CS-GY 6083 - B
Principles of Database Systems

Functions, Stored Procedures and Triggers

Trigger: A trigger is PL/SQL code which contains a set of SQL statements in database which is automatically executed whenever any special event occurs specific to condition defined, such as before or after of insert, delete, update etc. Triggers are used to implement complex business rules that cannot be defined using constraints.

We can define 6 types of DML triggers for the table:

AFTER INSERT: activated after data is inserted into the table.
AFTER UPDATE: activated after data in the table is modified.
AFTER DELETE: activated after data is deleted/removed from the table.
BEFORE INSERT: activated before data is inserted into the table.
BEFORE UPDATE: activated before data in the table is modified.
BEFORE DELETE: activated before data is deleted/removed from the table

Function: A function is PL/SQL code that accepts input parameter, and produces output based upon SQL instructions and calculation performed as coded. Function can be single row function or multi-row function (aggregate function).

Procedure: A procedure is also PL/SQL code and set of pre-compiled queries which can be used and shared among multiple programs. It can access and modify data in database as coded. A procedure can be thought of as a method. They can be invoked through triggers, other procedures, or applications on Java, PHP etc. All the statements of a block are passed to the database engine all at once which increases processing speed and decreases the traffic. They reduce the traffic between the database and the application. They add to code reusability, similar to how methods work in other languages such as C/C++ and Java.

Resources:

Oracle

https://docs.oracle.com/database/121/TDDDG/tdddg_triggers.htm#TDDDG52400
https://www.oracletutorial.com/plsql-tutorial/plsql-function/
https://docs.oracle.com/cd/B28359_01/appdev.111/b28843/tdddg_procedures.htm

MySQL

https://dev.mysql.com/doc/refman/5.7/en/trigger-syntax.html
https://www.sqlshack.com/learn-mysql-the-basics-of-mysql-stored-procedures/
https://www.mysqltutorial.org/mysql-stored-function/

Difference among Trigger, Function, Procedure

Trigger	Function	Procedure
Trigger is executed automatically on actions like update, delete, insert	We can call a function whenever required but function cannot be executed as it is not precompiled	A procedure can be executed explicitly whenever required
Trigger cannot be called from either function or procedure	Function can be called from trigger and procedure	Procedure cannot be called from function. It can be called from trigger.
Trigger cannot be called from other trigger	Function can be called from other function	Procedure can be called from other procedure
It never returns a value on execution.	It must return a value.	It may or may not return a value on execution
Cannot be used with SQL such as SELECT, INSERT, UPDATE, DELETE, MERGE etc.,	Can be used with SQL such as SELECT, INSERT, UPDATE, DELETE, MERGE etc.,	Cannot be used with SQL such as SELECT, INSERT, UPDATE, DELETE, MERGE etc.,
Transactions such as COMMIT, ROLLBACK, SAVEPOINT are not allowed	Transactions such as COMMIT, ROLLBACK, SAVEPOINT are not allowed	Transactions such as COMMIT, ROLLBACK, SAVEPOINT are allowed

A) FUNCTION EXAMPLE:

User defined function Min_To_Hr (Converts Minutes to Hours) : ORACLE

1. Code:

```
CREATE OR REPLACE FUNCTION Min_To_Hr_new(min_ IN NUMBER)
RETURN VARCHAR2
IS Hr VARCHAR2(15);
BEGIN
Hr := TO_CHAR(FLOOR(min_/60)) || ' HR ' || TO_CHAR(MOD(min_, 60)) || ' MIN';
RETURN Hr;
END;
/
```

2. Test Code:

```
CREATE TABLE FILM (
FILM_LEN number
);
INSERT ALL
INTO FILM(FILM_LEN) VALUES(11)
INTO FILM(FILM_LEN) VALUES(12)
INTO FILM(FILM_LEN) VALUES(13)
INTO FILM(FILM_LEN) VALUES(24)
INTO FILM(FILM_LEN) VALUES(25)
```

```
INTO FILM(FILM_LEN) VALUES(27)
INTO FILM(FILM_LEN) VALUES(62)
INTO FILM(FILM_LEN) VALUES(123)
INTO FILM(FILM_LEN) VALUES(134)
INTO FILM(FILM_LEN) VALUES(999)
SELECT * FROM dual;
```

3. Running result:

```
SELECT FILM_LEN as "Minutes Number", Min_To_Hr_new(FILM_LEN) as "Movie Time" FROM FILM;
```

Minutes Number	Movie Time
11	0 HR 11 MIN
12	0 HR 12 MIN
13	0 HR 13 MIN
24	0 HR 24 MIN
25	0 HR 25 MIN
27	0 HR 27 MIN
62	1 HR 2 MIN
123	2 HR 3 MIN
134	2 HR 14 MIN
999	16 HR 39 MIN

Download CSV
10 rows selected.

User defined function Min_To_Hr (Converts Minutes to Hours): MySQL

1. Code:

```
DELIMITER $$
CREATE FUNCTION Min_To_Hr_new(Min INT)
RETURNS VARCHAR(20)
DETERMINISTIC
BEGIN
DECLARE hr VARCHAR(20);
SET hr = concat(FLOOR(Min/60), ' HR ', MOD(Min,60), ' MIN');
RETURN (hr);
END;
$$
DELIMITER ;
```

2. Test Code:

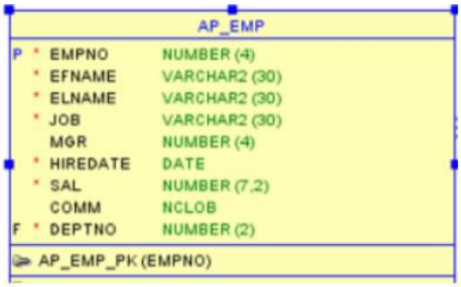
```
CREATE DATABASE test;
USE test;
CREATE TABLE IF NOT EXISTS `test`.`FILM` (`length` INT NOT NULL)
ENGINE = InnoDB
DEFAULT CHARACTER SET = utf8;

INSERT INTO FILM(length) VALUES(1);
INSERT INTO FILM(length) VALUES(3);
INSERT INTO FILM(length) VALUES(27);
INSERT INTO FILM(length) VALUES(134);
INSERT INTO FILM(length) VALUES(999);
```

3. Running result:

```
select length as 'Minutes Number', Min_To_Hr_new(length) as 'Movie time' from FILM;
```

```
+----------------+--------------+
| Minutes Number | Movie time   |
+----------------+--------------+
|              1 | 0 HR 1 MIN   |
|              3 | 0 HR 3 MIN   |
|             27 | 0 HR 27 MIN  |
|            134 | 2 HR 14 MIN  |
|            999 | 16 HR 39 MIN |
+----------------+--------------+
5 rows in set (0.00 sec)
```

B) PROCEDURE EXAMPLE:



Consider above relational table and do following,

a) **Create this table with your initial as prefix. Create history table AP_EMP_SAL_HIST (use your initial as prefix). The table AP_EMP_SAL_HIST table should have following columns: EMPNO, OLDSAL, NEWSAL, and CHANGE_DATE. The purpose of history table is to record history of salary change. Whenever the salary is updated in AP_EMP table, it should record EMPNO, OLDSAL, NEWSAL, and CHAGE_DATE in history table AP_EMP_SAL_HIST. The OLDSAL is the original salary (before the update of the salary), NEWSQL is the new salary (after the update of the salary), CHANGE_DATE is the date on which salary was updated, and should be default as System Date, i.e. current date. Employees may have their salary change multiple times during their employment. Define appropriate primary key of the history table.**

b) **Research on Database Procedure (Database procedure is a PL/SQL code that takes input parameters and do activities as coded in procedure to achieve desired result). The name of the procedure should be <your initial>_PROC_SAL_CHANGE. This procedure will take two input parameters, Employee Number and New Salary. The procure code will do two tasks, 1) update the salary of that employee to New Salary in AP_EMP table 2) insert a new record in history table AP_EMP_SAL_HIST with old and new salary and date of the salary change**

Data of AP_EMP (Result screenshot of SELECT * FROM AP_EMP)

```
1  SELECT * FROM AP_EMP;
2
3
4
```

EMPNO	EFNAME	ELNAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
7369	CHARLES	SMITH	CLERK	7902	08-OCT-01	2400	-	20
7499	GRAYSON	ALLEN	SALESMAN	7698	12-DEC-01	4800	600	30
7521	MATTHEW	WARD	SALESMAN	7698	14-DEC-01	3750	1000	30
7566	NICHOLAS	JONES	MANAGER	7839	22-JAN-02	8925	-	20
7654	CHRIS	MARTIN	SALESMAN	7698	20-JUL-02	3750	2800	30
7698	BLAKE	GRIFFIN	MANAGER	7839	20-FEB-02	8550	-	30
7782	KENT	CLARK	MANAGER	7839	31-MAR-02	7350	-	10
7788	DEVIN	BOOKER	ANALYST	7566	08-FEB-08	9000	-	20
7839	MARTIN	KING	PRESIDENT	-	08-SEP-02	15000	-	10
7844	WILLIAM	TURNER	SALESMAN	7698	30-JUN-02	4500	0	30
7876	JOHN	ADAMS	CLERK	7788	13-MAR-08	3300	-	20
7900	LEBRON	JAMES	CLERK	7698	24-SEP-02	2850	-	30
7902	CHRISTIAN	FORD	ANALYST	7566	24-SEP-02	9000	-	20
7934	MIKE	MILLER	CLERK	7782	14-NOV-02	3900	-	10

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14 rows selected.

DDL code of history table AP_EMP_SAL_HIST

Oracle Version:

```
CREATE TABLE ap_emp_sal_hist (
   empno       NUMBER(4) NOT NULL,
   change_date  DATE DEFAULT SYSDATE NOT NULL,
   oldsal      NUMBER(7, 2) NOT NULL,
   newsal      NUMBER(7, 2) NOT NULL
);

ALTER TABLE ap_emp_sal_hist ADD CONSTRAINT ap_emp_sal_hist_pk PRIMARY KEY ( empno, change_date );
```

MySQL Version:

```
CREATE TABLE ap_emp_sal_hist (
   empno       INT NOT NULL,
   change_date  DATETIME DEFAULT NOW() NOT NULL,
   oldsal      INT NOT NULL,
   newsal      INT NOT NULL
);

ALTER TABLE ap_emp_sal_hist ADD CONSTRAINT ap_emp_sal_hist_pk PRIMARY KEY ( empno, change_date );
```

Procedure code

Oracle Version:

```
CREATE OR REPLACE PROCEDURE ap_emp_sal_change (in_empno NUMBER, in_newsal NUMBER)
IS duration number;
BEGIN

   INSERT INTO ap_emp_sal_hist VALUES (in_empno, sysdate, (SELECT sal FROM ap_emp WHERE empno = in_empno), in_newsal);
   UPDATE ap_emp SET sal = in_newsal WHERE empno = in_empno;

END ap_emp_sal_change;
```

MySQL Version:

```
DELIMITER //
CREATE PROCEDURE ap_emp_sal_change (IN in_empno INT, IN in_newsal INT)
BEGIN
   INSERT INTO ap_emp_sal_hist VALUES (in_empno, sysdate, (SELECT sal FROM ap_emp WHERE empno = in_empno), in_newsal);
   UPDATE ap_emp SET sal = in_newsal WHERE empno = in_empno;

END; //
DELIMITER ;
```

Execute the procedure.

Oracle Version:

```
EXECUTE ap_emp_sal_change(7782, 4600);
EXECUTE ap_emp_sal_change(7369, 3000);
EXECUTE ap_emp_sal_change(7782, 5000);
```

MySQL Version:

```
CALL ap_emp_sal_change(7782, 4600);
CALL ap_emp_sal_change(7369, 3000);
CALL ap_emp_sal_change(7782, 5000);
```

C) TRIGGER EXAMPLE:

Example of a trigger to keep history of salary changes of employees.

--Oracle

```
CREATE TABLE ap_sal_history
(empno  NUMBER (4),
 oldsal NUMBER (7,2),
 newsal NUMBER (7,2),
 last_update_dt DATE
 );

ALTER TABLE ap_sal_history ADD CONSTRAINT pk_ap_sal_history PRIMARY KEY (empno, last_update_dt);
```

--Trigger code in Oracle

```
CREATE OR REPLACE TRIGGER TU_AP_EMP_SAL
AFTER UPDATE OF sal
   ON ap_emp
   FOR EACH ROW
DECLARE
   oldval number(7,2);
   newval number(7,2);
   eno    number(4);
BEGIN
   SELECT :old.sal, :new.sal, :new.empno into oldval,newval,eno from dual;
   INSERT INTO ap_sal_history(empno,oldsal,newsal,last_update_dt) values (eno,oldval,newval,sysdate);
END;
/
```

--Test: Update salary of employees as follow and then review salary history table

```
update ap_emp
set sal=sal+200 where empno=7369;

update ap_emp
set sal=sal+100 where deptno=20;

update ap_emp
set sal=sal+200 where deptno=30;

select empno,oldsal,newsal,to_char(last_update_dt,'mm/dd/yyyy hh24:mi:ss') from ap_sal_history
order by empno,last_update_dt;
```

--MySQL

```
use oltpdb;
CREATE TABLE ap_sal_history
(empno  smallint ,
 oldsal decimal(7,2),
 newsal decimal (7,2),
 last_update_dt datetime
 );

ALTER TABLE ap_sal_history ADD CONSTRAINT pk_ap_sal_history PRIMARY KEY (empno,last_update_dt);
```

--Trigger code in MySQL

```
DELIMITER $$
CREATE TRIGGER TU_AP_EMP_SAL
AFTER UPDATE ON ap_emp FOR EACH ROW
BEGIN
   IF old.sal<>new.sal THEN
      INSERT INTO ap_sal_history(empno,oldsal,newsal,last_update_dt) values (new.empno,old.sal, new.sal,current_timestamp() ) ;
   END IF;
END$$
```

```
DELIMITER ;

--Test: Update salary of employees as follow and then review salary history table

update ap_emp
set sal=sal+200 where empno=7499;

update ap_emp
set sal=sal+300 where empno=7499;

update ap_emp
set sal=sal+200 where empno=7566;

update ap_emp
set sal=sal+300 where empno=7566

select * from ap_sal_history;


select * from ap_sal_history order by empno,last_update_dt;
```