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Syllabus

- **Introduction to SQL**: Characteristics and advantages of SQL, SQL Data Types
- **DDL Commands, DCL Commands.**
- **SQL Queries**: DML Queries with Select Query Clauses, Creating, Modifying, Deleting.
- **Views**: Creating, Dropping, Updating, Indexes,
- Set Operations, Predicates and Joins, Set membership, Grouping and Aggregation, Aggregate Functions, Nested Queries,
- **PL/SQL Concepts**: PL/SQL Functions and Procedures, Cursors, Database Triggers.
- **Query Processing and Optimization**.

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Extensions to SQL (PL/SQL)

What is PL/SQL

PL/SQL:

- Stands for Procedural Language extension to SQL
- Is Oracle Corporation's standard data access language for relational databases
- Seamlessly integrates procedural constructs with SQL

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PL/SQL Comments

```
DECLARE
   v_salary number(9,2) := 40000;
BEGIN
   /* this is a multi-line comment that
      will be ignored by the pl/sql
      interpreter  */
   v_salary := v_salary * 2; -- nice raise
END; -- end of program
```

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PL/SQL Functions and Procedures

- SQL:1999 supports functions and procedures
  - Functions/procedures can be written in SQL itself, or in an external programming language (e.g., C, Java).
  - Functions written in an external languages are particularly useful with specialized data types such as images and geometric objects.
    - Example: functions to check if polygons overlap, or to compare images for similarity.
  - Some database systems support **table-valued functions**, which can return a relation as a result.
- SQL:1999 also supports a rich set of imperative constructs, including
  - Loops, if-then-else, assignment
- Many databases have proprietary procedural extensions to SQL that differ from SQL:1999.

Stored Function

PL/SQL Functions

- Functions are declared using the following syntax:

```
Create function <function-name> (param_1, …, param_k)
    returns <return_type>
    [not] deterministic          allow optimization if same output
                                 for the same input (use RAND not deterministic )
Begin
  -- execution code
end;
```

where param is:

[in | out | in out] <param_name> <param_type>

- You need ADMIN privilege to create functions on mysql-user server

PL/SQL Functions – Example 1

- 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
```

Example 1 (Cont)..

- 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
```

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Example 2

- A function that returns the level of a customer based on credit limit. We use the IF statement to determine the credit limit.

```
1  DELIMITER $$
2
3  CREATE FUNCTION CustomerLevel(p_creditLimit double) RETURNS VARCHAR(10)
4      DETERMINISTIC
5  BEGIN
6      DECLARE lvl varchar(10);
7
8      IF p_creditLimit > 50000 THEN
9   SET lvl = 'PLATINUM';
10     ELSEIF (p_creditLimit <= 50000 AND p_creditLimit >= 10000) THEN
11         SET lvl = 'GOLD';
12     ELSEIF p_creditLimit < 10000 THEN
13         SET lvl = 'SILVER';
14     END IF;
15
16   RETURN (lvl);
17 END
```

Example 2 (Cont..)

Calling function:

we can call the CustomerLevel() in a SELECT statement as follows:

```
1  SELECT
2      customerName,
3      CustomerLevel(creditLimit)
4  FROM
5      customers
6  ORDER BY
7      customerName;
```

Output:

	customerName	CustomerLevel(creditLimit)
▶	Alpha Cognac	PLATINUM
	American Souvenirs Inc	SILVER
	Amica Models & Co.	PLATINUM
	ANG Resellers	SILVER
	Anna's Decorations, Ltd	PLATINUM
	Anton Designs, Ltd.	SILVER

Example 3

```
mysql> select * from employee;
+----+-------+----------+--------+---------------+------+
| id | name  | superid  | salary | bdate         | dno  |
+----+-------+----------+--------+---------------+------+
|  1 | john  |        3 | 100000 | 1960-01-01    |    1 |
|  2 | mary  |        3 |  50000 | 1964-12-01    |    3 |
|  3 | bob   |     NULL |  80000 | 1974-02-07    |    3 |
|  4 | tom   |        1 |  50000 | 1970-01-17    |    2 |
|  5 | bill  |     NULL |   NULL | 1985-01-20    |    1 |
+----+-------+----------+--------+---------------+------+
5 rows in set (0.00 sec)

mysql> delimiter |
mysql> create function giveRaise (oldval double, amount double
    -> returns double
    -> deterministic
    -> begin
    ->         declare newval double;
    ->         set newval = oldval * (1 + amount);
    ->         return newval;
    -> end |
Query OK, 0 rows affected (0.00 sec)

mysql> delimiter ;
```

Example 3 (cont..)

```
mysql> select name, salary, giveRaise(salary, 0.1) as newsal
    -> from employee;
+------+--------+--------+
| name | salary | newsal |
+------+--------+--------+
| john | 100000 | 110000 |
| mary |  50000 |  55000 |
| bob  |  80000 |  88000 |
| tom  |  50000 |  55000 |
| bill |   NULL |   NULL |
+------+--------+--------+
5 rows in set (0.00 sec)
```

Stored Procedures

Stored Procedures in MySQL

- A stored procedure contains a sequence of SQL commands stored in the database catalog so that it can be invoked later by a program
- Stored procedures are declared using the following syntax:

```
Create Procedure <proc-name>
    (param_spec1, param_spec2, …, param_specn )
begin
  -- execution code
end;
```

where each param_spec is of the form:

[in | out | inout] <param_name> <param_type>

  - in mode: allows you to pass values into the procedure,
  - out mode: allows you to pass value back from procedure to the calling program

Example 1 – No parameters

- The GetAllProducts() stored procedure selects all products from the products table.

```
mysql> use classicmodels;
Database changed
mysql> DELIMITER //
mysql> CREATE PROCEDURE GetAllProducts()
    -> BEGIN
    -> SELECT * FROM products;
    -> END//
Query OK, 0 rows affected (0.00 sec)

mysql> DELIMITER ;
mysql>
```

Example 1 (Cont..)

- **Calling Procedure:**

```
CALL GetAllProducts();
```

- **Output:**

productCode	productName	productLine	productScale
S10_1678	1969 Harley Davidson Ultimate Chopper	Motorcycles	1:10
S10_1949	1952 Alpine Renault 1300	Classic Cars	1:10
S10_2016	1996 Moto Guzzi 1100i	Motorcycles	1:10
S10_4698	2003 Harley-Davidson Eagle Drag Bike	Motorcycles	1:10
S10_4757	1972 Alfa Romeo GTA	Classic Cars	1:10

Example 2 (with IN parameter)

```
mysql> select * from employee;
+----+------+---------+--------+------------+------+
| id | name | superid | salary | bdate      | dno  |
+----+------+---------+--------+------------+------+
|  1 | john |       3 | 100000 | 1960-01-01 |    1 |
|  2 | mary |       3 |  50000 | 1964-12-01 |    3 |
|  3 | bob  |    NULL |  80000 | 1974-02-07 |    3 |
|  4 | tom  |       1 |  50000 | 1978-01-17 |    2 |
|  5 | bill |    NULL |   NULL | 1985-01-20 |    1 |
+----+------+---------+--------+------------+------+
```

```
mysql> select * from department;
+---------+-------------+
| dnumber | dname       |
+---------+-------------+
|       1 | Payroll     |
|       2 | TechSupport |
|       3 | Research    |
+---------+-------------+
```

Suppose we want to keep track of the total salaries of employees working for each department

```
mysql> create table deptsal as
    -> select dnumber, 0 as totalsalary from department;
Query OK, 3 rows affected (0.00 sec)
Records: 3  Duplicates: 0  Warnings: 0

mysql> select * from deptsal;
+---------+-------------+
| dnumber | totalsalary |
+---------+-------------+
|       1 |           0 |
|       2 |           0 |
|       3 |           0 |
+---------+-------------+
```

We need to write a procedure to update the salaries in the deptsal table

Example 2 (Cont..)

```
mysql> delimiter //
mysql> create procedure updateSalary (IN param1 int)
    -> begin
    ->     update deptsal
    ->     set totalsalary = (select sum(salary) from employee where dno = param1)
    ->     where dnumber = param1;
    -> end; //
Query OK, 0 rows affected (0.01 sec)
```

1. Define a procedure called updateSalary which takes as input a department number.
2. The body of the procedure is an SQL command to update the totalsalary column of the deptsal table.

Example 2 (Cont..)

Step 3: Call the procedure to update the totalsalary for each department

```
mysql> call updateSalary(1);
Query OK, 0 rows affected (0.00 sec)

mysql> call updateSalary(2);
Query OK, 1 row affected (0.00 sec)

mysql> call updateSalary(3);
Query OK, 1 row affected (0.00 sec)
```

Example 2 (Cont..)

Step 4: Show the updated total salary in the deptsal table

```
mysql> select * from deptsal;
+---------+-------------+
| dnumber | totalsalary |
+---------+-------------+
|       1 |      100000 |
|       2 |       50000 |
|       3 |      130000 |
+---------+-------------+
3 rows in set (0.00 sec)
```

Example 3 (with OUT Parameter)

- The following example shows a simple stored procedure that uses an OUT parameter.
- Within the procedure MySQL MAX() function retrieves maximum salary from MAX_SALARY of jobs table.

```
mysql> CREATE PROCEDURE my_proc_OUT (OUT highest_salary INT)
-> BEGIN
-> SELECT MAX(MAX_SALARY) INTO highest_salary FROM JOBS;
-> END$$
Query OK, 0 rows affected (0.00 sec)
```

(Cont..)

Procedure Call:

```
mysql> CALL my_proc_OUT(@M)$$
Query OK, 1 row affected (0.03 sec)
mysql< SELECT @M$$
```

Output:

```
+-------+
| @M    |
+-------+
| 40000 |
+-------+
1 row in set (0.00 sec)
```

Example 4 (with INOUT Parameter)

- The following example shows a simple stored procedure that uses an INOUT parameter.
- 'count' is the INOUT parameter, which can store and return values and 'increment' is the IN parameter, which accepts the values from user.

```
mysql> DELIMITER // ;
mysql> Create PROCEDURE counter(INOUT count INT, IN increment INT)
    -> BEGIN
    -> SET count = count + increment;
    -> END //
Query OK, 0 rows affected (0.03 sec)
```

Example 4 (Cont..)

Function Call:

```
mysql> DELIMITER ;
mysql> SET @counter = 0;
Query OK, 0 rows affected (0.00 sec)

mysql> CALL counter(@Counter, 1);
Query OK, 0 rows affected (0.00 sec)

mysql> Select @Counter;
+----------+
| @Counter |
+----------+
| 1        |
+----------+
1 row in set (0.00 sec)
```

Stored Procedures (Cont..)

- Use show procedure status to display the list of stored procedures you have created

```
mysql> show procedure status;
+------+--------------+-----------+---------+---------------------+---------------------+----------
-----+---------+----------------------+----------------------+--------------------+
| Db   | Name         | Type      | Definer | Modified            | Created             | Security_
type | Comment | character_set_client | collation_connection | Database Collation |
+------+--------------+-----------+---------+---------------------+---------------------+----------
-----+---------+----------------------+----------------------+--------------------+
| ptan | updateSalary0 | PROCEDURE | ptan@%  | 2010-03-16 12:21:55 | 2010-03-16 12:21:55 | DEFINER
     |         | latin1               | latin1_swedish_ci    | latin1_swedish_ci  |
+------+--------------+-----------+---------+---------------------+---------------------+----------
-----+---------+----------------------+----------------------+--------------------+
1 row in set (0.02 sec)
```

- Use drop procedure to remove a stored procedure

```
mysql> drop procedure updateSalary;
Query OK, 0 rows affected (0.00 sec)
```

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

Language Constructs

- **CASE Statement**

```
CASE  case_expression
  WHEN when_expression_1 THEN commands
  WHEN when_expression_2 THEN commands
  ...
  ELSE commands
END CASE;
```

- **While** and **repeat** statements:

while *boolean expression* **do**
sequence of statements ;
end while

repeat
sequence of statements ;
until *boolean expression*
end repeat

Language Constructs (Cont.)

- **Loop, Leave and Iterate statements…**
  - Permits iteration over all results of a query.

```
loop_label:  LOOP
IF  x > 10 THEN
 LEAVE  loop_label;
END  IF;
SET  x = x + 1;
IF  (x mod 2) THEN
ITERATE  loop_label;
ELSE
        SET  str = CONCAT(str,x,',');
END  IF;
    END LOOP;
```

Language Constructs (Cont.)

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

```
IF expression THEN
  statements;
ELSE
  else-statements;
END IF;
```

Example:

```
IF creditlim > 50000 THEN
SET p_customerLevel = 'PLATINUM';
  ELSEIF (creditlim <= 50000 AND creditlim >= 10000) THEN
    SET p_customerLevel = 'GOLD';
  ELSEIF creditlim < 10000 THEN
    SET p_customerLevel = 'SILVER';
  END IF;
```

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Error Handling in MySQL

- The following handler means that if an error occurs, set the value of the has_error variable to 1 and continue the execution.

```
DECLARE CONTINUE HANDLER FOR SQLEXCEPTION SET has_error = 1;
```

- The following is another handler which means that in case an error occurs, rollback the previous operation, issue an error message, and exit the current code block.
- If we declare it inside the BEGIN END block of a stored procedure, it will terminate stored procedure immediately.

```
DECLARE EXIT HANDLER FOR SQLEXCEPTION
BEGIN
ROLLBACK;
SELECT 'An error has occurred, operation rollbacked and the stored procedure was termina
ted';
END;
```

Error Handling in MySQL

- The following handler means that if there are no more rows to fetch, in case of a cursor or SELECT INTO statement, set the value of the no_row_found variable to 1 and continue execution.

```
1 DECLARE CONTINUE HANDLER FOR NOT FOUND SET no_row_found = 1;
```

- The following handler means that if a duplicate key error occurs, MySQL error 1062 is issued. It issues an error message and continues execution.

```
1 DECLARE CONTINUE HANDLER FOR 1062
2 SELECT 'Error, duplicate key occurred';
```

Example

- First, create a new table named article_tags.

```
1  CREATE TABLE article_tags(
2      article_id INT,
3      tag_id     INT,
4      PRIMARY KEY(article_id,tag_id)
5  );
```

- The article_tags table stores the relationships between articles and tags. Each article may have many tags and vice versa.
- Next, create a stored procedure that inserts article id and tag id into the article_tags table.

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Example (Cont..)

```
1  DELIMITER $$
2
3  CREATE PROCEDURE insert_article_tags(IN article_id INT, IN tag_id INT)
4  BEGIN
5
6   DECLARE CONTINUE HANDLER FOR 1062
7   SELECT CONCAT('duplicate keys (',article_id,',',tag_id,') found') AS msg;
8
9   -- insert a new record into article_tags
10  INSERT INTO article_tags(article_id,tag_id)
11  VALUES(article_id,tag_id);
12
13  -- return tag count for the article
14  SELECT COUNT(*) FROM article_tags;
15 END
```

Example (Cont..)

- Then, Call the procedure

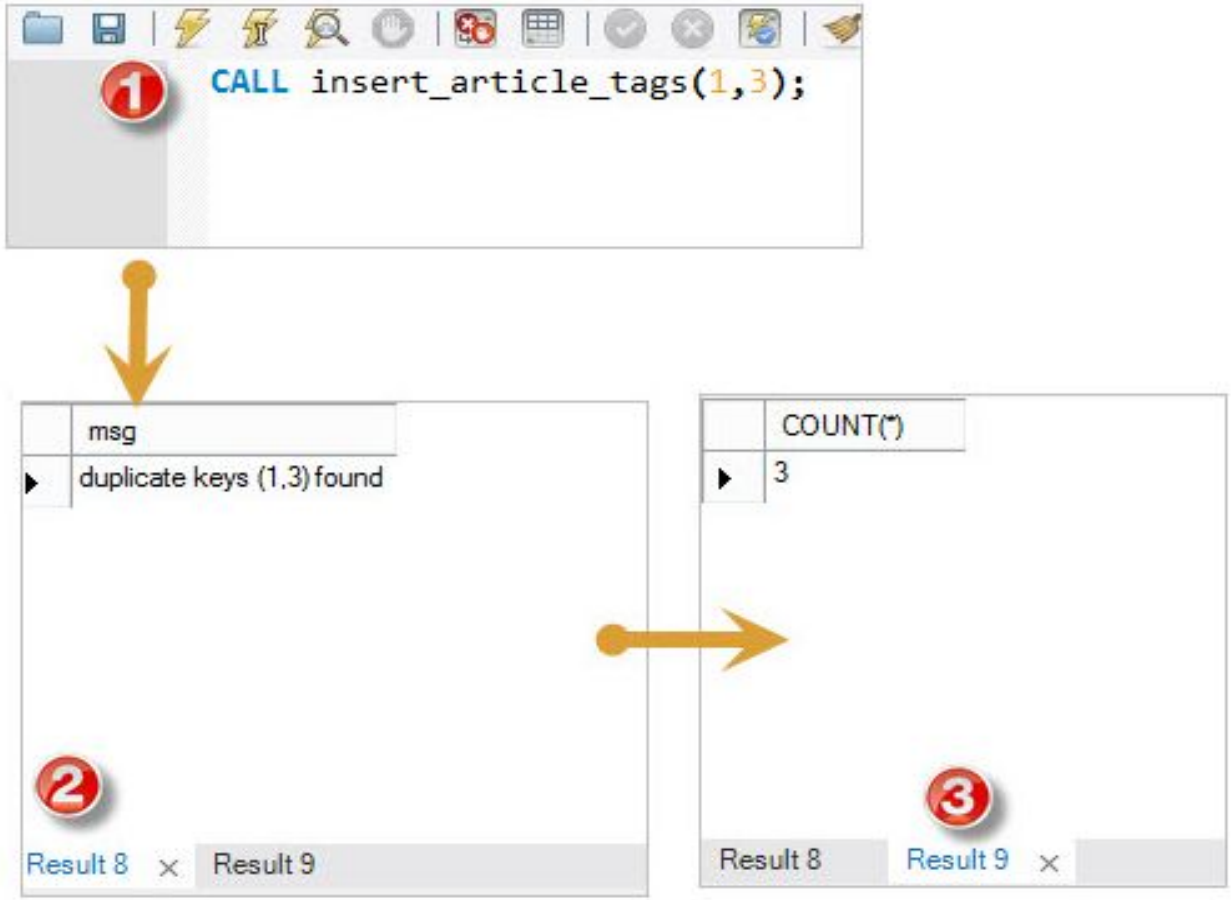
```
1 CALL insert_article_tags(1,1);
2 CALL insert_article_tags(1,2);
3 CALL insert_article_tags(1,3);
```

- After that, try to insert a duplicate key to check if the handler is really invoked.

```
1 CALL insert_article_tags(1,3);
```

- We will get an error message. However, because we declared the handler as a CONTINUE handler, the stored procedure continued the execution. As the result, we get the tag count for the article as well.

Example (Cont..)



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Cursors

Cursors

- To handle a result set inside a stored procedure, we use a cursor.
- A cursor allows us to iterate a set of rows returned by a query and process each row accordingly.
- The set of rows the cursor holds is referred to as the **active set**.

1. We can declare a cursor by using the DECLARE statement:

```
DECLARE cursor_name CURSOR FOR SELECT_statement;
```

- The cursor declaration must be after any variable declaration.
- A cursor must always be associated with a SELECT statement.

Cursors

2. Next, open the cursor by using the OPEN statement.

```
OPEN cursor_name;
```

3. Then, use the FETCH statement to retrieve the next row pointed by the cursor and move the cursor to the next row in the result set.

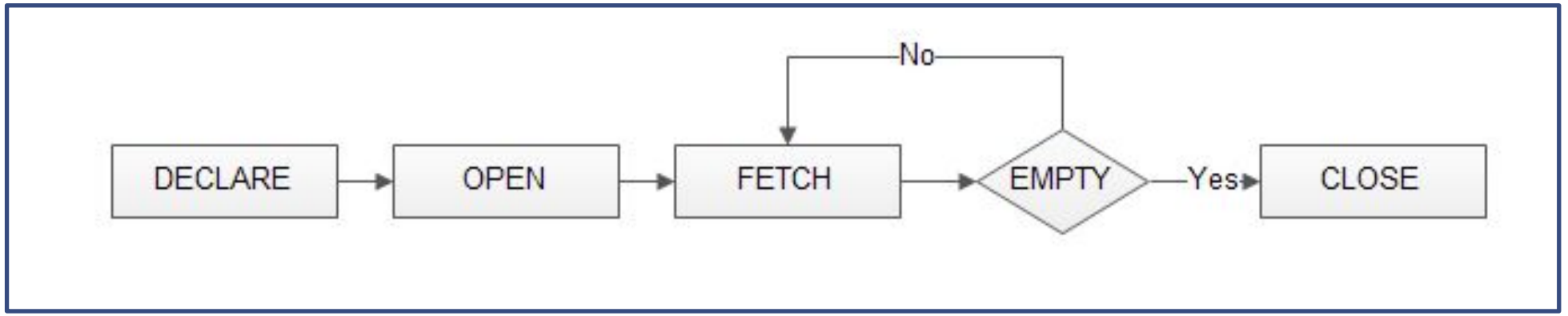
```
FETCH cursor_name INTO variables list;
```

4. Finally, call the CLOSE statement to deactivate the cursor and release the memory associated with it as follows:

```
CLOSE cursor_name;
```

Cursors

The following diagram illustrates how MySQL cursor works.



Example using Cursors

- **Example 2 in stored procedure updates one row in deptsal table based on input parameter.**

Suppose we want to update all the rows in deptsal simultaneously.

- First, let's reset the totalsalary in deptsal to zero.

```
mysql> update deptsal set totalsalary = 0;
Query OK, 0 rows affected (0.00 sec)
Rows matched: 3  Changed: 0  Warnings: 0

mysql> select * from deptsal;
+---------+-------------+
| dnumber | totalsalary |
+---------+-------------+
|       1 |           0 |
|       2 |           0 |
|       3 |           0 |
+---------+-------------+
3 rows in set (0.00 sec)
```

Example using Cursors

```
mysql> delimiter $$
mysql> drop procedure if exists updateSalary$$
Query OK, 0 rows affected (0.00 sec)

mysql> create procedure updateSalary()
    -> begin
    ->          declare done int default 0;
    ->          declare current_dnum int;
    ->          declare dnumcur cursor for select dnumber from deptsal;
    ->          declare continue handler for not found set done = 1;
    ->
    ->          open dnumcur;
    ->
    ->          repeat
    ->                fetch dnumcur into current_dnum;
    ->                update deptsal
    ->                set totalsalary = (select sum(salary) from employee
    ->                                   where dno = current_dnum)
    ->                where dnumber = current_dnum;
    ->          until done
    ->          end repeat;
    ->
    ->          close dnumcur;
    -> end$$
Query OK, 0 rows affected (0.00 sec)

mysql> delimiter ;
```

Drop the old procedure

Use cursor to iterate the rows

Example using Cursors

Call procedure :

```
mysql> select * from deptsal;
+---------+-------------+
| dnumber | totalsalary |
+---------+-------------+
|       1 |           0 |
|       2 |           0 |
|       3 |           0 |
+---------+-------------+
3 rows in set (0.01 sec)

mysql> call updateSalary;
Query OK, 0 rows affected (0.00 sec)

mysql> select * from deptsal;
+---------+-------------+
| dnumber | totalsalary |
+---------+-------------+
|       1 |      100000 |
|       2 |       50000 |
|       3 |      130000 |
+---------+-------------+
3 rows in set (0.00 sec)
```

Another Example

Create a procedure to give a raise to all employees

```
mysql> select * from emp;
+----+--------+---------+--------+------------+------+
| id | name   | superid | salary | bdate      | dno  |
+----+--------+---------+--------+------------+------+
|  1 | john   |       3 | 100000 | 1960-01-01 |    1 |
|  2 | mary   |       3 |  50000 | 1964-12-01 |    3 |
|  3 | bob    |    NULL |  80000 | 1974-02-07 |    3 |
|  4 | tom    |       1 |  50000 | 1978-01-17 |    2 |
|  5 | bill   |    NULL |   NULL | 1985-01-20 |    1 |
|  6 | lucy   |    NULL |  90000 | 1981-01-01 |    1 |
|  7 | george |    NULL |  45000 | 1971-11-11 | NULL |
+----+--------+---------+--------+------------+------+
7 rows in set (0.00 sec)
```

Another Example (Cont..)

```
mysql> delimiter |
mysql> create procedure giveRaise (in amount double)
    -> begin
    ->         declare done int default 0;
    ->         declare eid int;
    ->         declare sal int;
    ->         declare emprec cursor for select id, salary from employee;
    ->         declare continue handler for not found set done = 1;
    ->
    ->         open emprec;
    ->         repeat
    ->                 fetch emprec into eid, sal;
    ->                 update employee
    ->                 set salary = sal + round(sal * amount)
    ->                 where id = eid;
    ->         until done
    ->         end repeat;
    -> end |
Query OK, 0 rows affected (0.00 sec)
```

Another Example (Cont..)

```
mysql> delimiter ;
mysql> call giveRaise(0.1);
Query OK, 0 rows affected (0.00 sec)

mysql> select * from employee;
+----+------+---------+--------+------------+------+
| id | name | superid | salary | bdate      | dno  |
+----+------+---------+--------+------------+------+
|  1 | john |       3 | 110000 | 1960-01-01 |    1 |
|  2 | mary |       3 |  55000 | 1964-12-01 |    3 |
|  3 | bob  |    NULL |  88000 | 1974-02-07 |    3 |
|  4 | tom  |       1 |  55000 | 1978-01-17 |    2 |
|  5 | bill |    NULL |   NULL | 1985-01-20 |    1 |
+----+------+---------+--------+------------+------+
5 rows in set (0.00 sec)
```

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Triggers

Triggers

- A **trigger** is a statement that is executed automatically by the system as a side effect of a modification to the database i.e. when changes are made to the table.
- To monitor a database and take a corrective action when a condition occurs

  Examples:
  - Charge $10 overdraft fee if the balance of an account after a withdrawal transaction is less than $500
  - Limit the salary increase of an employee to no more than 5% raise
- SQL triggers provide an alternative way to check the integrity of data.

Triggering Events and Actions in SQL

- A trigger can be defined to be invoked either before or after the data is changed by **INSERT**, **UPDATE** or **DELETE** .
- MySQL allows you to define maximum six triggers for each table.
  - BEFORE INSERT – activated before data is inserted into the table.
  - AFTER INSERT- activated after data is inserted into the table.
  - BEFORE UPDATE – activated before data in the table is updated.
  - AFTER UPDATE - activated after data in the table is updated.
  - BEFORE DELETE – activated before data is removed from the table.
  - AFTER DELETE – activated after data is removed from the table.

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MySQL Trigger Syntax

```
1 CREATE TRIGGER trigger_name trigger_time trigger_event
2  ON table_name
3  FOR EACH ROW
4  BEGIN
5  ...
6  END;
```

MySQL Trigger Example 1

- Create a BEFORE UPDATE trigger that is invoked before a change is made to the employees table.
- we used the OLD keyword to access employeeNumber and lastname column of the row affected by the trigger.

```
1  DELIMITER $$
2  CREATE TRIGGER before_employee_update
3      BEFORE UPDATE ON employees
4      FOR EACH ROW
5  BEGIN
6      INSERT INTO employees_audit
7      SET action = 'update',
8       employeeNumber = OLD.employeeNumber,
9          lastname = OLD.lastname,
10         changedat = NOW();
11 END$$
12 DELIMITER ;
```

Continued…

- In a trigger defined for INSERT, you can use NEW keyword only. You cannot use the OLD keyword.
- However, in the trigger defined for DELETE, there is no new row so you can use the OLD keyword only.
- In the UPDATE trigger, OLD refers to the row before it is updated and NEW refers to the row after it is updated.

Example (Cont..)

- Update the employees table to check whether the trigger is invoked.

```
1 UPDATE employees
2 SET
3     lastName = 'Phan'
4 WHERE
5     employeeNumber = 1056;
```

- Finally, to check if the trigger was invoked by the UPDATE statement, we can query the employees_audit table using the following query:

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

Example (Cont..)

- The following is the output of the query:

	id	employeeNumber	lastname	changedat	action
▶	1	1056	Phan	2015-11-14 21:39:12	update

Example 2

```
mysql> select * from employee;
+----+-------+----------+--------+--------------+------+
| id | name  | superid  | salary | bdate        | dno  |
+----+-------+----------+--------+--------------+------+
|  1 | john  |        3 | 100000 | 1960-01-01   |    1 |
|  2 | mary  |        3 |  50000 | 1964-12-01   |    3 |
|  3 | bob   |     NULL |  80000 | 1974-02-07   |    3 |
|  4 | tom   |        1 |  50000 | 1970-01-17   |    2 |
|  5 | bill  |     NULL |   NULL | 1985-01-20   |    1 |
+----+-------+----------+--------+--------------+------+
5 rows in set (0.00 sec)

mysql> select * from deptsal;
+----------+---------------+
| dnumber  | totalsalary   |
+----------+---------------+
|        1 |        100000 |
|        2 |         50000 |
|        3 |        130000 |
+----------+---------------+
3 rows in set (0.00 sec)
```

We want to create a trigger to update the total salary of a department when a new employee is hired

Example 2 (Cont..)

Create a trigger to update the total salary of a department when a new employee is hired:

```
mysql> delimiter !
mysql> create trigger update_salary
    -> after insert on employee
    -> for each row
    -> begin
    ->       if new.dno is not null then
    ->           update deptsal
    ->           set totalsalary = totalsalary + new.salary
    ->           where dnumber = new.dno;
    ->       end if;
    -> end !
Query OK, 0 rows affected (0.06 sec)

mysql> delimiter ;
```

The keyword “new” refers to the new row inserted

Example 2 (Cont..)

```
mysql> select * from deptsal;
+---------+-------------+
| dnumber | totalsalary |
+---------+-------------+
|       1 |      100000 |
|       2 |       50000 |
|       3 |      130000 |
+---------+-------------+
3 rows in set (0.00 sec)

mysql> insert into employee values (6,'lucy',null,90000,'1981-01-01',1);
Query OK, 1 row affected (0.08 sec)

mysql> select * from deptsal;
+---------+-------------+
| dnumber | totalsalary |
+---------+-------------+
|       1 |      190000 |
|       2 |       50000 |
|       3 |      130000 |
+---------+-------------+
3 rows in set (0.00 sec)

mysql> insert into employee values (7,'george',null,45000,'1971-11-11',null);
Query OK, 1 row affected (0.02 sec)

mysql> select * from deptsal;
+---------+-------------+
| dnumber | totalsalary |
+---------+-------------+
|       1 |      190000 |
|       2 |       50000 |
|       3 |      130000 |
+---------+-------------+
3 rows in set (0.00 sec)

mysql> drop trigger update_salary;
Query OK, 0 rows affected (0.00 sec)
```

MySQL Trigger

- To list all the triggers we have created:

  mysql> show triggers;

```
1  SHOW TRIGGERS;
```

Trigger	Event	Table	Statement	Timing	Created	sql_mode	Definer
before_employee_update	UPDATE	employees	BEGIN INSERT INTO employ...	BEFORE	2015-11-14 21:39:09.08	STRICT_TRANS_TABLES,NO_AUTO_CREATE_U...	root@localhost

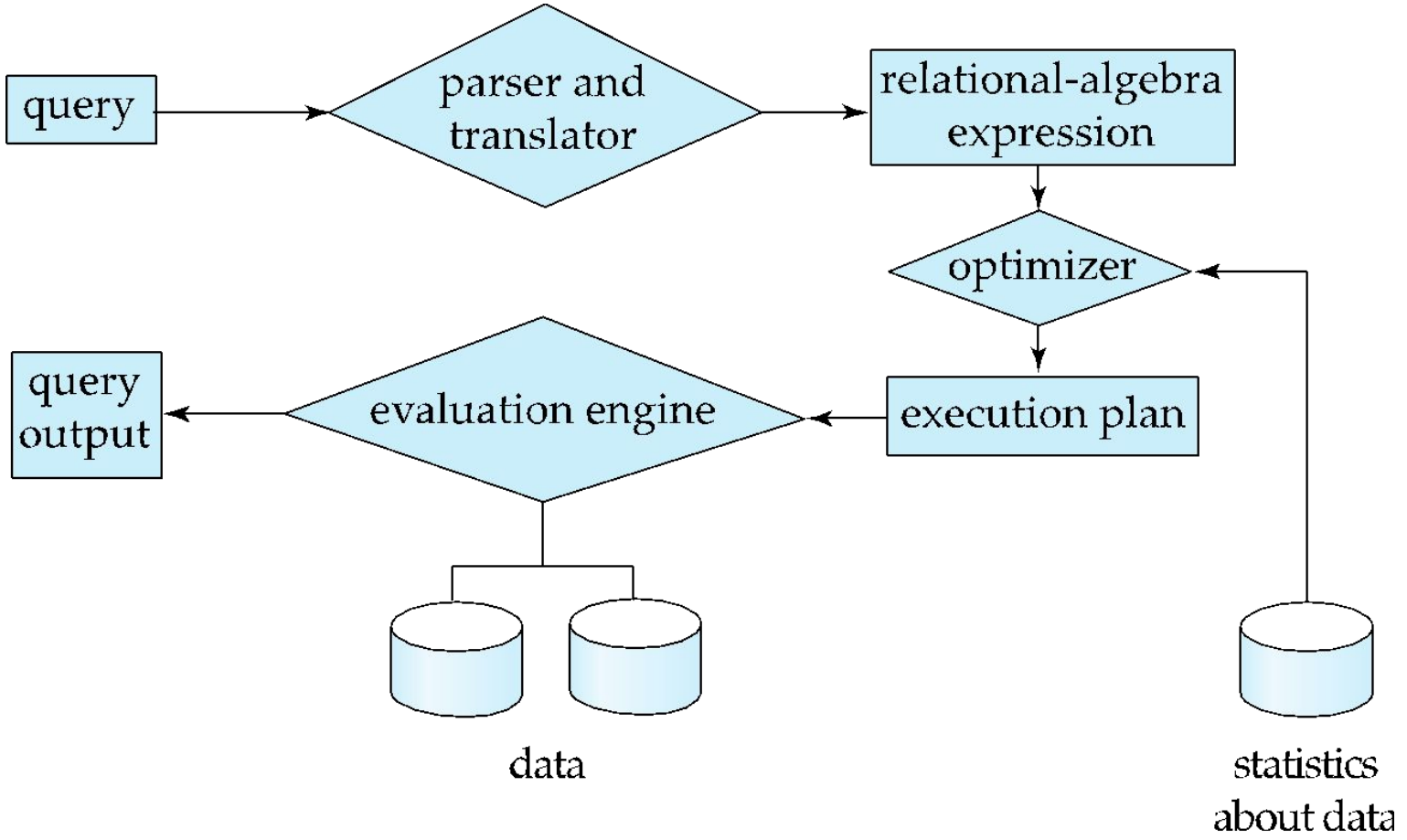
- To drop a trigger

  mysql> drop trigger <trigger name>

Query Processing and Optimization

Basic Steps in Query Processing

1. Parsing and translation
2. Optimization
3. Evaluation



Basic Steps in Query Processing(Contd..)

- Parsing and translation
  - translate the query into its internal form. This is then translated into relational algebra.
  - Parser checks syntax, verifies relations
- Evaluation
  - The query-execution engine takes a query-evaluation plan, executes that plan, and returns the answers to the query.

Basic Steps in Query Processing : Optimization

A relational algebra expression may have many equivalent expressions

- E.g., $\sigma_{salary<75000}(\prod_{salary}(instructor))$ is equivalent to $\prod_{salary}(\sigma_{salary<75000}(instructor))$

Each relational algebra operation can be evaluated using one of several different algorithms

- Correspondingly, a relational-algebra expression can be evaluated in many ways.

Annotated expression specifying detailed evaluation strategy is called an **evaluation-plan**.

- E.g., can use an index on *salary* to find instructors with salary < 75000,
- or can perform complete relation scan and discard instructors with salary ≥ 75000

Basic Steps: Optimization (Cont.)

Query Optimization:

Amongst all equivalent evaluation plans choose the one with lowest cost.

- Cost is estimated using statistical information from the database catalog
  - e.g. number of tuples in each relation, size of tuples, etc.

we will study how to measure query cost

Measures of Query Cost (Cont.)

- For simplicity we just use the **number of block transfers** *from disk and the* **number of seeks** as the cost measures
  - t_T – time to transfer one block
  - t_S – time for one seek
  - Cost for b block transfers plus S seeks

    $b * t_T + S * t_S$

Here ignore CPU costs for simplicity

- Real systems do take CPU cost into account

here do not include cost to writing output to disk in our cost formulae

Measures of Query Cost

- Cost is generally measured as total elapsed time for answering query
  - Many factors contribute to time cost
    - *disk accesses, CPU*, or even network *communication*
- Typically disk access is the predominant cost, and is also relatively easy to estimate. Measured by taking into account
  - Number of seeks * average-seek-cost
  - Number of blocks read * average-block-read-cost
  - Number of blocks written * average-block-write-cost
  - Cost to write a block is greater than cost to read a block
    - data is read back after being written to ensure that the write was successful.

Measures of Query Cost (Cont..)

- Several algorithms can reduce disk IO by using extra buffer space
  - Amount of real memory available to buffer depends on other concurrent queries and OS processes, known only during execution
    - We often use worst case estimates, assuming only the minimum amount of memory needed for the operation is available
- Required data may be buffer resident already, avoiding disk I/O
  - But hard to take into account for cost estimation

References

1. Silberschatz–Korth–Sudarshan's Database System Concepts, Seventh Edition.
2. MySQL Tutorial

   http://www.mysqltutorial.org/