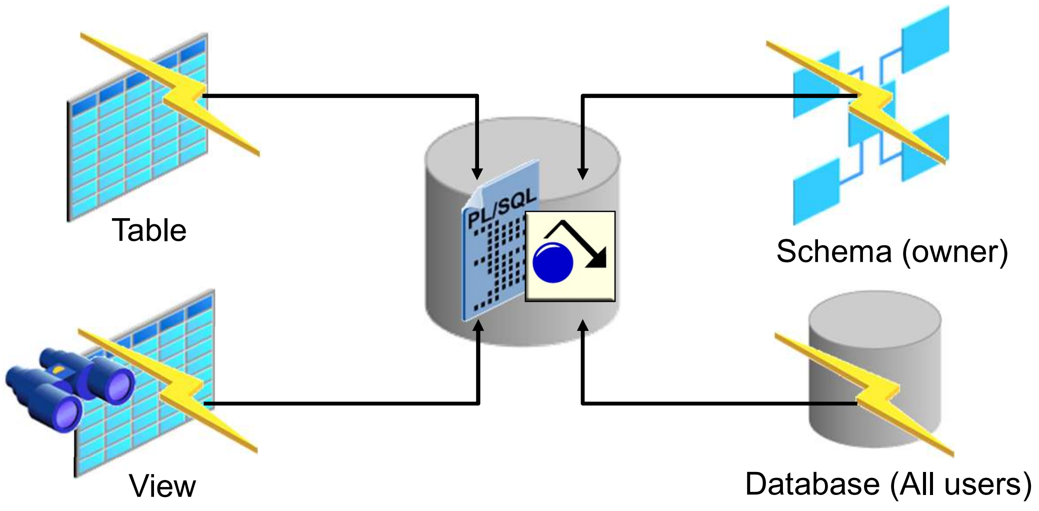
What Are Triggers?



- Triggers are similar to stored procedures.
- A trigger stored in the database contains PL/SQL in the form of an anonymous block, a call statement, or a compound trigger block.
- Procedures and triggers differ in the way that they are invoked.
- A procedure is explicitly run by a user, application, or trigger.
- Triggers are implicitly fired by the Oracle database when a triggering event occurs, no matter which user is connected or which application is being used.

Defining Triggers

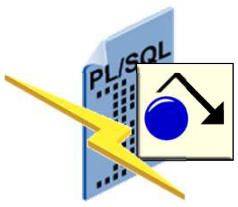
A trigger can be defined on the table, view, schema (schema owner), or database (all users).



Trigger Event Types

You can write triggers that fire whenever one of the following operations occurs in the database:

- A database manipulation (DML) statement (`DELETE`, `INSERT`, or `UPDATE`).
- A database definition (DDL) statement (`CREATE`, `ALTER`, or `DROP`).
- A database operation such as `SERVERERROR`, `LOGON`, `LOGOFF`, `STARTUP`, or `SHUTDOWN`.



Triggering Event or Statement

A triggering event or statement is the SQL statement, database event, or user event that causes a trigger to fire. A triggering event can be one or more of the following:

- An `INSERT`, `UPDATE`, or `DELETE` statement on a specific table (or view, in some cases)
- A `CREATE`, `ALTER`, or `DROP` statement on any schema object
- A database startup or instance shutdown
- A specific error message or any error message
- A user logon or logoff

Application and Database Triggers

- Database trigger (covered in this course):
  - Fires whenever a DML, a DLL, or system event occurs on a schema or database
- Application trigger:
  - Fires whenever an event occurs within a particular application

Types of Triggers

Application triggers execute implicitly whenever a particular data manipulation language (DML) event occurs within an application. An example of an application that uses triggers extensively is an application developed with Oracle Forms Developer.

Database triggers execute implicitly when any of the following events occur:

- DML operations on a table
- DML operations on a view, with an `INSTEAD OF` trigger
- DDL statements, such as `CREATE` and `ALTER`

This is the case no matter which user is connected or which application is used. Database triggers also execute implicitly when some user actions or database system actions occur (for example, when a user logs on or the DBA shuts down the database).

Database triggers can be system triggers on a database or a schema (covered in the next lesson). For databases, triggers fire for each event for all users; for a schema, they fire for each event for that specific user. Oracle Forms can define, store, and run triggers of a different sort. However, do not confuse Oracle Forms triggers with the triggers discussed in this lesson.

Business Application Scenarios for Implementing Triggers

You can use triggers for:

- Security
- Auditing
- Data integrity
- Referential integrity
- Table replication
- Event logging

Develop database triggers in order to enhance features that cannot otherwise be implemented by the Oracle server or as alternatives to those provided by the Oracle server.

- **Security:** The Oracle server allows table access to users or roles. Triggers allow table access according to data values.
- **Auditing:** The Oracle server tracks data operations on tables. Triggers track values for data operations on tables.
- **Data integrity:** The Oracle server enforces integrity constraints. Triggers implement complex integrity rules.
- **Referential integrity:** The Oracle server enforces standard referential integrity rules. Triggers implement nonstandard functionality.
- **Table replication:** The Oracle server copies tables asynchronously into snapshots. Triggers copy tables synchronously into replicas.
- **Derived data:** The Oracle server computes derived data values manually. Triggers compute derived data values automatically.
- **Event logging:** The Oracle server logs events explicitly. Triggers log events transparently.

Available Trigger Types

- Simple DML triggers
  - `BEFORE`
  - `AFTER`
  - `INSTEAD OF`
- Compound triggers
- Non-DML triggers
  - DDL event triggers
  - Database event triggers

Note

In this lesson, we will discuss the `BEFORE`, `AFTER`, and `INSTEAD OF` triggers. The other trigger types are discussed in the lesson titled “Creating Compound, DDL, and Event Database Triggers.”

Trigger Event Types and Body

- A trigger event type determines which DML statement causes the trigger to execute. The possible events are:
  - `INSERT`
  - `UPDATE [OF column]`
  - `DELETE`
- A trigger body determines what action is performed and is a PL/SQL block or a `CALL` to a procedure.

Triggering Event Types

The triggering event or statement can be an `INSERT`, `UPDATE`, or `DELETE` statement on a table.

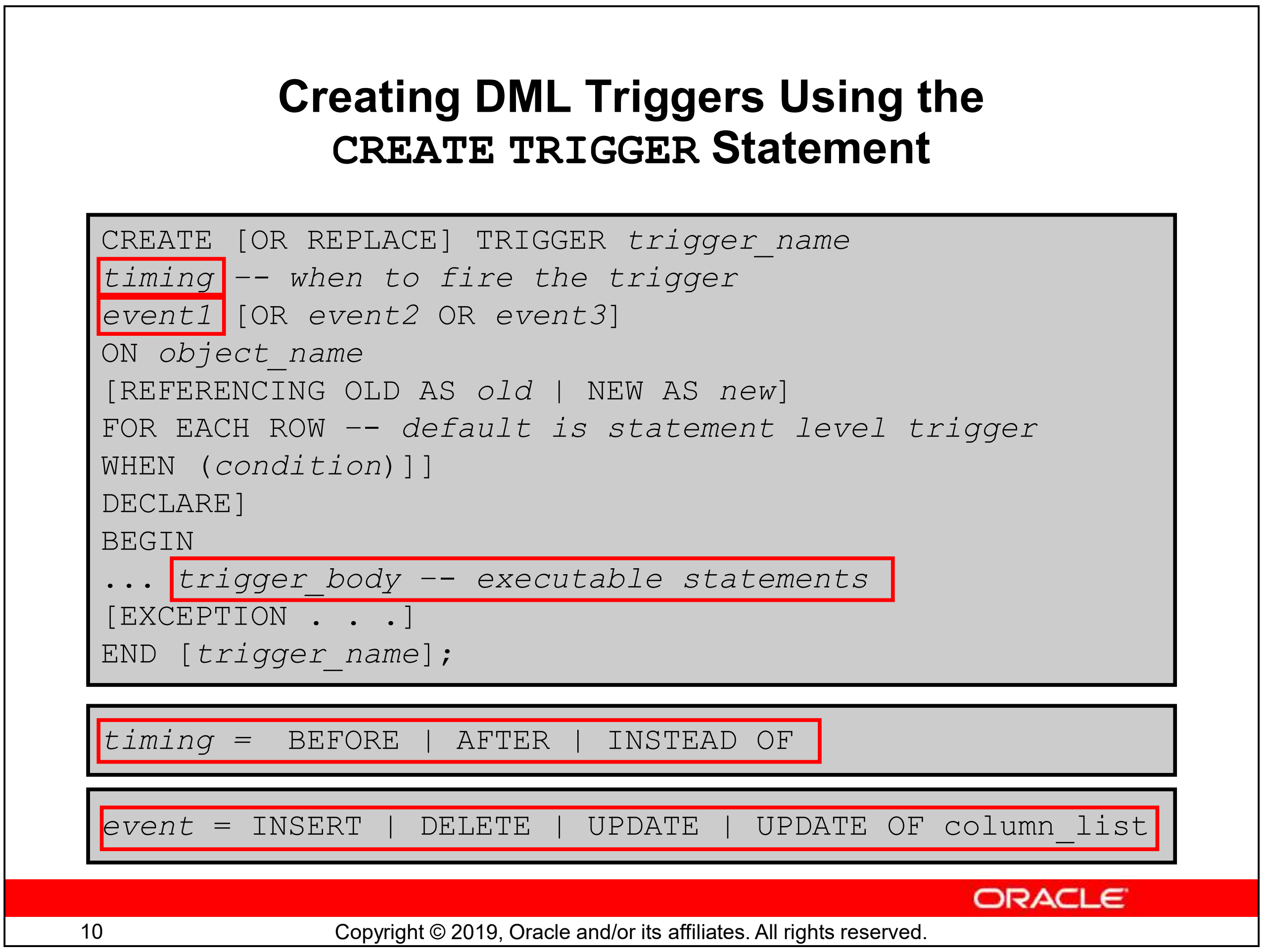
- When the triggering event is an `UPDATE` statement, you can include a column list to identify which columns must be changed to fire the trigger. You cannot specify a column list for an `INSERT` or for a `DELETE` statement because it always affects entire rows.

```
. . . UPDATE OF salary . . .
```

- The triggering event can contain one, two, or all three of these DML operations.

```
. . . INSERT or UPDATE or DELETE
. . . INSERT or UPDATE OF job_id . . .
```

The trigger body defines the action—that is, what needs to be done when the triggering event is issued. The PL/SQL block can contain SQL and PL/SQL statements, and can define PL/SQL constructs such as variables, cursors, exceptions, and so on. You can also call a PL/SQL procedure or a Java procedure.



Creating DML Triggers Using the `CREATE TRIGGER` Statement

```
CREATE [OR REPLACE] TRIGGER trigger_name
timing -- when to fire the trigger
event1 [OR event2 OR event3]
ON object_name
[REFERENCING OLD AS old | NEW AS new]
FOR EACH ROW -- default is statement level trigger
WHEN (condition)]]
DECLARE]
BEGIN
... trigger_body -- executable statements
[EXCEPTION . . .]
END [trigger_name];
```

```
timing =  BEFORE | AFTER | INSTEAD OF
```

```
event = INSERT | DELETE | UPDATE | UPDATE OF column_list
```

Creating DML Triggers

The components of the trigger syntax are:

- *`trigger_name`* uniquely identifies the trigger.
- *`timing`* indicates when the trigger fires in relation to the triggering event. Values are `BEFORE`, `AFTER`, and `INSTEAD OF`.
- `event` identifies the DML operation causing the trigger to fire.
  Values are `INSERT`, `UPDATE [OF column]`, and `DELETE`.
- *`object_name`* indicates the table or view associated with the trigger.
- For row triggers, you can specify:
  - A `REFERENCING` clause to choose correlation names for referencing the old and new values of the current row (default values are `OLD` and `NEW`)
  - `FOR EACH ROW` to designate that the trigger is a row trigger
  - A `WHEN` clause to apply a conditional predicate, in parentheses, which is evaluated for each row to determine whether or not to execute the trigger body

- The *`trigger_body`* is the action performed by the trigger, implemented as either of the following:
  - An anonymous block with a `DECLARE` or `BEGIN`, and an `END`
  - A `CALL` clause to invoke a stand-alone or packaged stored procedure, such as:

    ```
    CALL my_procedure;
    ```

Specifying the Trigger Firing (Timing)

You can specify the trigger timing as to whether to run the trigger's action before or after the triggering statement:

- `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.

Trigger Timing

The `BEFORE` trigger timing is frequently used in the following situations:

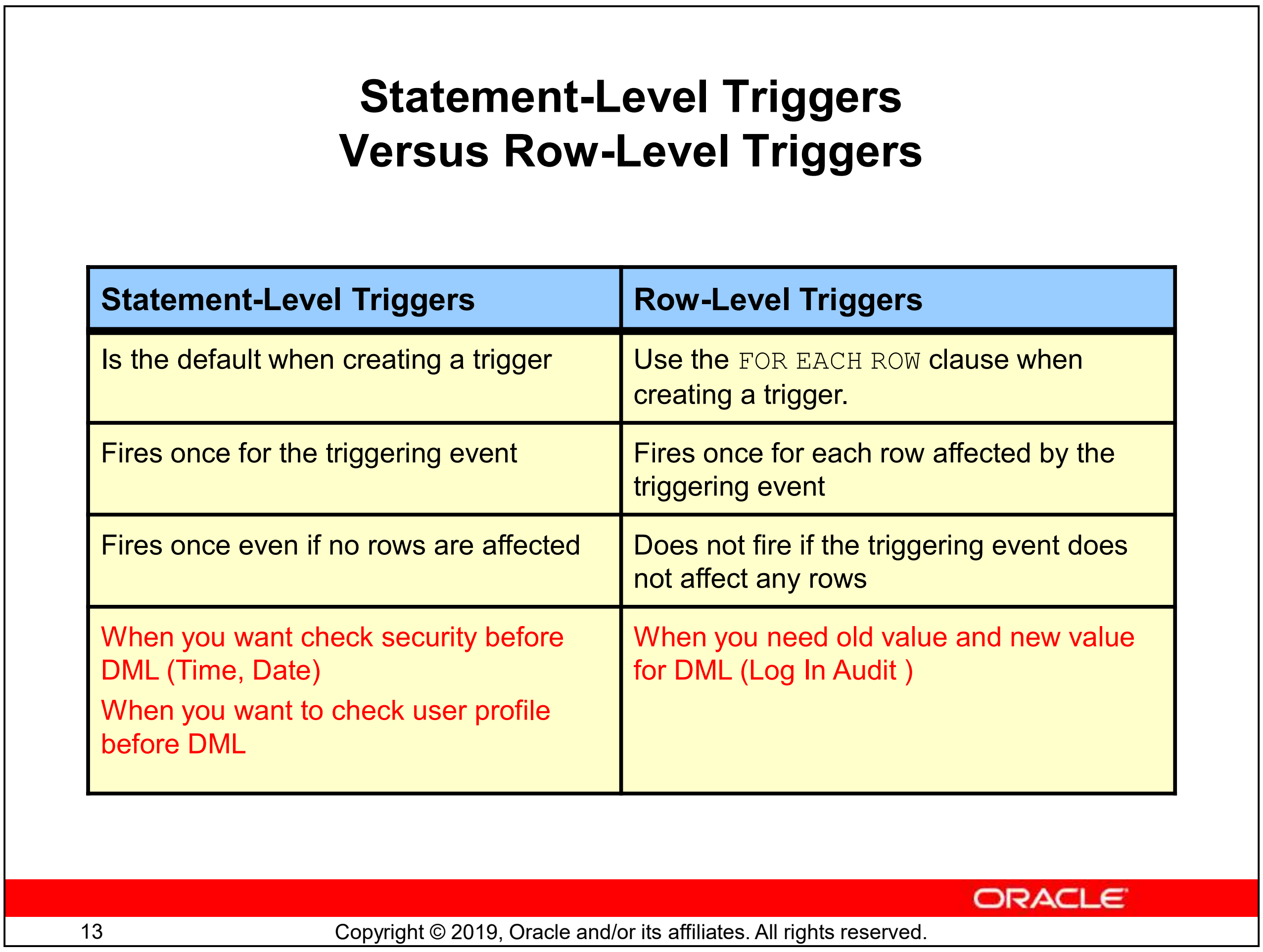
- To determine whether the triggering statement should be allowed to complete (This eliminates unnecessary processing and enables a rollback in cases where an exception is raised in the triggering action.)
- To derive column values before completing an `INSERT` or `UPDATE` statement
- To initialize global variables or flags, and to validate complex business rules

The `AFTER` triggers are frequently used in the following situations:

- To complete the triggering statement before executing the triggering action
- To perform different actions on the same triggering statement if a `BEFORE` trigger is already present

The `INSTEAD OF` triggers provide a transparent way of modifying views that cannot be modified directly through SQL DML statements because a view is not always modifiable. You can write appropriate DML statements inside the body of an `INSTEAD OF` trigger to perform actions directly on the underlying tables of views.

If it is practical, replace the set of individual triggers with different timing points with a single compound trigger that explicitly codes the actions in the order you intend. If two or more triggers are defined with the same timing point, and the order in which they fire is important, then you can control the firing order using the `FOLLOWS` and `PRECEDES` clauses.



Statement-Level Triggers Versus Row-Level Triggers

Statement-Level Triggers	**Row-Level Triggers**
Is the default when creating a trigger	Use the `FOR EACH ROW` clause when creating a trigger.
Fires once for the triggering event	Fires once for each row affected by the triggering event
Fires once even if no rows are affected	Does not fire if the triggering event does not affect any rows
When you want check security before DML (Time, Date) When you want to check user profile before DML	When you need old value and new value for DML (Log In Audit)

Types of DML Triggers

You can specify that the trigger will be executed once for every row affected by the triggering statement (such as a multiple row `UPDATE`) or once for the triggering statement, no matter how many rows it affects.

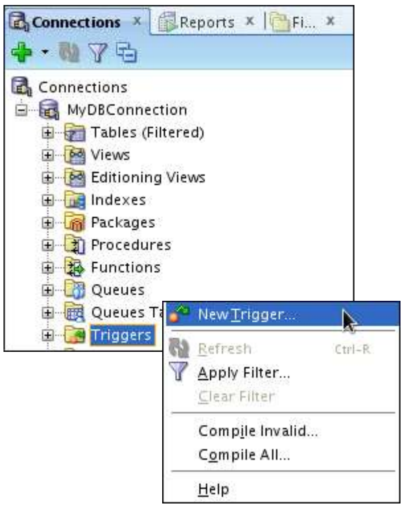
Statement Trigger

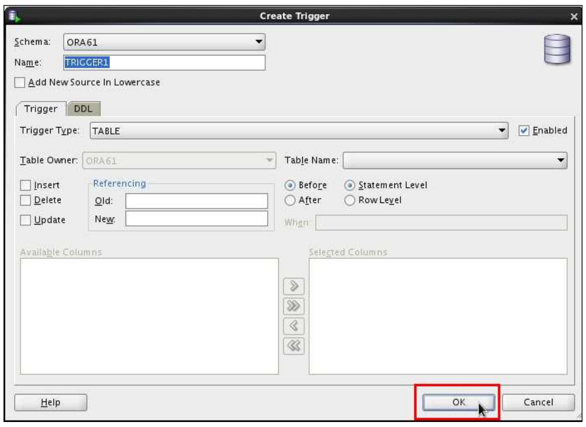
A statement trigger is fired once on behalf of the triggering event, even if no rows are affected at all. Statement triggers are useful if the trigger action does not depend on the data from rows that are affected or on data provided by the triggering event itself (for example, a trigger that performs a complex security check on the current user).

Row Trigger

A row trigger fires each time the table is affected by the triggering event. If the triggering event affects no rows, a row trigger is not executed. Row triggers are useful if the trigger action depends on data of the rows that are affected or on data provided by the triggering event itself.

Creating DML Triggers Using SQL Developer

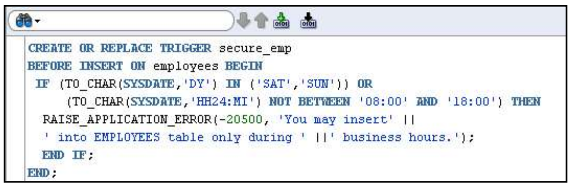



Create Trigger

Schema: ORA61
Name: TRIGGER1
[ ] Add New Source In Lowercase

Trigger | DDL

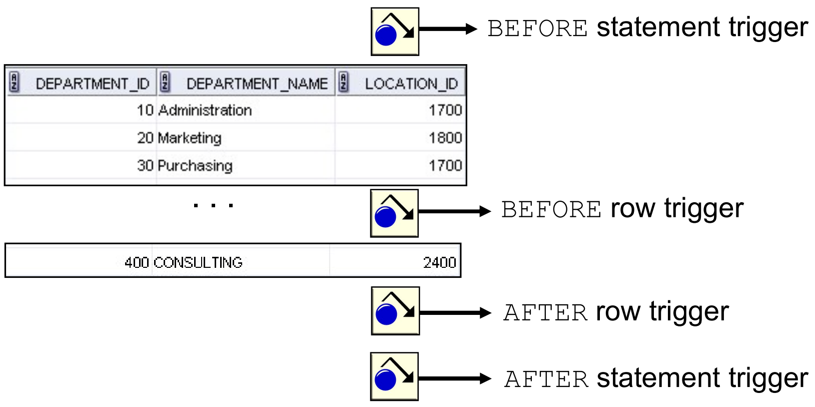
Trigger Type: TABLE [✓] Enabled
Table Owner: ORA61 Table Name:
[ ] Insert [ ] Delete [ ] Update
Referencing Old: New:
[✓ Before] After
[✓ Statement Level] Row Level
When:
Available Columns
Selected Columns


```
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-Firing Sequence: Single-Row Manipulation

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

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



Create a statement trigger or a row trigger based on the requirement that the trigger must fire once for each row affected by the triggering statement, or just once for the triggering statement, regardless of the number of rows affected.

When the triggering DML statement affects a single row, both the statement trigger and the row trigger fire exactly once.

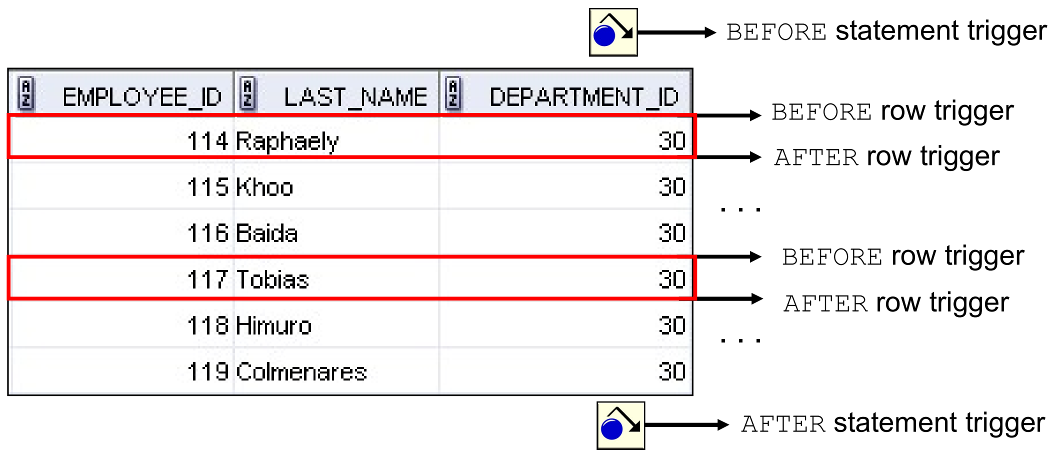
Example

The SQL statement in the slide does not differentiate statement triggers from row triggers because exactly one row is inserted into the table using the syntax for the `INSERT` statement shown in the slide.

Trigger-Firing Sequence: Multirow Manipulation

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;
```

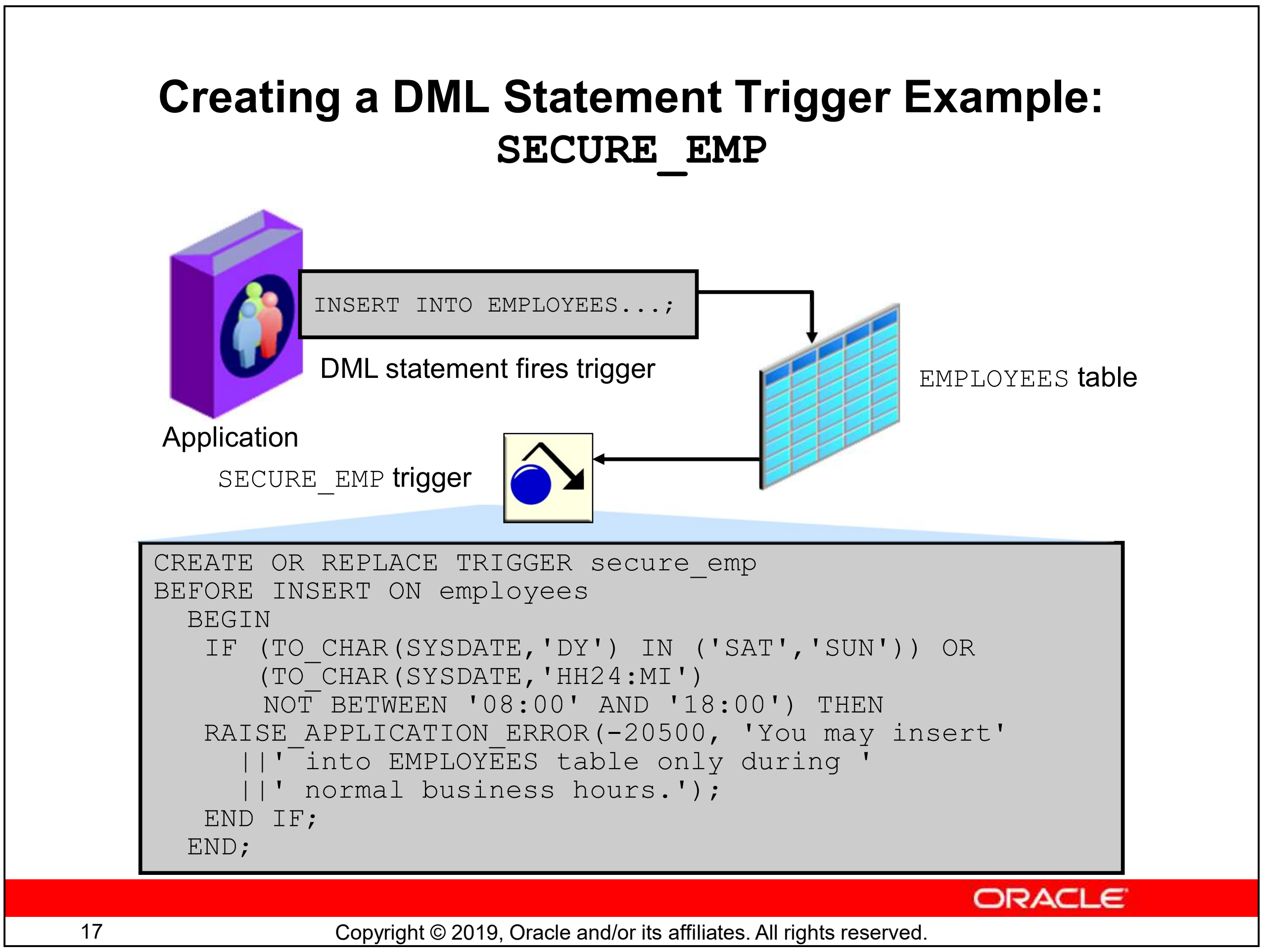


EMPLOYEE_ID	LAST_NAME	DEPARTMENT_ID
114	Raphaely	30
115	Khoo	30
116	Baida	30
117	Tobias	30
118	Himuro	30
119	Colmenares	30

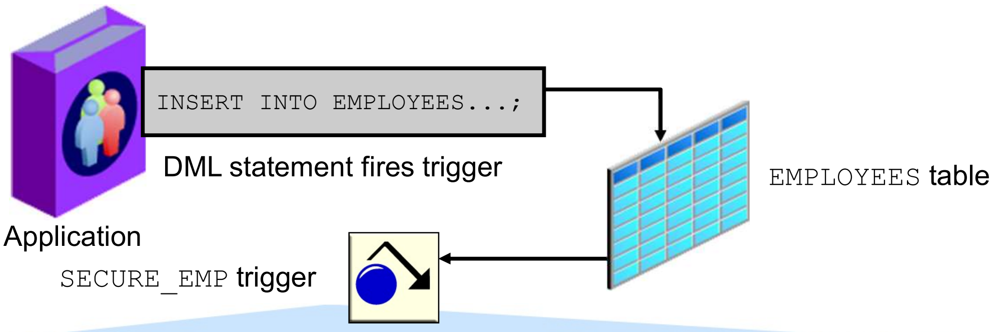
When the triggering DML statement affects many rows, the statement trigger fires exactly once, and the row trigger fires once for every row affected by the statement.

Example

The SQL statement in the slide causes a row-level trigger to fire a number of times equal to the number of rows that satisfy the `WHERE` clause (that is, the number of employees reporting to department 30).



Creating a DML Statement Trigger Example: SECURE_EMP



```
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 '
     ||' normal business hours.');
   END IF;
  END;
```

Creating a DML Statement Trigger

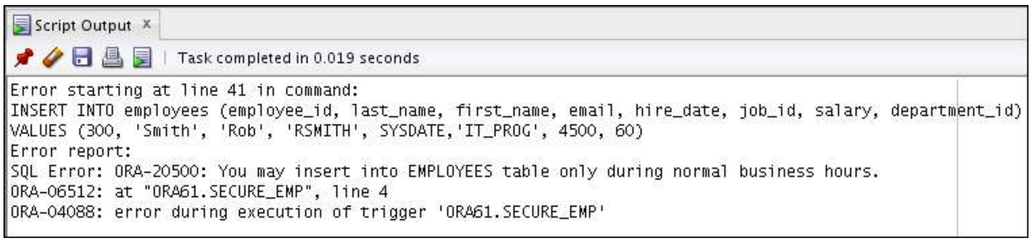
In the example in the slide, the SECURE_EMP database trigger is a BEFORE statement trigger that prevents the INSERT operation from succeeding if the business condition is violated. In this case, the trigger restricts inserts into the EMPLOYEES table during certain business hours, Monday through Friday.

If a user attempts to insert a row into the EMPLOYEES table on Saturday, then the user sees an error message, the trigger fails, and the triggering statement is rolled back. Remember that the RAISE_APPLICATION_ERROR is a server-side built-in procedure that returns an error to the user and causes the PL/SQL block to fail.

When a database trigger fails, the triggering statement is automatically rolled back by the Oracle server.

Testing Trigger `SECURE_EMP`

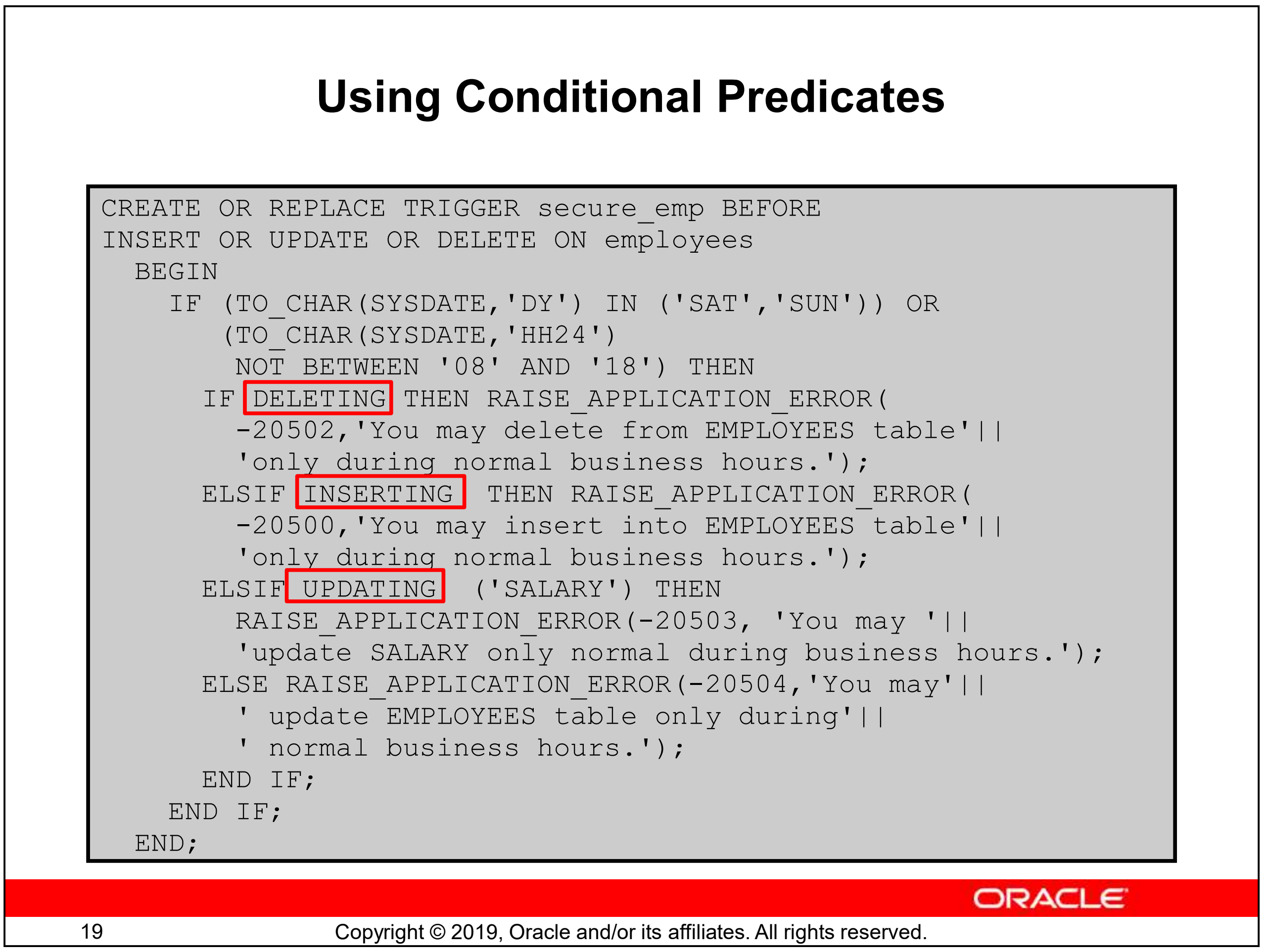
```
INSERT INTO employees (employee_id, last_name,
    first_name, email, hire_date, job_id, salary,
    department_id)
VALUES (300, 'Smith', 'Rob', 'RSMITH', SYSDATE,
  'IT_PROG', 4500, 60);
```



```
Error starting at line 41 in command:
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)
Error report:
SQL Error: ORA-20500: You may insert into EMPLOYEES table only during normal business hours.
ORA-06512: at "ORA61.SECURE_EMP", line 4
ORA-04088: error during execution of trigger 'ORA61.SECURE_EMP'
```

Testing `SECURE_EMP`

To test the trigger, insert a row into the `EMPLOYEES` table during nonbusiness hours. When the date and time are out of the business hours specified in the trigger, you receive the error message shown in the slide.



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 normal business hours.');
      ELSIF INSERTING  THEN RAISE_APPLICATION_ERROR(
        -20500,'You may insert into EMPLOYEES table'||
        'only during normal business hours.');
      ELSIF UPDATING  ('SALARY') THEN
        RAISE_APPLICATION_ERROR(-20503, 'You may '||
        'update SALARY only normal during business hours.');
      ELSE RAISE_APPLICATION_ERROR(-20504,'You may'||
        ' update EMPLOYEES table only during'||
        ' normal business hours.');
      END IF;
    END IF;
  END;
```

Detecting the DML Operation That Fired a Trigger

If more than one type of DML operation can fire a trigger (for example, `ON INSERT OR DELETE OR UPDATE OF Emp_tab`), the trigger body can use the conditional predicates `INSERTING`, `DELETING`, and `UPDATING` to check which type of statement fired the trigger.

You can combine several triggering events into one by taking advantage of the special conditional predicates `INSERTING`, `UPDATING`, and `DELETING` within the trigger body.

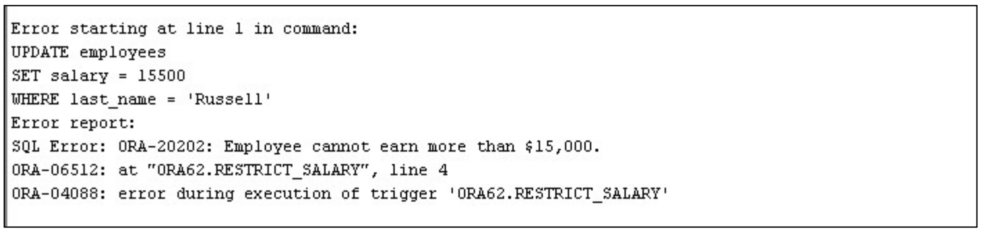
Example

Create one trigger to restrict all data manipulation events on the `EMPLOYEES` table to certain business hours, 8 AM to 6 PM, Monday through Friday.

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;
```

```
UPDATE employees
SET salary = 15500
WHERE last_name = 'Russell';
```



```
Error starting at line 1 in command:
UPDATE employees
SET salary = 15500
WHERE last_name = 'Russell'
Error report:
SQL Error: ORA-20202: Employee cannot earn more than $15,000.
ORA-06512: at "ORA62.RESTRICT_SALARY", line 4
ORA-04088: error during execution of trigger 'ORA62.RESTRICT_SALARY'
```

You can create a `BEFORE` row trigger in order to prevent the triggering operation from succeeding if a certain condition is violated.

In the first example in the slide, a trigger is created to allow only employees whose job IDs are either `AD_PRES` or `AD_VP` to earn a salary of more than 15,000. If you try to update the salary of employee `Russell` whose employee ID is `SA_MAN`, the trigger raises the exception displayed in the slide.

Note: Before executing the first code example in the slide, make sure you disable the `secure_emp` and `secure_employees` triggers.

Using OLD and NEW Qualifiers

- When a row-level trigger fires, the PL/SQL run-time engine creates and populates two data structures:
  - `OLD`: Stores the original values of the record processed by the trigger
  - `NEW`: Contains the new values
- `NEW` and `OLD` have the same structure as a record declared using the `%ROWTYPE` on the table to which the trigger is attached.

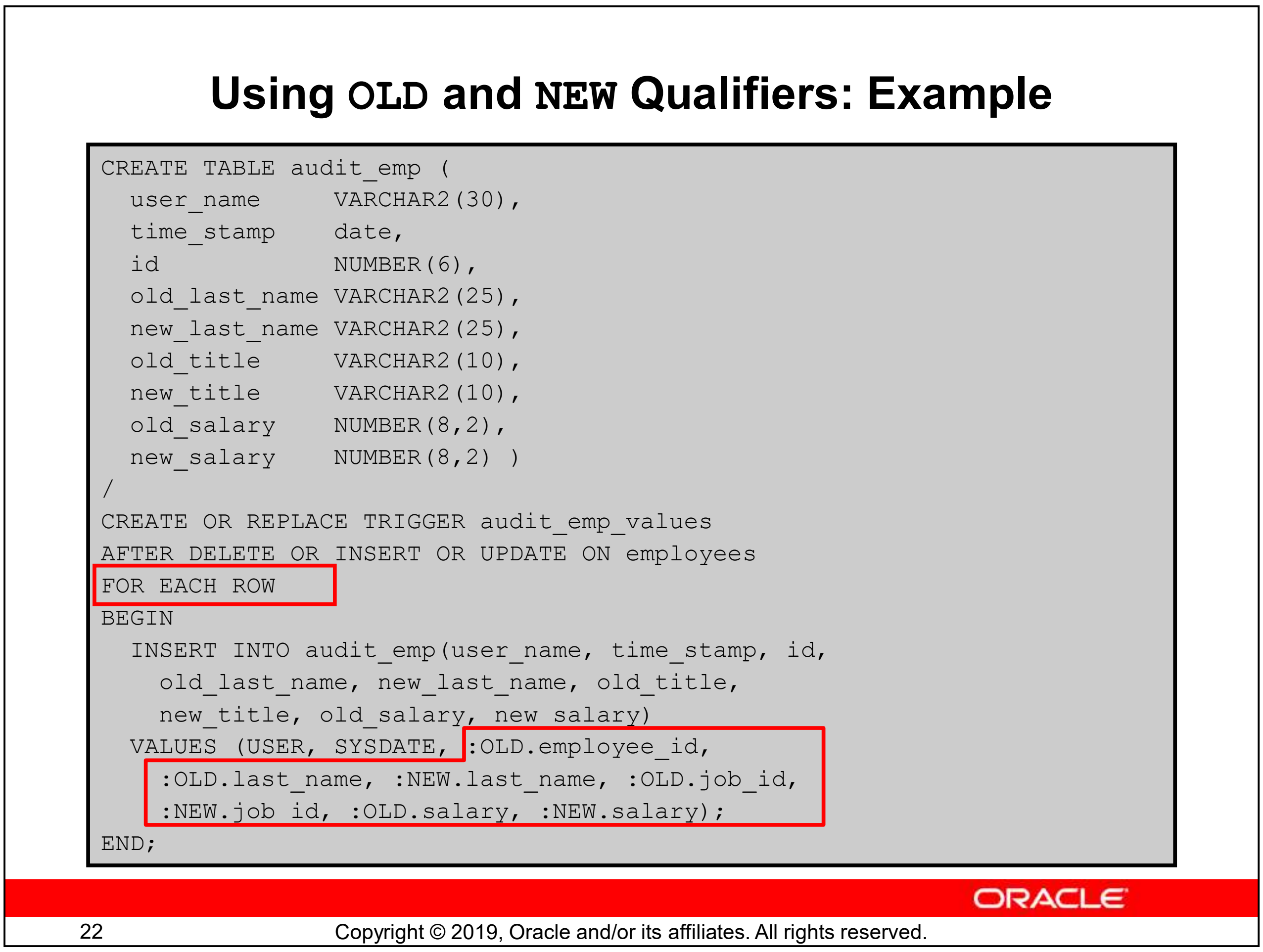
Data Operations	Old Value	New Value
`INSERT`	`NULL`	Inserted value
`UPDATE`	Value before update	Value after update
`DELETE`	Value before delete	`NULL`

ORACLE

Within a `ROW` trigger, you can reference the value of a column before and after the data change by prefixing it with the `OLD` and `NEW` qualifiers.

Note

- The `OLD` and `NEW` qualifiers are available only in `ROW` triggers.
- Prefix these qualifiers with a colon (`:`) in every SQL and PL/SQL statement.
- There is no colon (`:`) prefix if the qualifiers are referenced in the `WHEN` restricting condition.
- Row triggers can decrease the performance if you perform many updates on larger tables.



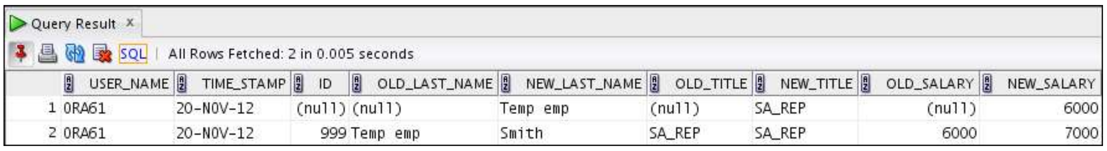
Using OLD and NEW Qualifiers: Example

```
CREATE TABLE audit_emp (
  user_name      VARCHAR2(30),
  time_stamp     date,
  id             NUMBER(6),
  old_last_name  VARCHAR2(25),
  new_last_name  VARCHAR2(25),
  old_title      VARCHAR2(10),
  new_title      VARCHAR2(10),
  old_salary     NUMBER(8,2),
  new_salary     NUMBER(8,2) )
/
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;
```

In the example in the slide, the AUDIT_EMP_VALUES trigger is created on the EMPLOYEES table. The trigger adds rows to a user table, AUDIT_EMP, logging a user's activity against the EMPLOYEES table. The trigger records the values of several columns both before and after the data changes by using the OLD and NEW qualifiers with the respective column name.

Using OLD and NEW Qualifiers: Example

```
INSERT INTO employees (employee_id, last_name, job_id,
salary, email, hire_date)
VALUES (999, 'Temp emp', 'SA_REP', 6000, 'TEMPEMP',
TRUNC(SYSDATE))
/
UPDATE employees
 SET salary = 7000, last_name = 'Smith'
 WHERE employee_id = 999
/
SELECT *
FROM  audit_emp;
```



Query Result

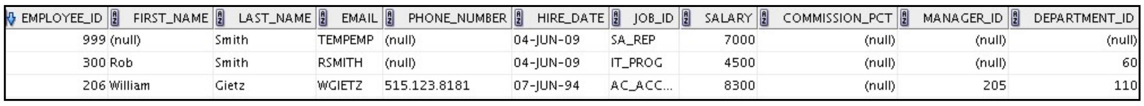
All Rows Fetched: 2 in 0.005 seconds

	USER_NAME	TIME_STAMP	ID	OLD_LAST_NAME	NEW_LAST_NAME	OLD_TITLE	NEW_TITLE	OLD_SALARY	NEW_SALARY
1	ORA61	20-NOV-12	(null)	(null)	Temp emp	(null)	SA_REP	(null)	6000
2	ORA61	20-NOV-12	999	Temp emp	Smith	SA_REP	SA_REP	6000	7000

Using OLD and NEW Qualifiers: Example the Using AUDIT_EMP Table

Create a trigger on the EMPLOYEES table to add rows to a user table, AUDIT_EMP, logging a user's activity against the EMPLOYEES table. The trigger records the values of several columns both before and after the data changes by using the OLD and NEW qualifiers with the respective column name.

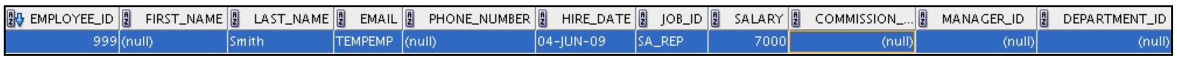
The following is the result of inserting the employee record into the EMPLOYEES table:



EMPLOYEE_ID	FIRST_NAME	LAST_NAME	EMAIL	PHONE_NUMBER	HIRE_DATE	JOB_ID	SALARY	COMMISSION_PCT	MANAGER_ID	DEPARTMENT_ID
999	(null)	Smith	TEMPEMP	(null)	04-JUN-09	SA_REP	7000	(null)	(null)	(null)
300	Rob	Smith	RSMITH	(null)	04-JUN-09	IT_PROG	4500	(null)	(null)	60
206	William	Gietz	WGIETZ	515.123.8181	07-JUN-94	AC_ACC...	8300	(null)	205	110

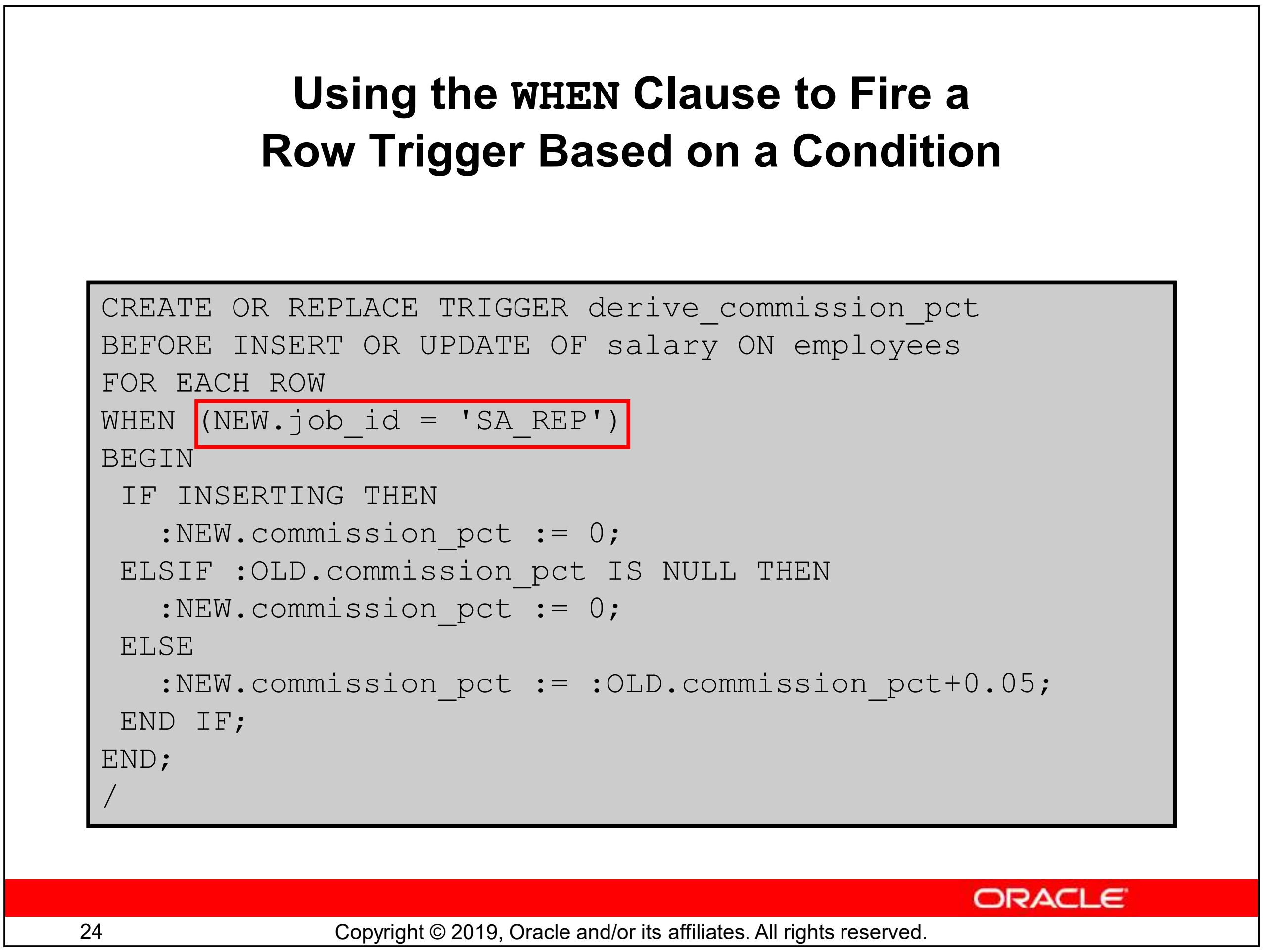
. . .

The following is the result of updating the salary for employee "Smith":



EMPLOYEE_ID	FIRST_NAME	LAST_NAME	EMAIL	PHONE_NUMBER	HIRE_DATE	JOB_ID	SALARY	COMMISSION_...	MANAGER_ID	DEPARTMENT_ID
999	(null)	Smith	TEMPEMP	(null)	04-JUN-09	SA_REP	7000	(null)	(null)	(null)

. . .



Using the WHEN Clause to Fire a Row Trigger Based on a Condition

```
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;
/
```

Restricting a Row Trigger: Example

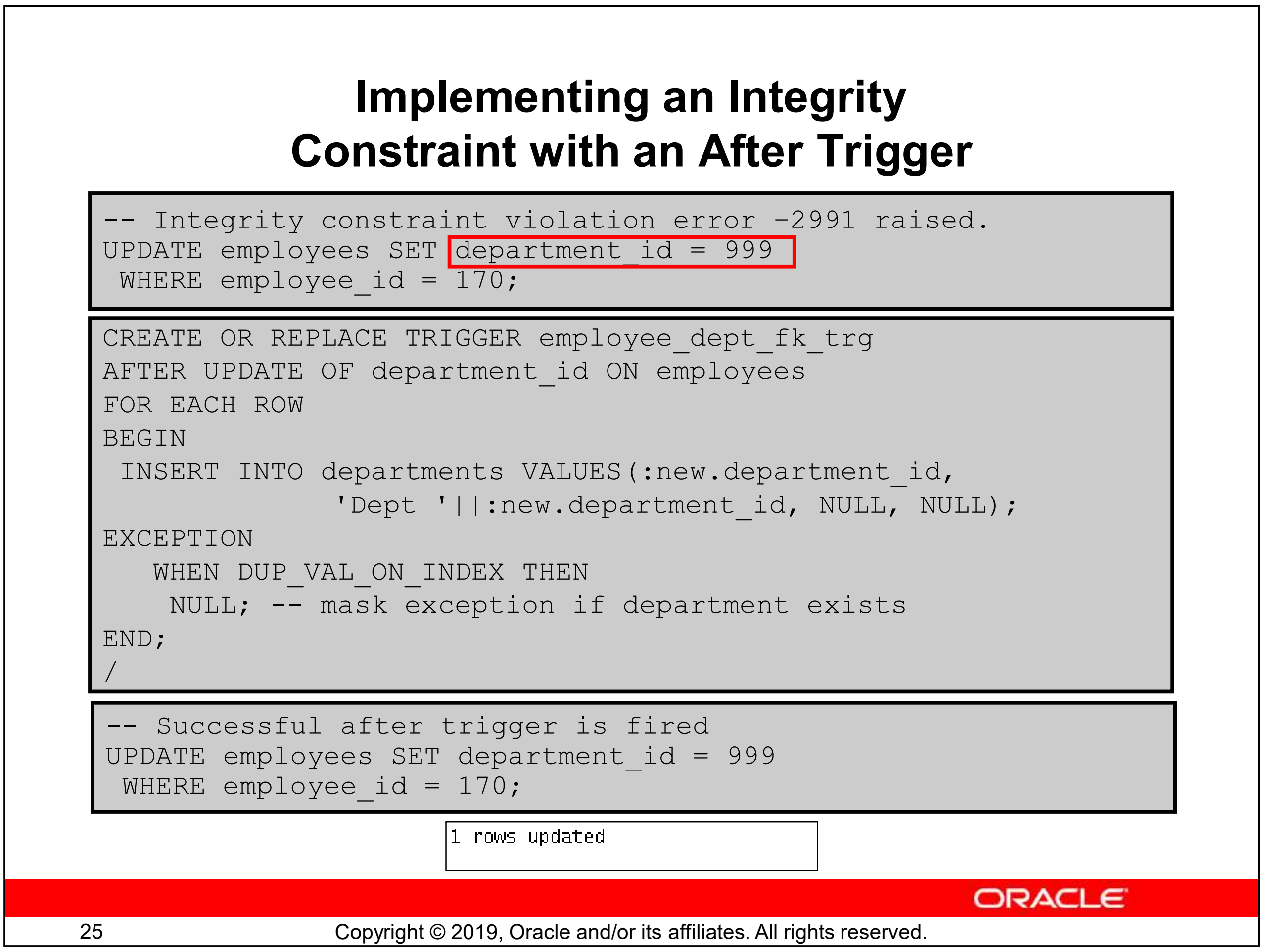
Optionally, you can include a trigger restriction in the definition of a row trigger by specifying a Boolean SQL expression in a `WHEN` clause. If you include a `WHEN` clause in the trigger, then the expression in the `WHEN` clause is evaluated for each row that the trigger affects.

If the expression evaluates to `TRUE` for a row, then the trigger body executes on behalf of that row. However, if the expression evaluates to `FALSE` or `NOT TRUE` for a row (unknown, as with nulls), then the trigger body does not execute for that row. The evaluation of the `WHEN` clause does not have an effect on the execution of the triggering SQL statement (in other words, the triggering statement is not rolled back if the expression in a `WHEN` clause evaluates to `FALSE`).

Note: A `WHEN` clause cannot be included in the definition of a statement trigger.

In the example in the slide, a trigger is created on the `EMPLOYEES` table to calculate an employee's commission when a row is added to the `EMPLOYEES` table, or when an employee's salary is modified.

The `NEW` qualifier cannot be prefixed with a colon in the `WHEN` clause because the `WHEN` clause is outside the PL/SQL blocks.



Implementing an Integrity Constraint with an After Trigger

```
-- Integrity constraint violation error -2991 raised.
UPDATE employees SET department_id = 999
 WHERE employee_id = 170;
```

```
CREATE OR REPLACE TRIGGER employee_dept_fk_trg
AFTER UPDATE OF department_id ON employees
FOR EACH ROW
BEGIN
 INSERT INTO departments VALUES(:new.department_id,
              'Dept '||:new.department_id, NULL, NULL);
EXCEPTION
   WHEN DUP_VAL_ON_INDEX THEN
    NULL; -- mask exception if department exists
END;
/
```

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

```
1 rows updated
```

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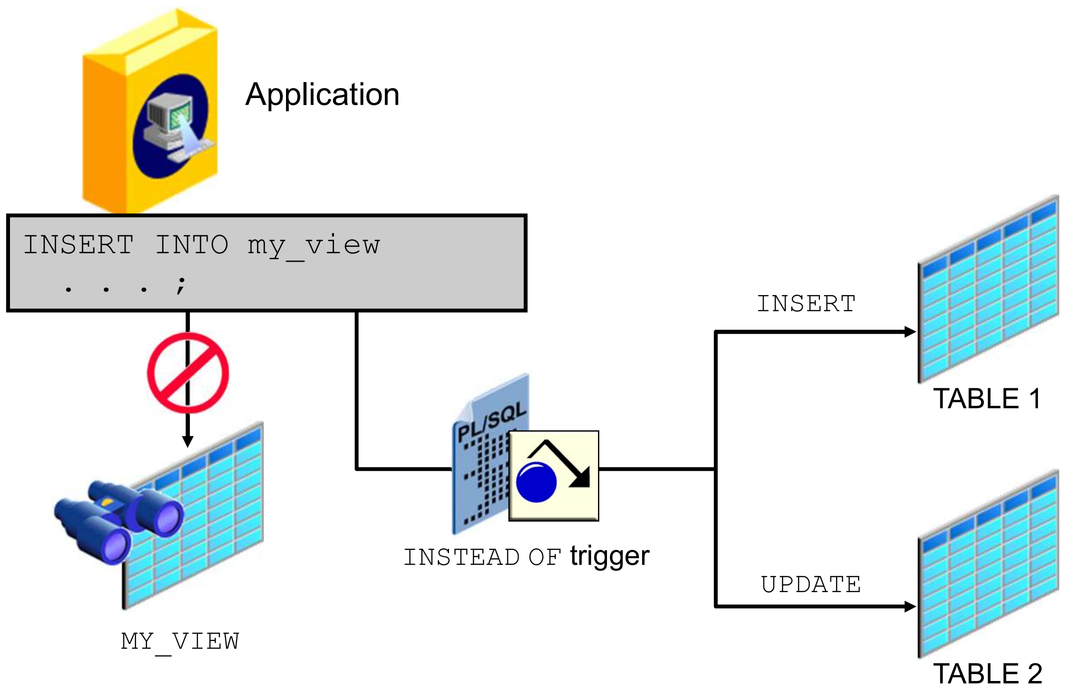
The example in the slide explains a situation in which the integrity constraint can be taken care of by using an `AFTER` trigger. The `EMPLOYEES` table has a foreign key constraint on the `DEPARTMENT_ID` column of the `DEPARTMENTS` table.

In the first SQL statement, the `DEPARTMENT_ID` of the employee 170 is modified to 999. Because department 999 does not exist in the `DEPARTMENTS` table, the statement raises exception –2291 for the integrity constraint violation.

The `EMPLOYEE_DEPT_FK_TRG` trigger is created and it inserts a new row into the `DEPARTMENTS` table by using `:NEW.DEPARTMENT_ID` for the value of the new department's `DEPARTMENT_ID`. The trigger fires when the `UPDATE` statement modifies the `DEPARTMENT_ID` of employee 170 to 999. When the foreign key constraint is checked, it is successful because the trigger inserted the department 999 into the `DEPARTMENTS` table. Therefore, no exception occurs unless the department already exists when the trigger attempts to insert the new row. However, the `EXCEPTION` handler traps and masks the exception allowing the operation to succeed.

Note: Although the example shown in the slide is somewhat contrived due to the limited data in the `HR` schema, the point is that if you defer the constraint check until the commit, you then have the ability to engineer a trigger to detect that constraint failure and repair it prior to the commit action.

INSTEAD OF Triggers



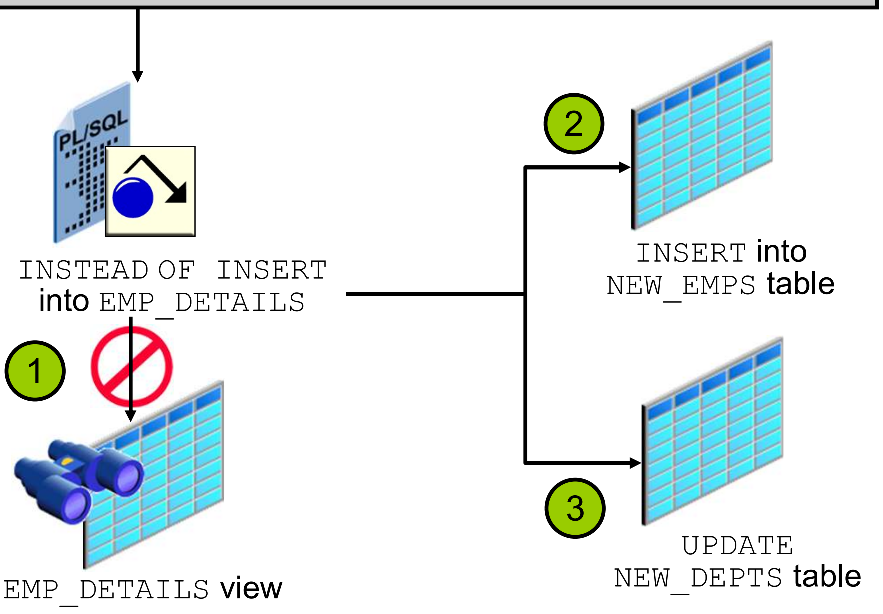
```
INSERT INTO my_view
  . . . ;
```

Use INSTEAD OF triggers to modify data in which the DML statement has been issued against an inherently un-updatable view. These triggers are called INSTEAD OF triggers because, unlike other triggers, the Oracle server fires the trigger instead of executing the triggering statement. These triggers are used to perform INSERT, UPDATE, and DELETE operations directly on the underlying tables. You can write INSERT, UPDATE, and DELETE statements against a view, and the INSTEAD OF trigger works invisibly in the background to make the right actions take place. A view cannot be modified by normal DML statements if the view query contains set operators, group functions, clauses such as GROUP BY, CONNECT BY, START, the DISTINCT operator, or joins. For example, if a view consists of more than one table, an insert to the view may entail an insertion into one table and an update to another. So you write an INSTEAD OF trigger that fires when you write an insert against the view. Instead of the original insertion, the trigger body executes, which results in an insertion of data into one table and an update to another table.

Note: If a view is inherently updatable and has INSTEAD OF triggers, then the triggers take precedence. INSTEAD OF triggers are row triggers. The CHECK option for views is not enforced when insertions or updates to the view are performed by using INSTEAD OF triggers. The INSTEAD OF trigger body must enforce the check.

Creating an INSTEAD OF Trigger: Example

```
INSERT INTO emp_details
VALUES (9001,'ABBOTT',3000, 10, 'Administration');
```

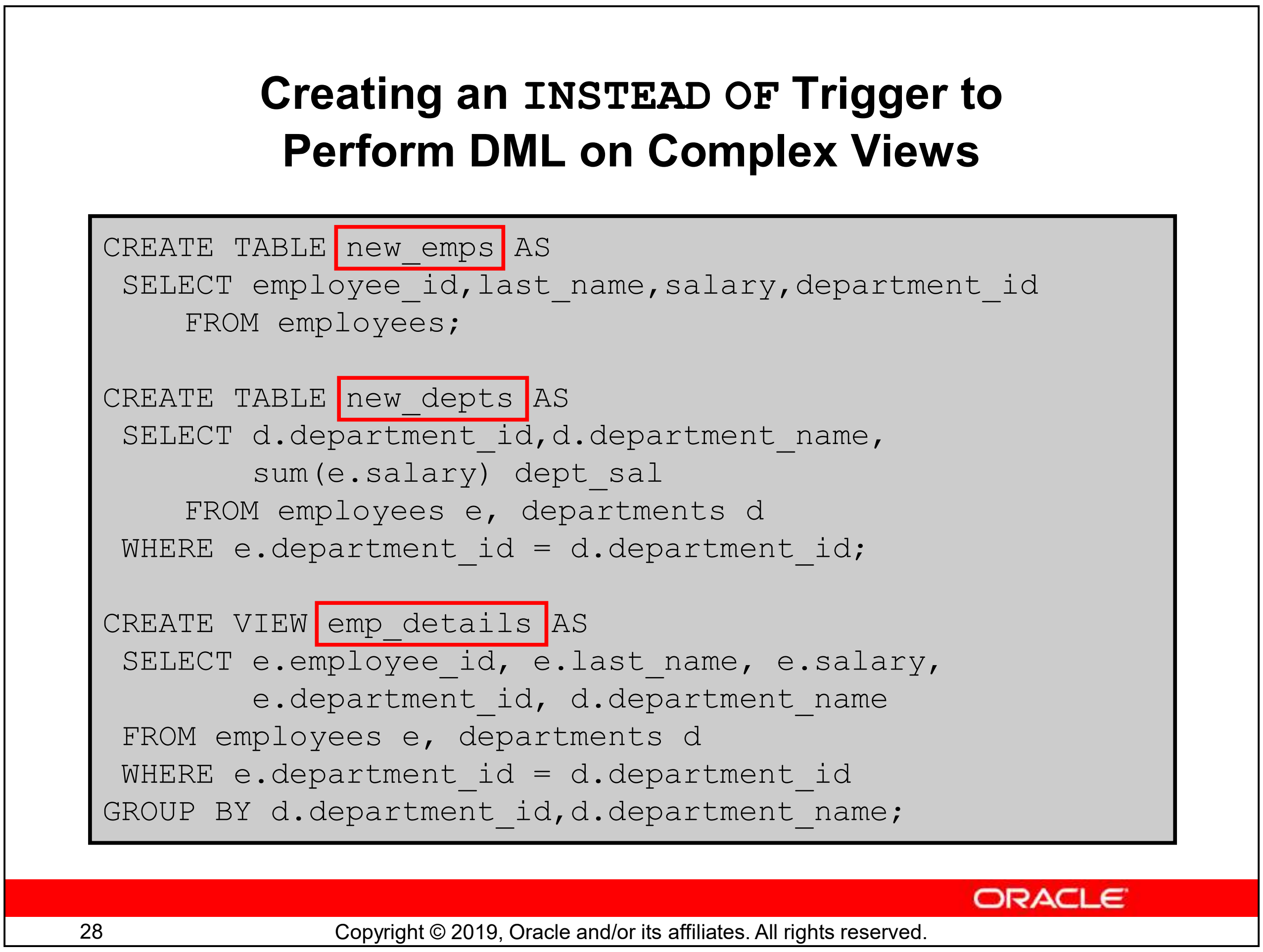


You can create an INSTEAD OF trigger in order to maintain the base tables on which a view is based.

The example in the slide illustrates an employee being inserted into the view EMP_DETAILS, whose query is based on the EMPLOYEES and DEPARTMENTS tables. The NEW_EMP_DEPT (INSTEAD OF) trigger executes in place of the INSERT operation that causes the trigger to fire. The INSTEAD OF trigger then issues the appropriate INSERT and UPDATE to the base tables used by the EMP_DETAILS view. Therefore, instead of inserting the new employee record into the EMPLOYEES table, the following actions take place:

1. The NEW_EMP_DEPT INSTEAD OF trigger fires.
2. A row is inserted into the NEW_EMPS table.
3. The DEPT_SAL column of the NEW_DEPTS table is updated. The salary value supplied for the new employee is added to the existing total salary of the department to which the new employee has been assigned.

Note: Before you run the example in the slide, you must create the required structures shown on the next two pages.



Creating an `INSTEAD OF` Trigger to Perform DML on Complex Views

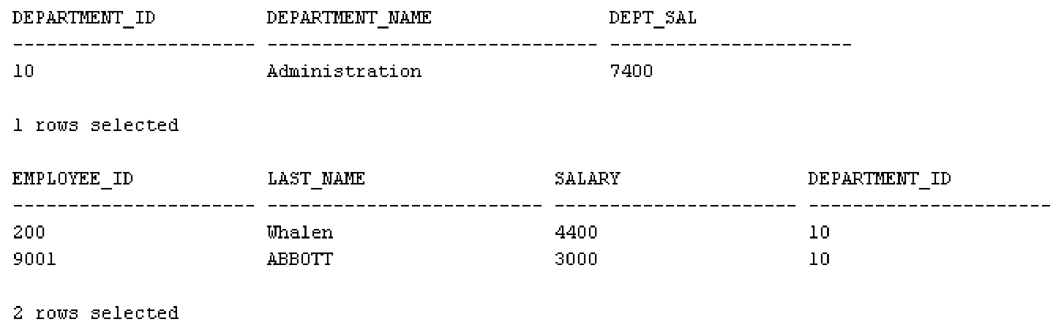
```
CREATE TABLE new_emps AS
 SELECT employee_id,last_name,salary,department_id
    FROM employees;

CREATE TABLE new_depts AS
 SELECT d.department_id,d.department_name,
        sum(e.salary) dept_sal
    FROM employees e, departments d
 WHERE e.department_id = d.department_id;

CREATE VIEW emp_details AS
 SELECT e.employee_id, e.last_name, e.salary,
        e.department_id, d.department_name
 FROM employees e, departments d
 WHERE e.department_id = d.department_id
GROUP BY d.department_id,d.department_name;
```

The example in the slide creates two new tables, `NEW_EMPS` and `NEW_DEPTS`, that are based on the `EMPLOYEES` and `DEPARTMENTS` tables, respectively. It also creates an `EMP_DETAILS` view from the `EMPLOYEES` and `DEPARTMENTS` tables.

If a view has a complex query structure, then it is not always possible to perform DML directly on the view to affect the underlying tables. The example requires creation of an `INSTEAD OF` trigger, called `NEW_EMP_DEPT`, shown on the next page. The `NEW_DEPT_EMP` trigger handles DML in the following way:

- When a row is inserted into the `EMP_DETAILS` view, instead of inserting the row directly into the view, rows are added into the `NEW_EMPS` and `NEW_DEPTS` tables, using the data values supplied with the `INSERT` statement.
- When a row is modified or deleted through the `EMP_DETAILS` view, corresponding rows in the `NEW_EMPS` and `NEW_DEPTS` tables are affected.

Note: `INSTEAD OF` triggers can be written only for views, and the `BEFORE` and `AFTER` timing options are not valid.

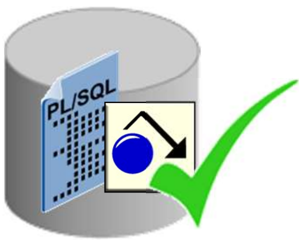


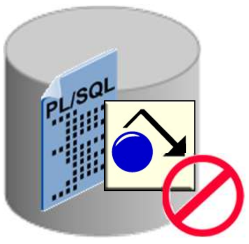
```
DEPARTMENT_ID          DEPARTMENT_NAME                DEPT_SAL
---------------------- ------------------------------ ----------------------
10                     Administration                 7400

1 rows selected

EMPLOYEE_ID            LAST_NAME                 SALARY                 DEPARTMENT_ID
---------------------- ------------------------- ---------------------- ----------------------
200                    Whalen                    4400                   10
9001                   ABBOTT                    3000                   10

2 rows selected
```

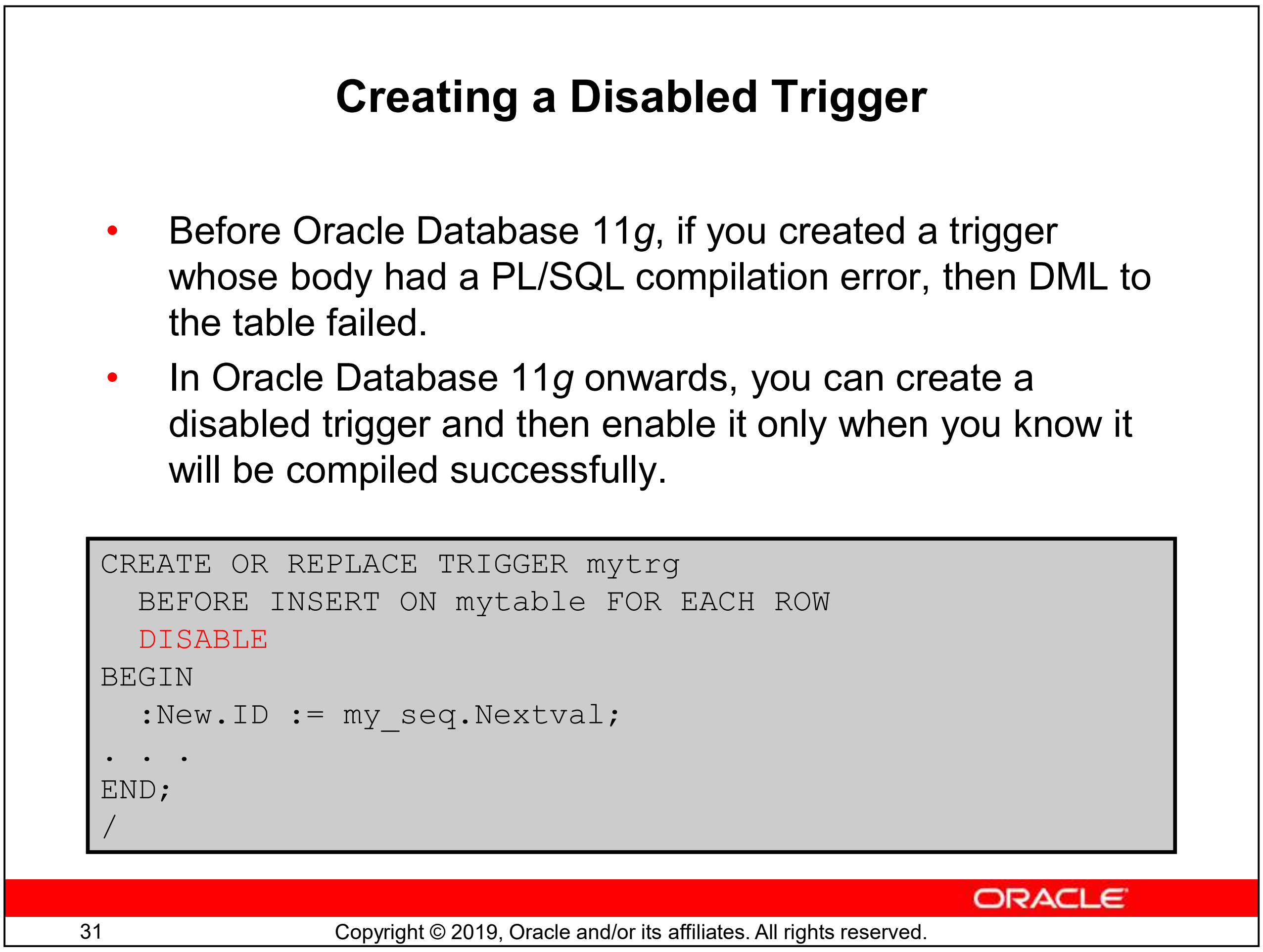
The Status of a Trigger

A trigger is in either of two distinct modes:

- Enabled: The trigger runs its trigger action if a triggering statement is issued and the trigger restriction (if any) evaluates to true (default).
- Disabled: The trigger does not run its trigger action, even if a triggering statement is issued and the trigger restriction (if any) would evaluate to true.







Creating a Disabled Trigger

- Before Oracle Database 11*g*, if you created a trigger whose body had a PL/SQL compilation error, then DML to the table failed.
- In Oracle Database 11*g* onwards, you can create a disabled trigger and then enable it only when you know it will be compiled successfully.

```
CREATE OR REPLACE TRIGGER mytrg
  BEFORE INSERT ON mytable FOR EACH ROW
  DISABLE
BEGIN
  :New.ID := my_seq.Nextval;
. . .
END;
/
```

Before Oracle Database 11*g*, if you created a trigger whose body had a PL/SQL compilation error, then DML to the table failed. The following error message was displayed:

```
ORA-04098: trigger 'TRG' is invalid and failed re-validation
```

In Oracle Database 11*g* onwards, you can create a disabled trigger, and then enable it only when you know it will be compiled successfully.

You can also temporarily disable a trigger in the following situations:

- An object it references is not available.
- You need to perform a large data load, and you want it to proceed quickly without firing triggers.
- You are reloading data.

Note: The code example in the slide assumes that you have an existing sequence named `my_seq`.

Managing Triggers Using the `ALTER` and `DROP` SQL Statements

```
-- 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;
```

```
-- Remove a trigger from the database:

DROP TRIGGER trigger_name;
```

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Managing Triggers

A trigger has two modes or states: `ENABLED` and `DISABLED`. When a trigger is first created, it is enabled by default. The Oracle server checks integrity constraints for enabled triggers and guarantees that triggers cannot compromise them. In addition, the Oracle server provides read-consistent views for queries and constraints, manages the dependencies, and provides a two-phase commit process if a trigger updates remote tables in a distributed database.

Disabling a Trigger

Use the `ALTER TRIGGER` command to disable a trigger. You can also disable all triggers on a table by using the `ALTER TABLE` command. You can disable triggers to improve performance or to avoid data integrity checks when loading massive amounts of data with utilities such as SQL*Loader. You might also disable a trigger when it references a database object that is currently unavailable, due to a failed network connection, disk crash, offline data file, or offline tablespace.

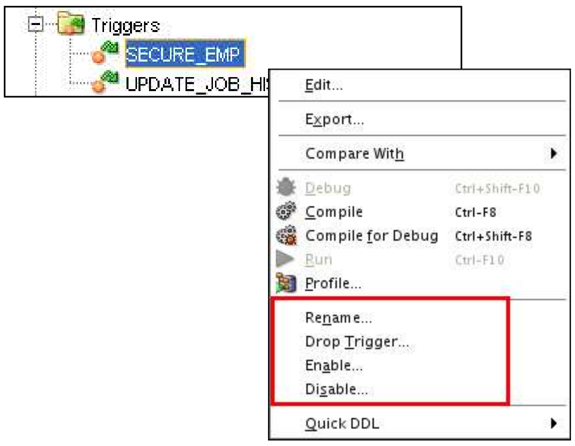
Recompiling a Trigger

Use the `ALTER TRIGGER` command to explicitly recompile a trigger that is invalid.

Removing Triggers

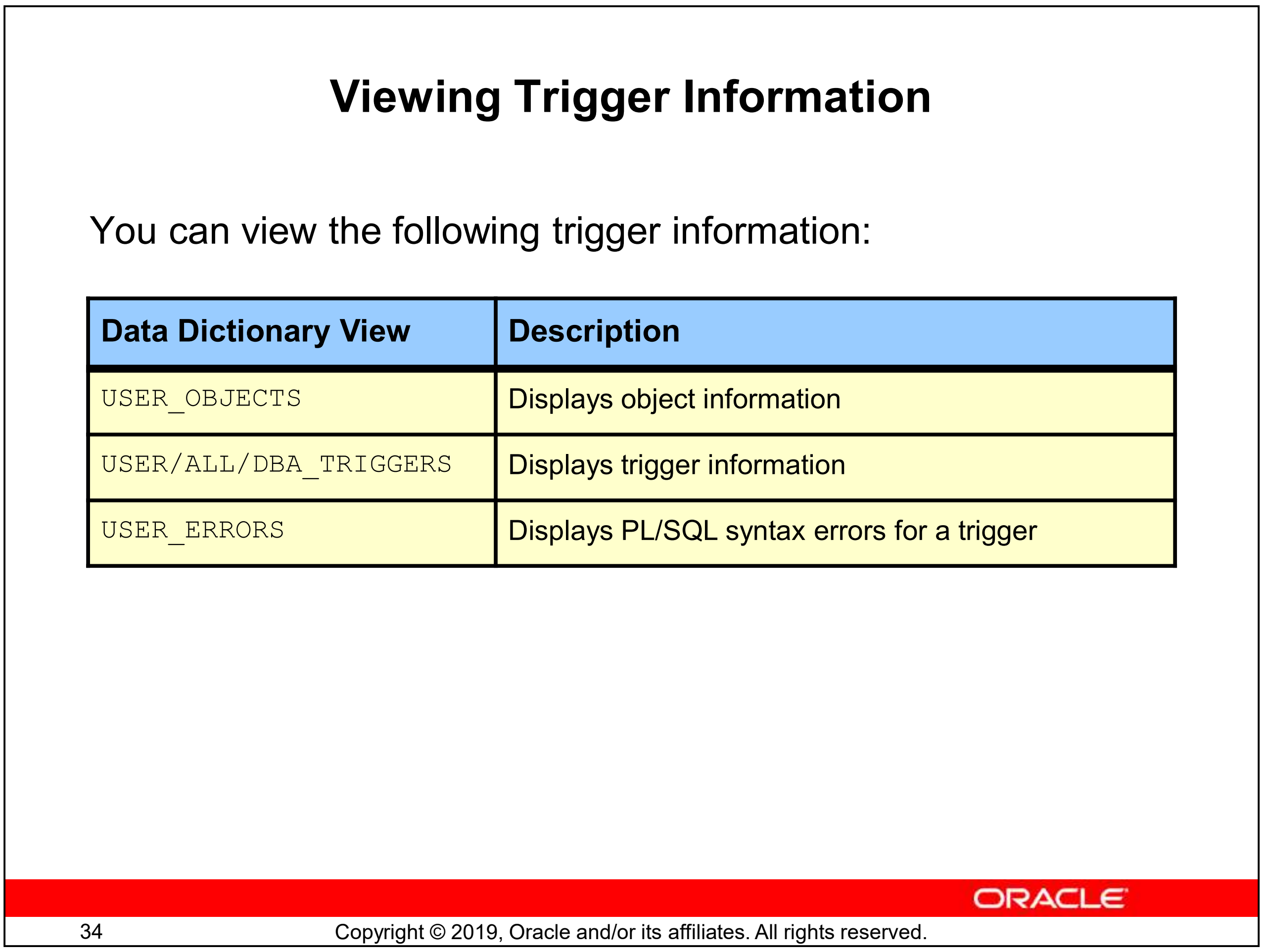
When a trigger is no longer required, use a SQL statement in SQL Developer or SQL*Plus to remove it. When you remove a table, all triggers on that table are also removed.

Managing Triggers Using SQL Developer



You can use the Triggers node in the Connections navigation tree to manage triggers. Right-click a trigger name, and then select one of the following options:

- Edit
- Compile
- Compile for Debug
- Rename
- Drop Trigger
- Enable
- Disable



Viewing Trigger Information

You can view the following trigger information:

Data Dictionary View	Description
`USER_OBJECTS`	Displays object information
`USER/ALL/DBA_TRIGGERS`	Displays trigger information
`USER_ERRORS`	Displays PL/SQL syntax errors for a trigger

The slide shows the data dictionary views that you can access to get information regarding the triggers.

The `USER_OBJECTS` view contains the name and status of the trigger and the date and time when the trigger was created.

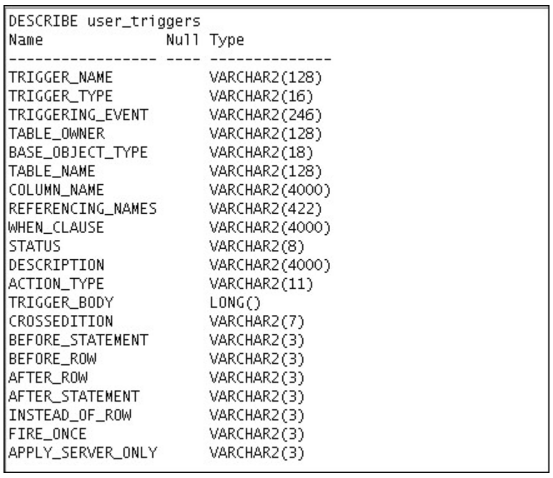
The `USER_ERRORS` view contains the details about the compilation errors that occurred while a trigger was compiling. The contents of these views are similar to those for subprograms.

The `USER_TRIGGERS` view contains details such as name, type, triggering event, the table on which the trigger is created, and the body of the trigger.

The `SELECT Username FROM USER_USERS;` statement gives the name of the owner of the trigger, not the name of the user who is updating the table.

Using USER_TRIGGERS

```
DESCRIBE user_triggers
```



```
DESCRIBE user_triggers
Name              Null Type
----------------- ---- --------------
TRIGGER_NAME           VARCHAR2(128)
TRIGGER_TYPE           VARCHAR2(16)
TRIGGERING_EVENT       VARCHAR2(246)
TABLE_OWNER            VARCHAR2(128)
BASE_OBJECT_TYPE       VARCHAR2(18)
TABLE_NAME             VARCHAR2(128)
COLUMN_NAME            VARCHAR2(4000)
REFERENCING_NAMES      VARCHAR2(422)
WHEN_CLAUSE            VARCHAR2(4000)
STATUS                 VARCHAR2(8)
DESCRIPTION            VARCHAR2(4000)
ACTION_TYPE            VARCHAR2(11)
TRIGGER_BODY           LONG()
CROSSEDITION           VARCHAR2(7)
BEFORE_STATEMENT       VARCHAR2(3)
BEFORE_ROW             VARCHAR2(3)
AFTER_ROW              VARCHAR2(3)
AFTER_STATEMENT        VARCHAR2(3)
INSTEAD_OF_ROW         VARCHAR2(3)
FIRE_ONCE              VARCHAR2(3)
APPLY_SERVER_ONLY      VARCHAR2(3)
```

```
SELECT trigger_type, trigger_body
FROM user_triggers
WHERE trigger_name = 'SECURE_EMP';
```

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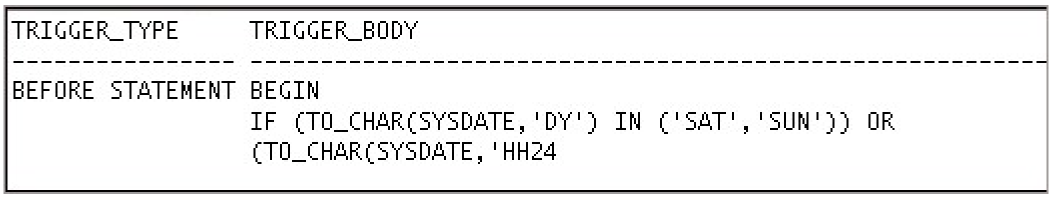
If the source file is unavailable, then you can use the SQL Worksheet in SQL Developer or SQL*Plus to regenerate it from `USER_TRIGGERS`. You can also examine the `ALL_TRIGGERS` and `DBA_TRIGGERS` views, each of which contains the additional column `OWNER`, for the owner of the object. The result for the second example in the slide is as follows:



```
TRIGGER_TYPE     TRIGGER_BODY
---------------- ------------------------------------------------------------
BEFORE STATEMENT BEGIN
                 IF (TO_CHAR(SYSDATE,'DY') IN ('SAT','SUN')) OR
                 (TO_CHAR(SYSDATE,'HH24
```

Quiz

A triggering event can be one or more of the following:

a. An `INSERT`, `UPDATE`, or `DELETE` statement on a specific table (or view, in some cases)
b. A `CREATE`, `ALTER`, or `DROP` statement on any schema object
c. A database startup or instance shutdown
d. A specific error message or any error message
e. A user logon or logoff

Answer: a, b, c, d, e

Summary

In this lesson, you should have learned how to:

- Describe database triggers and their uses
- Describe the different types of triggers
- Create database triggers
- Describe database trigger-firing rules
- Remove database triggers
- Display trigger information

This lesson covered creating database triggers that execute before, after, or instead of a specified DML operation. Triggers are associated with database tables or views. The `BEFORE` and `AFTER` timings apply to DML operations on tables. The `INSTEAD OF` trigger is used as a way to replace DML operations on a view with appropriate DML statements against other tables in the database.

Triggers are enabled by default but can be disabled to suppress their operation until enabled again. If business rules change, triggers can be removed or altered as required.