## National University of Computer & Emerging Sciences, Peshawar Software Engineering- School of Computing



**Spring 2025, Lab Manual – 09**

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| **Course Code:**  **CL-2005** | **Course: Database Systems Lab** |
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### Contents:

* Triggers in PL/SQL.

# Triggers:

Triggers are named PL/SQL blocks which are stored in the database. We can also say that they are specialized stored programs which execute implicitly when a triggering event occurs. This means we cannot call and execute them directly instead they only get triggered by events in the database.

**Events Which Fires the Database Triggers**

These events can be anything such as:

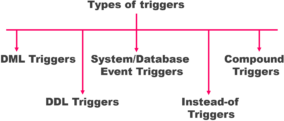
1. **A DML Statement** – An Update, Insert or Delete statement executing on any table of your database. You can program your trigger to execute either BEFORE or AFTER executing your DML statement. For

example, you can create a trigger which will get fired *Before* the Update. Similarly, you can create a trigger which will get triggered after the execution of your INSERT DML statement.

1. **A DDL Statement** – Next type of triggering statement can be a DDL Statement such as CREATE or ALTER. These triggers can also be executed either BEFORE or AFTER the execution of your DDL statement. These triggers are generally used by DBAs for auditing purposes. And they really come in handy when you want to keep an eye on the various changes on your schema. For instance, who created the object or which user. Just like some cool spy tricks.
2. **A system event**. – Yes, you can create a trigger on a system event. And by a system event, I mean shut down or startup of your database.
3. **A User Events** – Another type of triggering event can be User Events such as log off or log on onto your database. You can create a trigger which will either execute before or after the event. Furthermore, it will record the information such as time of event occur, the username who created it.

**Types of Database Triggers**

There are 5 types of triggers in the Oracle database. Three of them are based on the triggering event which are discussed in the previous section.



* **Data Manipulation Language Triggers or DML triggers:** As the name suggests these are the triggers which depend on DML statements such as Update, Insert or Delete. They get fired either before or after them. Using DML trigger you can control the behavior of your DML statements. You can audit, check, replace or save values before they are changed. Automatic Increment of your Numeric primary key is one of the most frequent tasks of these types of triggers.
* **Data Definition Language Triggers or DDL triggers:** Again as the name suggests these are the type of triggers which are created over DDL statements such as CREATE or ALTER. They get fired either before or after the execution of your DDL statements. Using this type of trigger, you can monitor the behavior and force rules on your DDL statements.
* **System or Database Event triggers:** Third type of triggers is system or database triggers. These are the type of triggers which come into action when some system event occurs such as database log on or log off. You can use these triggers for auditing purposes. For example, keeping an eye on information of system access like say who connects with your database and when. Most of the time System or Database Event triggers work as Swiss Knife for DBAs and help them in increasing the security of the data.
* **Instead-of Trigger:** This is a type of trigger which enables you to stop and redirect the performance of a DML statement. Often this type of trigger helps you in managing the way you write to non-updatable views. You can also see the application of business rules by INSTEAD OF triggers where they insert, update or delete rows directly in tables that are defining updatable views. Alternatively, sometimes the INSTEAD OF triggers are also seen inserting, updating or deleting rows in designated tables that are otherwise unrelated to the view.
* **Compound Triggers:** These are multi-tasking triggers that act as both statement as well as row-level triggers when the data is inserted, updated or deleted from a table. You can capture information at four timing points using this trigger:
  1. before the firing statement.
  2. prior to the change of each row from the firing statement.
  3. post each row changes from the firing statement.
  4. After the firing statement.

All these types of triggers can be used to audit, check, save and replace the values. Even before they are changed right when there is a need to take action at the statement as well as at row event levels.

## The Syntax of Database Trigger

**CREATE [OR REPLACE] TRIGGER** trigger\_name {**BEFORE|AFTER**} Triggering\_event **ON** table\_name [**FOR EACH ROW**] [**FOLLOWS** another\_trigger\_name]

[**ENABLE/DISABLE**] [**WHEN** condition]

**DECLARE**

Declaration statements

**BEGIN**

executable statements

**EXCEPTION**

exception-handling statements

**END**;

### Uses of Database triggers.

Using database triggers, we can enforce business rules that can’t be defined by using integrity constants. Using triggers, we can gain strong control over the security. We can also collect statistical information on the table

access. We can automatically generate values for derived columns such as auto increment numeric primary key. Using database triggers we can prevent the invalid transactions.

## Data Manipulation Language (DML) Triggers.

As the name suggests, these are the triggers which execute on DML events or say depend on DML statements such as Update, Insert or Delete. Using DML trigger, you can control the behavior of your DML statements.

### Examples

To demonstrate the creation process of DML trigger, we need to first create a table.

### Create table Superheroes (sh\_name VARCHAR2(15));

I have created this table with the name SUPERHEROES which has only one column sh\_name with data type varchar2 and data width 15. Now I will write a DML trigger which will work on this table.

### Example 1. Before Insert Trigger

In the first example, we will see how to create a trigger over Insert DML. This trigger will print a user defined message every time a user inserts a new row in the superheroes table.

**CREATE OR REPLACE TRIGGER** bi\_Superheroes

**BEFORE INSERT ON** superheroes

**FOR EACH ROW ENABLE**

**DECLARE**

v\_user VARCHAR2 (15);

**BEGIN**

SELECT user INTO v\_user FROM dual;

DBMS\_OUTPUT.PUT\_LINE('You Just Inserted a Row Mr.'|| v\_user);

**END;**/

### Example 2: Before Update Trigger.

Update Trigger is the one which will execute either before or after Update DML. The creation process of an Update trigger is the same as that of Insert Trigger. You just have to replace Keyword INSERT with UPDATE in the 2nd Line of the above example.

**CREATE OR REPLACE TRIGGER** bu\_Superheroes

**BEFORE UPDATE ON** superheroes

**FOR EACH ROW ENABLE**

**DECLARE**

v\_user VARCHAR2 (15);

**BEGIN**

SELECT user INTO v\_user FROM dual;

DBMS\_OUTPUT.PUT\_LINE('You Just Updated a Row Mr.'|| v\_user);

**END;**/

### Example 3: Before Delete Trigger

Like Insert and Update DML, you can write a trigger over Delete DML. This trigger will execute either before or after a user deletes a row from the underlying table.

**CREATE OR REPLACE TRIGGER** bu\_Superheroes

**BEFORE DELETE ON** superheroes

**FOR EACH ROW ENABLE**

**DECLARE**

v\_user VARCHAR2 (15);

**BEGIN**

SELECT user INTO v\_user FROM dual;

DBMS\_OUTPUT.PUT\_LINE('You Just Deleted a Row Mr.'|| v\_user);

**END;**/

**INSERT, UPDATE, DELETE All in One DML Trigger Using IF-THEN-ELSIF**

**CREATE OR REPLACE TRIGGER** tr\_superheroes **BEFORE INSERT OR DELETE OR UPDATE ON** superheroes

**FOR EACH ROW ENABE DECLARE**

v\_user VARCHAR2(15);

**BEGIN**

SELECT user INTO v\_user FROM dual;

**IF** INSERTING THEN

DBMS\_OUTPUT.PUT\_LINE('one line inserted by '||v\_user);

**ELSIF** DELETING THEN

DBMS\_OUTPUT.PUT\_LINE('one line Deleted by '||v\_user); -

**ELSIF** UPDATING THEN

DBMS\_OUTPUT.PUT\_LINE('one line Updated by '||v\_user);

**END IF**;

**END**;/

# Table Auditing

Table auditing means keeping a track of all the DML activities performed on a specific table of the database for example which user Inserted, updated or deleted a row from the table and when. It is like spying on the users who are messing up your table’s data.

### Example

For the demonstration we will use the table ‘Superheroes’ which we created in the previous tutorial. Suppose

you want to keep an eye on the users who are inserting, updating or deleting data from the “Superheroes” table. Let's see how we can achieve this. To do so, we will need another table in which we can journal the auditing data entries:

### Create table sh\_audit(

**New\_name VARCHAR2(30), Old\_name VARCHAR2(30), User\_name VARCHAR2(30), Entry\_date Date, Operation VARCHAR2(30)**

**);**

This table sh\_audit has 5 columns which will store the auditing information such as the new data inserted or updated, old data which is updated or deleted from the table, name of the user who did it along with the date and time, also the type of DML operation performed.

**Write a trigger on the source table superheroes and will store the data into the auditing table sh\_audit.**

**CREATE OR REPLACE** trigger superheroes\_audit

**BEFORE INSERT OR DELETE OR UPDATE ON** superheroes

**FOR EACH ROW ENABLE DECLARE**

v\_user varchar2 (30); v\_date varchar2(30);

**BEGIN**

SELECT user, TO\_CHAR(sysdate, 'DD/MON/YYYY HH24:MI:SS') INTO v\_user, v\_date FROM dual;

**IF INSERTING THEN**

INSERT INTO sh\_audit (new\_name,old\_name, user\_name, entry\_date, operation) VALUES(:NEW.SH\_NAME, Null , v\_user, v\_date, 'Insert');

**ELSIF DELETING THEN**

INSERT INTO sh\_audit (new\_name,old\_name, user\_name, entry\_date, operation) VALUES(NULL,:OLD.SH\_NAME, v\_user, v\_date, 'Delete');

**ELSIF UPDATING THEN**

INSERT INTO sh\_audit (new\_name,old\_name, user\_name, entry\_date, operation) VALUES(:NEW.SH\_NAME, :OLD.SH\_NAME, v\_user, v\_date,'Update');

**END IF;**

**END;**

# Pseudo Records (New/Old):

These Pseudo Records help us in fetching data from the sh\_name column of the underlying source table ‘Superheroes’ and storing it into the audit table sh\_audit.

Pseudo Record ‘: NEW’, allows you to access a row currently being processed. In other words, when a row is

being inserted or updated into the superheroes table. Whereas Pseudo Record ‘: OLD’ allows you to access a row which is already being either Updated or Deleted from the superheroes table.

In order to fetch the data from the source table, you have to first write the proper Pseudo Record (New/Old)

followed by dot (.) and the name of the column of the source table whose value you want to fetch. For example, in our case we want to fetch the data from the sh\_name column which belongs to our source table superheroes. Thus, we will write “: New. sh\_name” for fetching the current value and to fetch the previously stored value we will write “: OLD. sh\_name”. Once the values are fetched the INSERT DML will store these values into the respective columns of the audit table.

**Restriction on Pseudo Record**

* For an INSERT trigger, OLD contains no values, and NEW contains the new values.
* For an UPDATE trigger, OLD contain the old values, and NEW contain the new values.
* For a DELETE trigger, OLD contains the old values, and NEW contains no values.



Once you execute and compile this trigger, then you can take it on a test run by writing DML statements on the underlying source table ‘Superheroes’. For example, you can try Inserting a row in the superheroes table and then check the audit table whether there is some data or not.

# Synchronized backup copy of a table.

The backup table gets automatically populated or updated with the main table simultaneously. For the

demonstration we will require two identical tables; one which will serve as your main table that will accept the data from your database user and the second which will be your backup table. I will use the Superheroes table which we have been using since the beginning of this DML trigger series as our main table.

### CREATE TABLE superheroes (Sh\_name VARCHAR2(30));

Next we will have to create an identical table to this one which will work as our backup table. Let’s create this backup table.

### CREATE TABLE superheroes\_backup AS SELECT \* FROM superheroes WHERE 1=2;

The above command will create the identical table just like the main table superheroes only without data**.** Next, we have to write the trigger which will insert, update or delete the rows from the backup table when someone does the same with our main tabl

**CREATE or REPLACE** trigger Sh\_Backup **BEFORE INSERT OR DELETE OR UPDATE ON** superheroes

**FOR EACH ROW ENABLE BEGIN**

**IF INSERTING THEN**

INSERT INTO superheroes\_backup (SH\_NAME) VALUES (:NEW.SH\_NAME);

**ELSIF DELETING THEN**

DELETE FROM superheroes\_backup WHERE SH\_NAME =:old.sh\_name;

**ELSIF UPDATING THEN**

UPDATE superheroes\_backup SET SH\_NAME =:new.sh\_name WHERE SH\_NAME =:old.sh\_name;

**END IF;**

**END;**

/

# Schema & Database Auditing Using DDL Trigger In PL/SQL

DDL triggers are the triggers which are created over DDL statements such as CREATE, DROP or ALTER. Using this type of trigger you can monitor the behavior and force rules on your DDL statements. In order to proceed ahead and start writing the trigger, first we need a table in which we can journal the auditing information created by the trigger.

### Create table schema\_audit( Ddl\_date date,

**Ddl\_user VARCHAR2(30), Object\_created VARCHAR2(30), Object\_name VARCHAR2(30), Ddl\_Operation VARCHAR2(30)**

**);**

In case of schema/user auditing using DDL trigger, creates this table in the same schema which you are auditing and in case of Database auditing using DDL trigger create this table in sys or system schema (sys or system both schemas can be used to perform database auditing).

### DDL Trigger for Schema Auditing

First you need to log on to the database using the schema which you want to audit. For example, suppose you want to create the DDL trigger to audit the HR schema then log on to your database using the HR schema.

### Then Write, Execute and Compile the below trigger.

**CREATE OR REPLACE TRIGGER** hr\_audit\_tr

**AFTER DDL ON SCHEMA BEGIN**

INSERT INTO schema\_audit VALUES ( sysdate, sys\_context('USERENV','CURRENT\_USER'),

ora\_dict\_obj\_type, ora\_dict\_obj\_name, ora\_sysevent);

**END;**

/

If you will notice carefully the second line of the code (“AFTER DDL ON SCHEMA”) indicates that this trigger will work on the schema in which it is created. On successful compilation this trigger will insert the respective information such as the date when the DDL is executed, username who executed the DDL, type of database object created, name of the object given by the user at the time of its creation and the type of DDL into the table which we created earlier.

### DDL Trigger for Database Auditing.

Like the schema auditing with some minor changes in the above trigger you can audit your database too. But for that first you need to logon to the database using either SYS user or SYSTEM user.

After doing that you have to create the above shown table under the same user so that your trigger can dump the auditing data without any read and write error

**CREATE OR REPLACE TRIGGER** db\_audit\_tr

**AFTER DDL ON DATABASE BEGIN**

INSERT INTO schema\_audit VALUES (SYSDATE, sys\_context('USERENV','CURRENT\_USER'), ora\_dict\_obj\_type, ora\_dict\_obj\_name, ora\_sysevent);

**END**;/

If you notice the second line of this code carefully then you will find that we have replaced the keyword Schema with the keyword Database which indicates that this trigger will work for the whole database and will perform the underlying work.

To create a trigger on the database we require ADMINISTER DATABASE TRIGGER system privilege. All the administrative users such as sys or system already have these privileges by default that is the reason we created this database auditing DDL trigger using these users. Though you can create the same trigger with any user by granting the same privileges to them but that is not advisable because of your database security reasons.

# Schema Level Database LOGON Trigger in PL/SQL

Database event triggers also known as system event triggers come into action when some system event occurs such as database log on, log off, start up or shut down. These types of triggers are majorly used for monitoring activity of the system events and have been proved quite a powerful tool for a DBA.

## Types of Database Event Triggers.

1. Schema Level Event Triggers
2. Database Level Event Triggers

Schema level event triggers can work on some specific schemas while the database event triggers have database wide scope. In other words database event triggers can be created to monitor the system event activities of either a specific user/schema or the whole database.

## Object/System Privileges

Schema level event triggers can be created by any user of your database who has CREATE TRIGGER system privilege while the database event trigger can only be created by privileged user such as SYS or SYSTEM who has ‘Administrative Database Trigger’ System Privileges.

**Syntax**

**CREATE OR REPLACE TRIGGER** trigger\_name

**BEFORE | AFTER** database\_event ON database/schema

**BEGIN**

PL/SQL Code

**END;**

/

## Example. Schema Level Event Trigger.

Suppose user HR is a control freak and wants to monitor its every log on and log off activity. In this case what HR can do is, create event triggers on Log on and log off database events in its own schema.

# Step 1: Connect to the database and Create a Table

CREATE TABLE hr\_evnt\_audit( event\_type VARCHAR2(30), logon\_date DATE,

logon\_time VARCHAR2(15),

logof\_date DATE, logof\_time VARCHAR2(15) );

# Step2: Write the trigger Logon Schema Event Trigger.

This trigger will fire every time an HR user logs on to the database and respective values will be stored into the table which we just created in step 2.

**CREATE OR REPLACE TRIGGER** hr\_lgon\_audit

**AFTER LOGON ON SCHEMA BEGIN**

INSERT INTO hr\_evnt\_audit VALUES(

ora\_sysevent, sysdate, TO\_CHAR(sysdate, 'hh24:mi:ss'), NULL, NULL );

**COMMIT;**

**END;**

/

**Schema Level Logoff System Event Trigger Step 1: Logon to the database**

**Step 2: Create a table.**

**Step 3: Write the trigger.**

**CREATE OR REPLACE TRIGGER** log\_off\_audit

**BEFORE LOGOFF ON SCHEMA BEGIN**

INSERT INTO hr\_evnt\_audit VALUES( ora\_sysevent, NULL, NULL, SYSDATE, TO\_CHAR(sysdate, 'hh24:mi:ss'));

**COMMIT; END;**

/

**Database Level System/Database Event Trigger**

Example: How To Create Database Level Logoff event Trigger In Oracle PL/SQL

## Step 1: Logon to the database

As only the user with ADMINISTER DATABASE TRIGGER system privilege can create a database level event trigger thus we need to make sure that this time we should log on to the database using one of these users. (**SYSDBA**)

**Step 2: Create a Table**

**Step 3: Write the Database Level logoff system event trigger.**

**CREATE OR REPLACE TRIGGER** db\_lgof\_audit

**BEFORE LOGOFF ON DATABASE BEGIN**

INSERT INTO db\_evnt\_audit VALUES( user, ora\_sysevent, NULL, NULL, SYSDATE,

TO\_CHAR(sysdate, 'hh24:mi:ss'));

**END;**

/

# Startup Trigger.

Startup triggers execute during the startup process of the database. In order to create a database event trigger for shutdown and startup events we either need to logon to the database as a user with DBA privileges such as sys or we must possess the ADMINISTER DATABASE TRIGGER system privilege.

## Example

**Step1: Logon to the database**

In order to create a trigger on Startup Database Event first we will have to logon to our database using the user SYS with DBA privileges.

## Step 2: Create a Table

To store the data generated by the execution of the trigger we will require a table.

**CREATE TABLE startup\_audit ( Event\_type VARCHAR2(15),**

**event\_date DATE,**

**event\_time VARCHAR2(15)**

**);**

**Step 3: Create the database Event Startup Trigger**

**CREATE OR REPLACE TRIGGER** startup\_audit

**AFTER STARTUP ON DATABASE BEGIN**

INSERT INTO startup\_audit VALUES( ora\_sysevent, SYSDATE, TO\_CHAR(sysdate, 'hh24:mm:ss'));

**END;**

/

# Shutdown Triggers

SHUTDOWN triggers execute before database shutdown processing is performed. Similar to the startup trigger, only a user with DBA role or ADMINISTER DATABASE TRIGGER system privilege can create a shutdown trigger.

## First 2 steps of creating a database event shutdown triggers are same as that of the startup trigger which we saw above.

**CREATE OR REPLACE TRIGGER** tr\_shutdown\_audit

**BEFORE SHUTDOWN ON DATABASE BEGIN**

INSERT INTO startup\_audit VALUES( ora\_sysevent, SYSDATE,

TO\_CHAR(sysdate, 'hh24:mm:ss'));

**END;**

/

You can also use shutdown database event triggers for gathering your database system statistics. Here is an example

**CREATE OR REPLACE TRIGGER** before\_shutdown

**BEFORE SHUTDOWN ON DATABASE BEGIN**

gather\_system\_stats;

**END;**

/

# Instead Of Trigger

Instead-of triggers in oracle database provide a way of modifying views that cannot be modified directly through the DML statements. By using Instead-of triggers, you can perform Insert, Update, Delete and Merge operations on a view in oracle database

## Restriction on Instead-of View.

Instead-of triggers can control Insert, Delete, Update and Merge operations of the View, not the table. Yes you heard it right, you can write an instead-of trigger on Views only and not on tables in Oracle database. That is the restriction that you have to comply with. Along with this you even have to comply with every general restriction that is imposed on all types of triggers

## Uses of Instead-of trigger.

Since an Instead-of trigger can only be used with views therefore we can use them to make a non- updatable view updatable as well as to override the default behavior of views that are updatable.

## What are Modifiable and Non Modifiable Views?

A view is naturally modifiable if you do not require INSTEAD OF triggers to insert, delete or update data as well as if it complies to the restrictions discussed herewith. If the view query comprises of any of the mentioned constructs, then it is not naturally modifiable and therefore you cannot perform inserts, updates, or deletes on the view:

* Set operators
* Aggregate functions
* GROUP BY, CONNECT BY, or START WITH clauses
* The DISTINCT operator
* Joins (however, some join views are updatable)

In case a view consists of pseudo columns or expressions, then it is only possible to update it with an UPDATE statement and that also when it does not refer to any such pseudo columns or for that matter, expressions.

**Syntax of Instead-Of Trigger**

**CREATE [OR REPLACE] TRIGGER** trigger\_name

**INSTEAD OF** operation ON view\_name

**FOR EACH ROW**

**BEGIN**

---Your SQL Code—

**END;**/

**Examples**

**Instead-of Insert Trigger**

Instead-of trigger can be best demonstrated using a View joining two or more tables.

## Step1: Create tables

CREATE TABLE trainer ( full\_name VARCHAR2(20) ); CREATE TABLE subject ( subject\_name VARCHAR2(15)); **Insert dummy data into the above tables**

INSERT INTO trainer VALUES (Faraz Ahmed);

INSERT INTO subject VALUES (Database Systems);

## Step 2: Create View

CREATE VIEW db\_lab\_09\_view AS

SELECT full\_name, subject\_name FROM trainer, subject;

This is a **non-updatable view** which you can confirm by executing any DML statement over it. Error as a result of DML operation on this view will be your confirmation.

**Step 3: Create Trigger**

**CREATE OR REPLACE TRIGGER** tr\_Io\_Insert **INSTEAD OF INSERT ON db\_lab\_09 FOR EACH ROW BEGIN**

INSERT INTO trainer (full\_name) VALUES (:new.full\_name);

INSERT INTO subject (subject\_name) VALUES (:new.subject\_name);

**END;**

**/**

# Instead-Of Update Trigger

Instead-of update trigger will override the default behavior of your update operation when you execute the update statement and will let you update the data of the underlying tables over which your view is created.

## Example:

Tables (Trainer and Subject) and View (db\_lab\_09) used in this example are the same as the ones we created.

**CREATE OR REPLACE TRIGGER** io\_update

**INSTEAD OF UPDATE ON db\_lab\_09 FOR EACH**

**ROW BEGIN**

**UPDATE** trainer **SET** FULL\_NAME = :new.full\_name

**WHERE** FULL\_NAME = :old.full\_name;

**UPDATE** subject **SET** subject\_NAME = :new.subject\_name

**WHERE** subject\_NAME = :old.subject\_name;

**END;**

/

# Instead-of Delete trigger.

Needless to say that executing DELETE DML on this view will return an error because of its non-updatable nature. Thus the only way to perform DELETE DML on this view is by using an Instead of trigger. Let’s quickly create one.

## Example

**CREATE OR REPLACE TRIGGER** io\_delete

**INSTEAD OF DELETE ON** vw\_RebellionRider

**FOR EACH ROW BEGIN**

DELETE FROM trainer WHERE FULL\_NAME = :old.FULL\_NAME; DELETE FROM subject WHERE SUBJECT\_NAME= :old.SUBJECT\_NAME;

**END;**

/