W4111 – Introduction to Databases
Fall 003/V03, Fall 2022

Lecture 6: ER, Relational, SQL (IV)

Functions, Procedures, Triggers

Concepts

Functions and Procedures

- Functions and procedures allow "business logic" to be stored in the database and executed from SQL statements.
- These can be defined either by the procedural component of SQL or by an external programming language such as Java, C, or C++.
- The syntax we present here is defined by the SQL standard.
  - Most databases implement nonstandard versions of this syntax.

Note:

- The programming language, runtime and tools for functions, procedures and triggers are not easy to use.
- My view is that calling external functions is an anti-pattern (bad idea).
  - External code degrades the reliability, security and performance of the database.
  - Databases are often mission critical and the heart of environments.

Language Constructs for Procedures & Functions

- SQL supports constructs that gives it almost all the power of a general-purpose programming language.
  - Warning: most database systems implement their own variant of the standard syntax below.
- Compound statement: **begin** … **end,**
  - May contain multiple SQL statements between **begin** and **end**.
  - Local variables can be declared within a compound statements
- While and repeat statements:

  -
    ```
    while boolean expression  do
          sequence of statements ;
       end while
    ```

  -
    ```
    repeat
          sequence of statements ;
       until boolean expression
       end repeat
    ```

(Core) Language Constructs (Cont.)

- **For** loop
  - Permits iteration over all results of a query
- Example: Find the budget of all departments

```
declare n  integer default 0;
for r  as
      select budget from department
           where dept_name = 'Music'
do
                 set n = n + r.budget
end for
```

Note:

- There are various other looping constructs.

(Core) Language Constructs – if-then-else

- Conditional statements (**if-then-else**)

```
if boolean  expression
            then statement or compound statement
        elseif boolean  expression
            then statement or compound statement
 else statement or compound statement
        end if
```

Note:

- We will not spend a lot of time writing functions, procedures, or triggers.
- The language and development environment are not easy to use.

Functions

Declaring SQL Functions

- Define a function that, given the name of a department, returns the count of the number of instructors in that department.

```
create function dept_count (dept_name varchar(20))
    returns integer
    begin
    declare d_count  integer;
        select count (* ) into d_count
        from instructor
        where instructor.dept_name = dept_name
    return d_count;
end
```

- The function *dept_*count can be used to find the department names and budget of all departments with more that 12 instructors.

```
select dept_name, budget
from department
where dept_count (dept_name ) > 12
```

Table Functions

- The SQL standard supports functions that can return tables as results; such functions are called **table functions**
- Example: Return all instructors in a given department

```
create function instructor_of (dept_name char(20))
        returns table  (
          ID varchar(5),
               name varchar(20),
          dept_name varchar(20),
               salary numeric(8,2))
      return table
              (select ID, name, dept_name, salary
               from instructor
               where instructor.dept_name = instructor_of.dept_name)
```

- Usage

```
select *
from table (instructor_of ('Music'))
```

Procedures

SQL Procedures

- The *dept_count* function could instead be written as procedure:

```
create procedure dept_count_proc (in dept_name varchar(20),
                                  out d_count integer)
  begin
     select count(*) into d_count
     from instructor
     where instructor.dept_name = dept_count_proc.dept_name
  end
```

- The keywords **in** and **out** are parameters that are expected to have values assigned to them and parameters whose values are set in the procedure in order to return results.
- Procedures can be invoked either from an SQL procedure or from embedded SQL, using the **call** statement.

```
        declare d_count integer;
        call dept_count_proc( 'Physics', d_count);
```

SQL Procedures (Cont.)

- Procedures and functions can be invoked also from dynamic SQL
- SQL allows more than one procedure of the so long as the number of arguments of the procedures with the same name is different.
- The name, along with the number of arguments, is used to identify the procedure.

Triggers

Triggers

- A **trigger** is a statement that is executed automatically by the system as a side effect of a modification to the database.
- To design a trigger mechanism, we must:
  - Specify the conditions under which the trigger is to be executed.
  - Specify the actions to be taken when the trigger executes.
- Triggers introduced to SQL standard in SQL:1999, but supported even earlier using non-standard syntax by most databases.
  - Syntax illustrated here may not work exactly on your database system; check the system manuals

Triggering Events and Actions in SQL

- Triggering event can be **insert**, **delete** or **update**
- Triggers on update can be restricted to specific attributes
  - For example, **after update of** *takes* **on** *grade*
- Values of attributes before and after an update can be referenced
  - **referencing old row as   :** for deletes and updates
  - **referencing new row as :** for inserts and updates
- Triggers can be activated before an event, which can serve as extra constraints. For example, convert blank grades to null.

```
    create trigger setnull_trigger before update of takes
    referencing new row as nrow
    for each row
        when (nrow.grade = ' ')
    begin atomic
           set nrow.grade = null;
end;
```

Trigger to Maintain credits_earned value

```
create trigger credits_earned after update of takes on (grade)
referencing new row as nrow
referencing old row as orow
for each row
when nrow.grade <> 'F' and nrow.grade is not null
   and (orow.grade = 'F' or orow.grade is null)
begin atomic
    update student
    set tot_cred= tot_cred +
         (select credits
          from course
          where course.course_id= nrow.course_id)
    where student.id = nrow.id;
end;
```

Statement Level Triggers

- Instead of executing a separate action for each affected row, a single action can be executed for all rows affected by a transaction
  - Use **for each statement** instead of **for each row**
  - Use **referencing old table** or **referencing new table** to refer to temporary tables (called ***transition tables***) containing the affected rows
  - Can be more efficient when dealing with SQL statements that update a large number of rows

When Not To Use Triggers

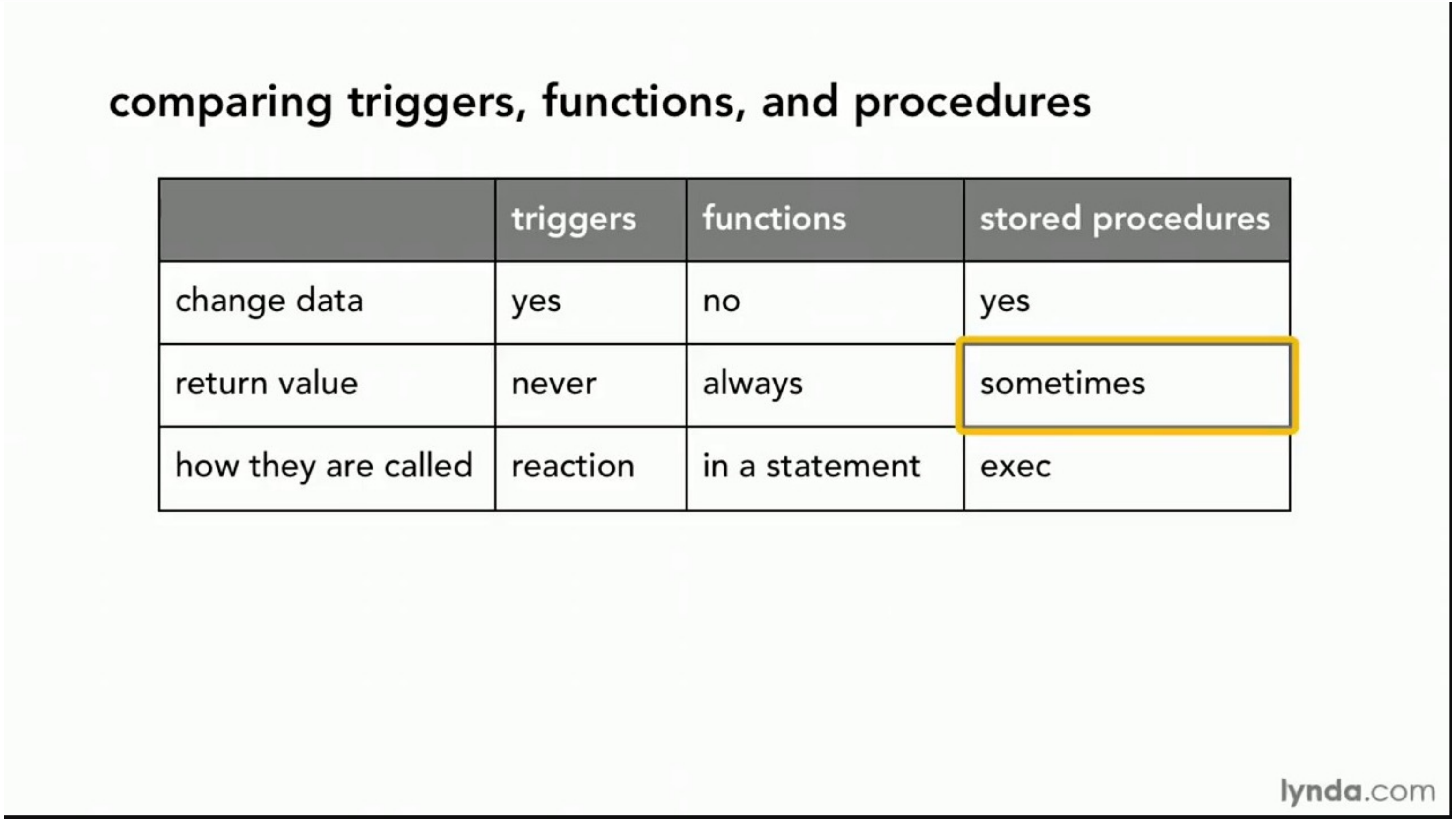
- Triggers were used earlier for tasks such as
  - Maintaining summary data (e.g., total salary of each department)
  - Replicating databases by recording changes to special relations (called **change** or **delta** relations) and having a separate process that applies the changes over to a replica
- There are better ways of doing these now:
  - Databases today provide built in materialized view facilities to maintain summary data
  - Databases provide built-in support for replication
- Encapsulation facilities can be used instead of triggers in many cases
  - Define methods to update fields
  - Carry out actions as part of the update methods instead of through a trigger

When Not To Use Triggers (Cont.)

- Risk of unintended execution of triggers, for example, when
  - Loading data from a backup copy
  - Replicating updates at a remote site
  - Trigger execution can be disabled before such actions.
- Other risks with triggers:
  - Error leading to failure of critical transactions that set off the trigger
  - Cascading execution

Summary

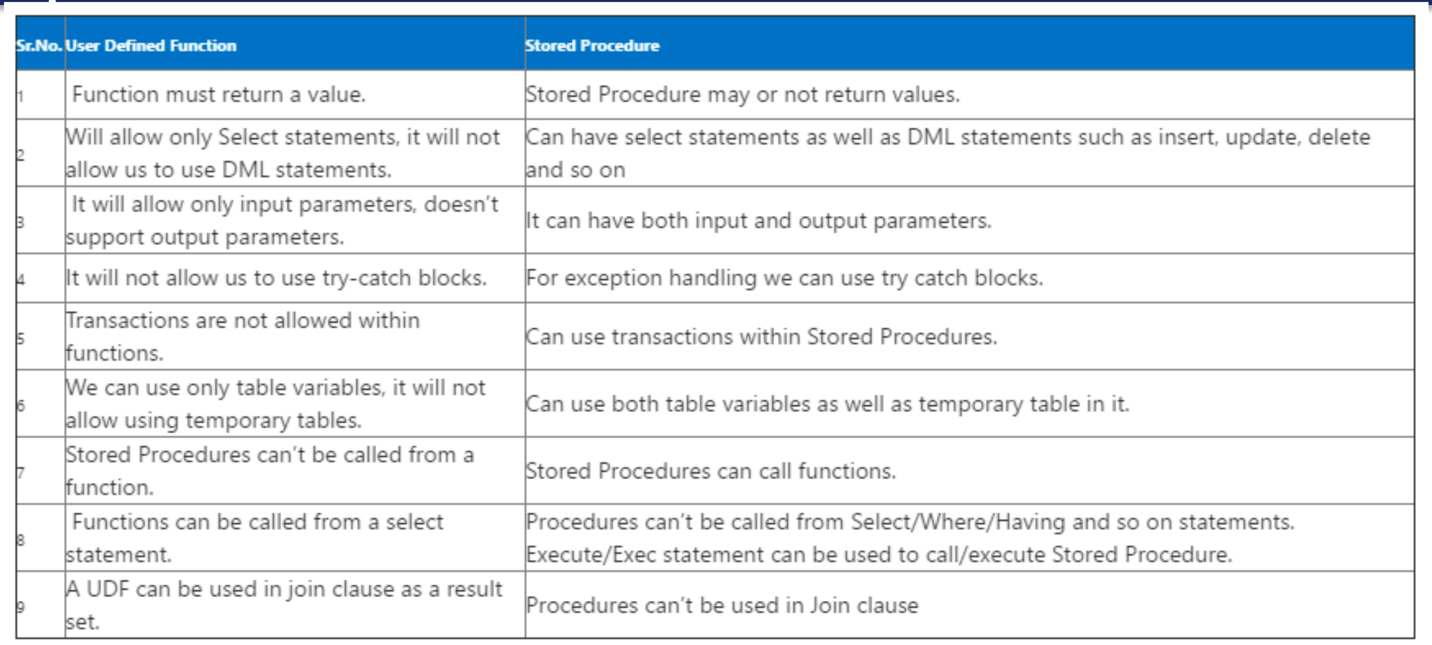
Comparison



comparing triggers, functions, and procedures

	triggers	functions	stored procedures
change data	yes	no	yes
return value	never	always	sometimes
how they are called	reaction	in a statement	exec

Comparison – Some Details



Sr.No.	User Defined Function	Stored Procedure
1	Function must return a value.	Stored Procedure may or not return values.
2	Will allow only Select statements, it will not allow us to use DML statements.	Can have select statements as well as DML statements such as insert, update, delete and so on
3	It will allow only input parameters, doesn't support output parameters.	It can have both input and output parameters.
4	It will not allow us to use try-catch blocks.	For exception handling we can use try catch blocks.
5	Transactions are not allowed within functions.	Can use transactions within Stored Procedures.
6	We can use only table variables, it will not allow using temporary tables.	Can use both table variables as well as temporary table in it.
7	Stored Procedures can't be called from a function.	Stored Procedures can call functions.
8	Functions can be called from a select statement.	Procedures can't be called from Select/Where/Having and so on statements. Execute/Exec statement can be used to call/execute Stored Procedure.
9	A UDF can be used in join clause as a result set.	Procedures can't be used in Join clause

A *trigger* has capabilities like a procedure, except ...

- You do not call it. The DB engine calls it before or after an INSERT, UPDATE, DELETE.
- The inputs are the list of incoming new, modified rows.
- The outputs are the modified versions of the new or modified rows.