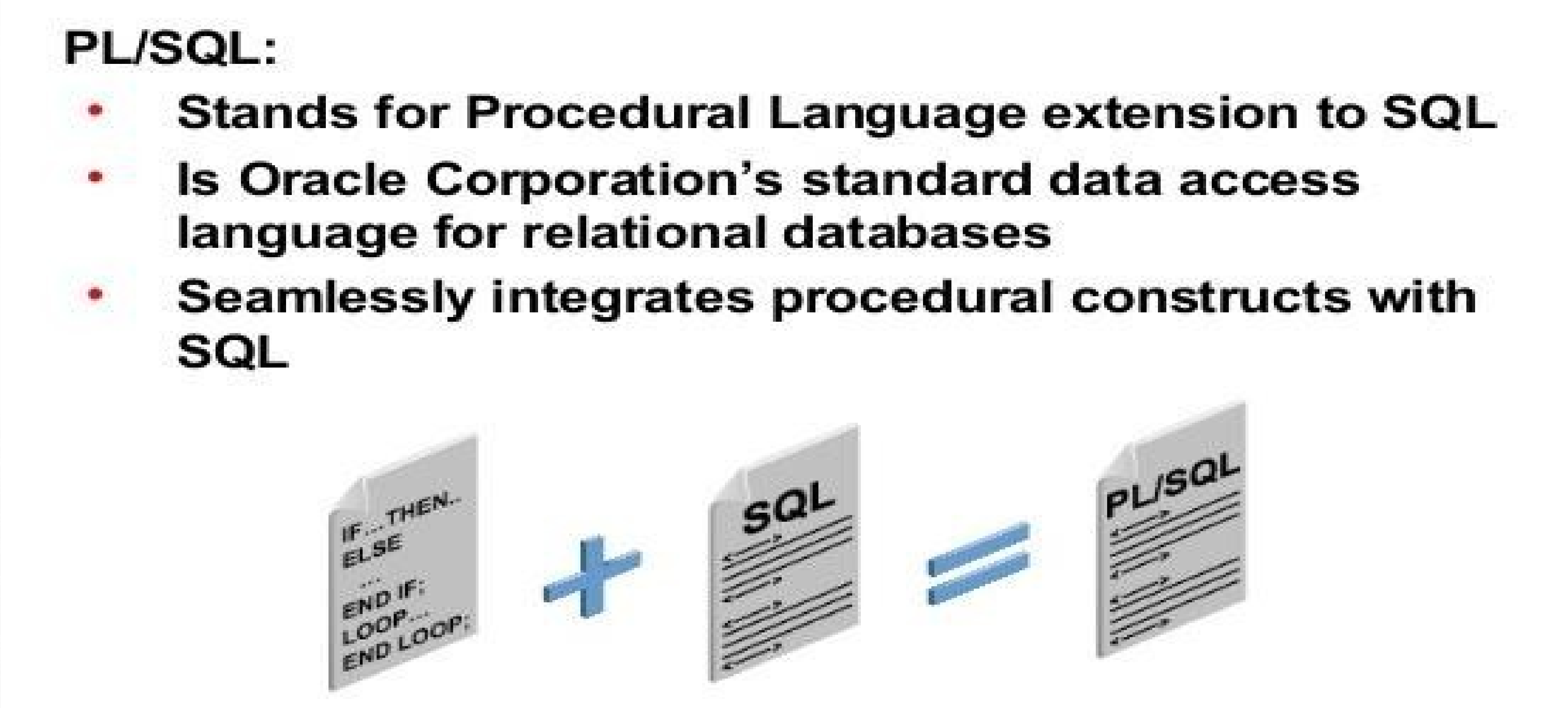
# Extensions to SQL (PL/SQL)

# What is PL/SQL

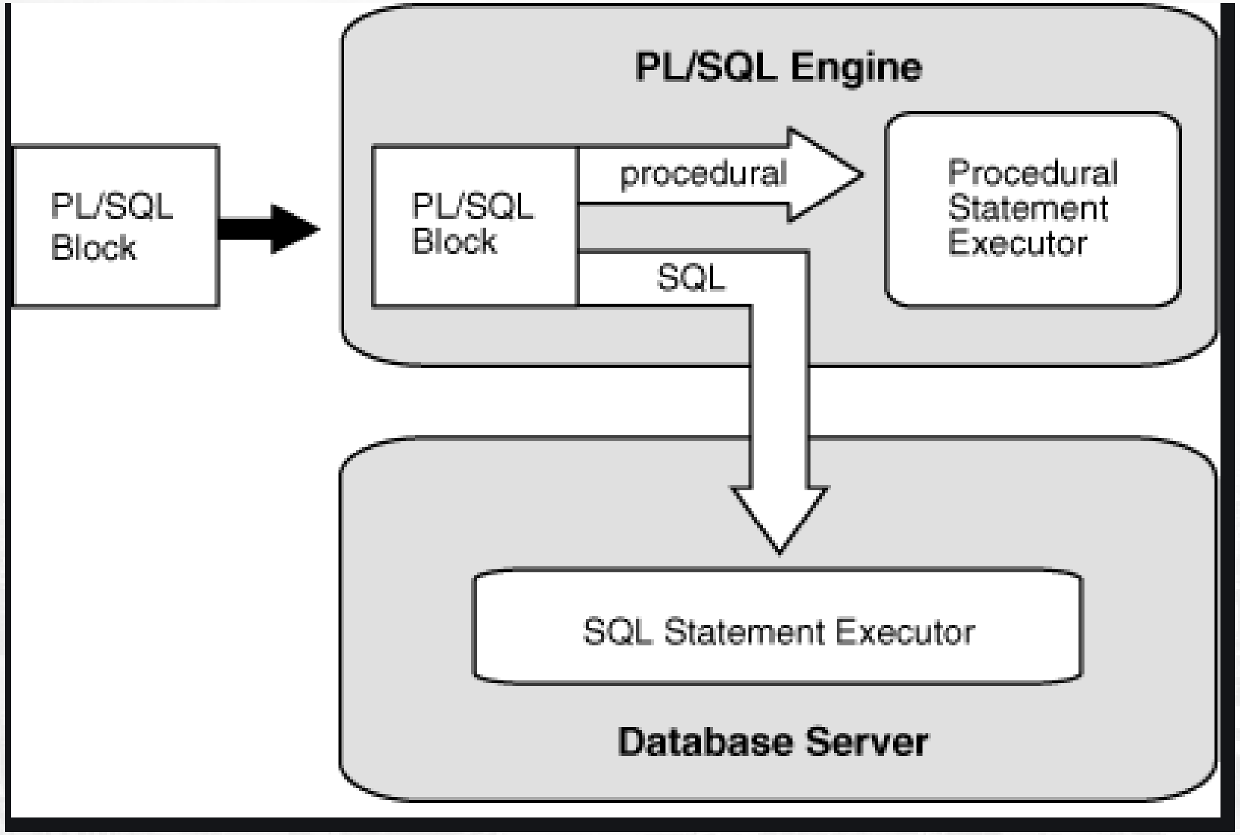


PL/SQL:

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

IF... THEN..
ELSE
...
END IF;
LOOP...
END LOOP;
SQL
PL/SQL

# PL/SQL Execution



## Advantages

- PL/SQL is a completely portable, high-performance transaction-processing language.
- PL/SQL provides a built-in, interpreted and OS independent programming environment.
- It supports structured programming through functions and procedures.
- Direct call can also be made from external programming language calls to database.

# Basic Structure of PL/SQL

- PL/SQL stands for Procedural Language/SQL.
- PL/SQL extends SQL by adding constructs found in procedural languages
- The basic unit in PL/SQL is a block. All PL/SQL programs are made up of blocks, which can be nested within each other.
- Each block performs a logical action in the program.
- The only SQL statements allowed in a PL/SQL program are SELECT, INSERT, UPDATE, DELETE and several other data manipulation statements plus some transaction control.
- Data definition statements like CREATE, DROP, or ALTER are not allowed.
- The executable section also contains constructs such as assignments, branches, loops, procedure calls, and triggers,
- PL/SQL is not case sensitive. C style comments (/* ... */) may be used.

# Basic Structure of PL/SQL

A block has the following structure:

```
DECLARE
    /* Declarative section: variables, types, and local subprograms. */
 BEGIN


    /* Executable section: procedural and SQL statements go here. */


    /* This is the only section of the block that is required. */


EXCEPTION


    /* Exception handling section: error handling statements go here. */
END;
```

To execute a PL/SQL program,

- A line with a single dot ("."), and then
- A line with run;

# Variables and Types

- Information is transmitted between a PL/SQL program and the database through variables. Every variable has a specific type associated with it. That type can be

  - One of the types used by SQL for database columns
  - A generic type used in PL/SQL such as NUMBER
  - Declared to be the same as the type of some database column

# Variables and Types(Contd..)

Variables of type NUMBER can hold either an integer or a real number. The most commonly used character string type is VARCHAR(n), where n is the maximum length of the string in bytes

```
DECLARE
    price  NUMBER;
    product VARCHAR(20);
```

In cases, where a PL/SQL variable will be used to manipulate data stored in a existing relation use %TYPE.

```
DECLARE
    myProduct Product.name%TYPE;
```

A variable may also have a type that is a record with several fields.

```
DECLARE
    ProductTuple Product%ROWTYPE;
```

# Variables and Types(Contd..)

The initial value of any variable, regardless of its type, is NULL. We can assign values to variables, using the ":=" operator. The assignment can occur either immediately after the type of the variable is declared, or anywhere in the executable portion of the program. For example:

```
DECLARE
   a NUMBER := 3;
BEGIN
   a := a + 1;
END;
```

# 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).
  - 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.
- Procedures and functions are stored in `mysql.routines`

`and` `mysql.parameters` tables, which are part of the data dictionary.

# Simple Programs in PL/SQL

The simplest form of program has some declarations followed by an executable section consisting of one or more of the SQL statements

```
CREATE TABLE T1(
   e INTEGER,
   f INTEGER
);
DELETE FROM T1;
INSERT INTO T1 VALUES(1, 3);
INSERT INTO T1 VALUES(2, 4);

/* Above is plain SQL; below is the PL/SQL program. */
DECLARE
   a NUMBER;
   b NUMBER;
BEGIN
   SELECT e,f INTO a,b FROM T1 WHERE e>1;
   INSERT INTO T1 VALUES(b,a);
END;
```

# Control Flow in PL/SQL

PL/SQL allows you to branch and create loops in a fairly familiar way. An IF statement looks like:

*IF <condition> THEN <statement_list> ELSE <statement_list> END IF;*

*The ELSE part is optional. If you want a multiway branch, use:*

*IF <condition_1> THEN …*

*ELSIF <condition_2> THEN …*
*… …*
*ELSIF <condition_n> THEN …*
*ELSE …*

*END IF;*

# Control Flow in PL/SQL

Loops are created with the following:

```
LOOP

    <loop_body> /* A list of statements. */

END LOOP;
```

At least one of the statements in <loop_body> should be an EXIT statement of the form

```
EXIT WHEN <condition>;
```

*The loop breaks if <condition> is true.*

# Control Flow in PL/SQL

Loops are created with the following:

```
DECLARE
   i NUMBER := 1;

BEGIN
          LOOP
           INSERT INTO T1 VALUES(i, i);
           i := i+1;
           EXIT WHEN i>100;
   END LOOP;
END;
```

# PL/SQL Control Flow

```
DECLARE
  b_profitable BOOLEAN;
  n_sales      NUMBER;
  n_costs      NUMBER;
BEGIN
  b_profitable := false;
  IF n_sales > n_costs THEN
    b_profitable := true;
  END IF;
END;
```

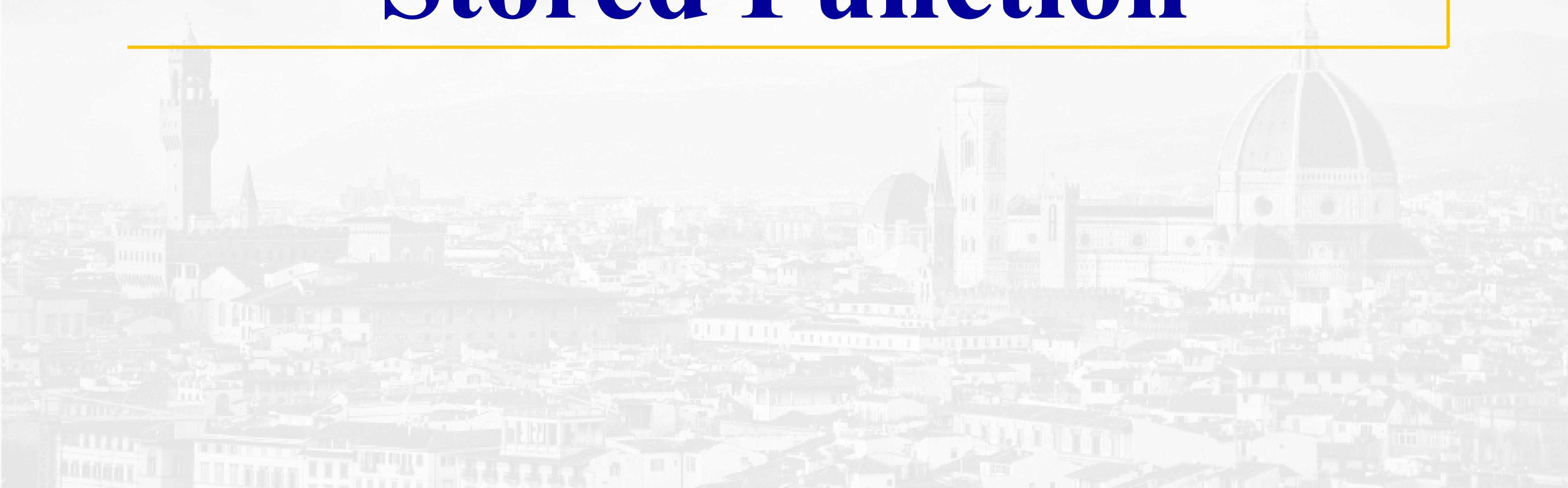
# PL/SQL Control Flow

```
DECLARE
  n_sales NUMBER := 300000;
  n_commission NUMBER( 10, 2 ) := 0;
BEGIN
  IF n_sales > 200000 THEN
    n_commission := n_sales * 0.1;
  ELSE
    n_commission := n_sales * 0.05;
  END IF;
END;
```

# PL/SQL Control Flow

```
DECLARE
  n_sales NUMBER := 300000;
  n_commission NUMBER( 10, 2 ) := 0;
BEGIN
  IF n_sales > 200000 THEN
    n_commission := n_sales * 0.1;
  ELSIF n_sales <= 200000 AND n_sales > 100000 THEN
    n_commission := n_sales * 0.05;
  ELSIF n_sales <= 100000 AND n_sales > 50000 THEN
    n_commission := n_sales * 0.03;
  ELSE
    n_commission := n_sales * 0.02;
  END IF;
END;
```

# 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;
```

For a FUNCTION, parameters are always regarded as IN parameters.

For a Procedure , parameter as IN, OUT, or INOUT is valid.

# Deterministic and Non- deterministic Functions

- A deterministic function always returns the same result for the same input parameters whereas a non-deterministic function returns different results for the same input parameters.
- If you don’t use DETERMINISTIC or NOT DETERMINISTIC, MySQL uses the NOT DETERMINISTIC option by default.
- **rand()** is nondeterministic function. That means we do not know what it will return ahead of time.
- Some **deterministic** functions
- ISNULL, ISNUMERIC, DATEDIFF, POWER, CEILING, FLOOR, DATEADD, DAY, MONTH, YEAR, SQUARE, SQRT etc.
- Some **non deterministic** functions
- RAND(), RANK(), SYSDATE()

# 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
```

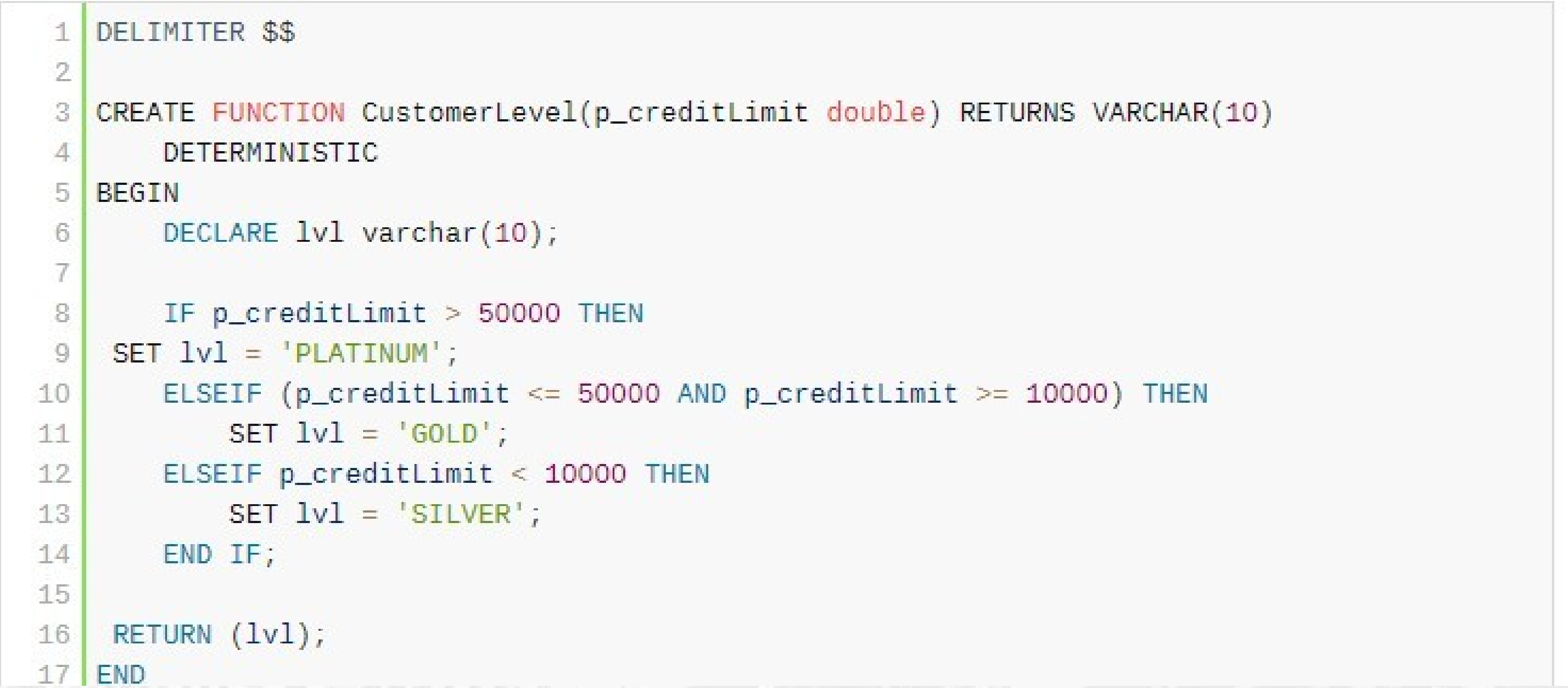
# Example 1 (Cont)..

- The function dept_count can be used to find the department names and budget of all departments with more than 12 instructors.

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

# Example 2

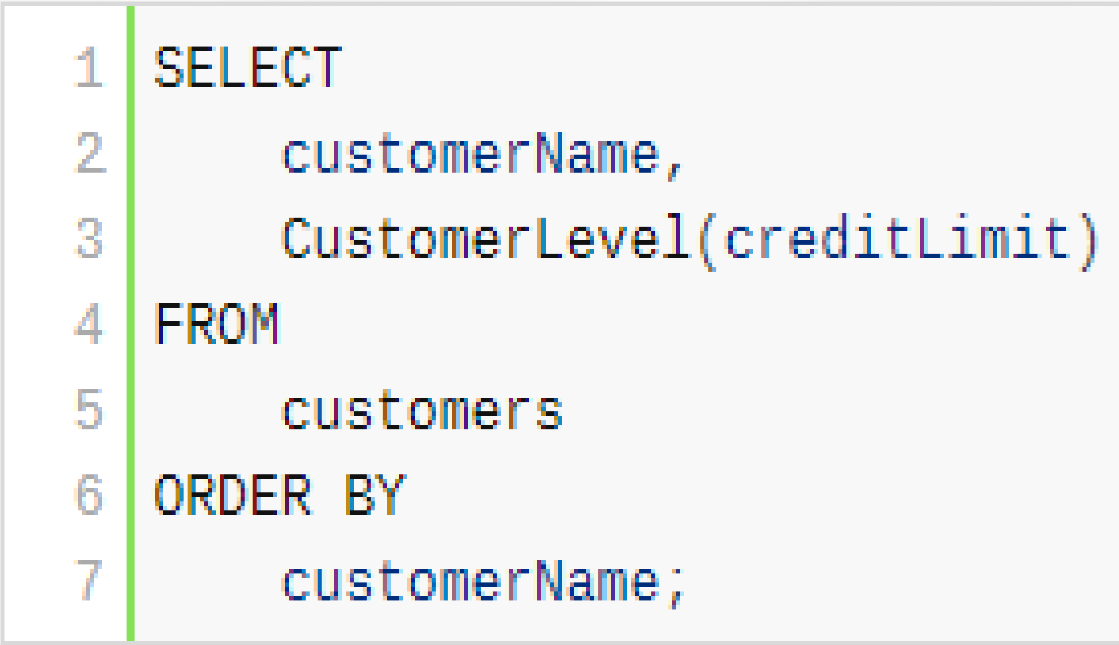
- A function that returns the level of a customer based on credit limit. We use the IF statement to determine the credit limit.



```
DELIMITER $$

CREATE FUNCTION CustomerLevel(p_creditLimit double) RETURNS VARCHAR(10)
    DETERMINISTIC
BEGIN
    DECLARE lvl varchar(10);

    IF p_creditLimit > 50000 THEN
 SET lvl = 'PLATINUM';
    ELSEIF (p_creditLimit <= 50000 AND p_creditLimit >= 10000) THEN
        SET lvl = 'GOLD';
    ELSEIF p_creditLimit < 10000 THEN
        SET lvl = 'SILVER';
    END IF;

 RETURN (lvl);
END
```

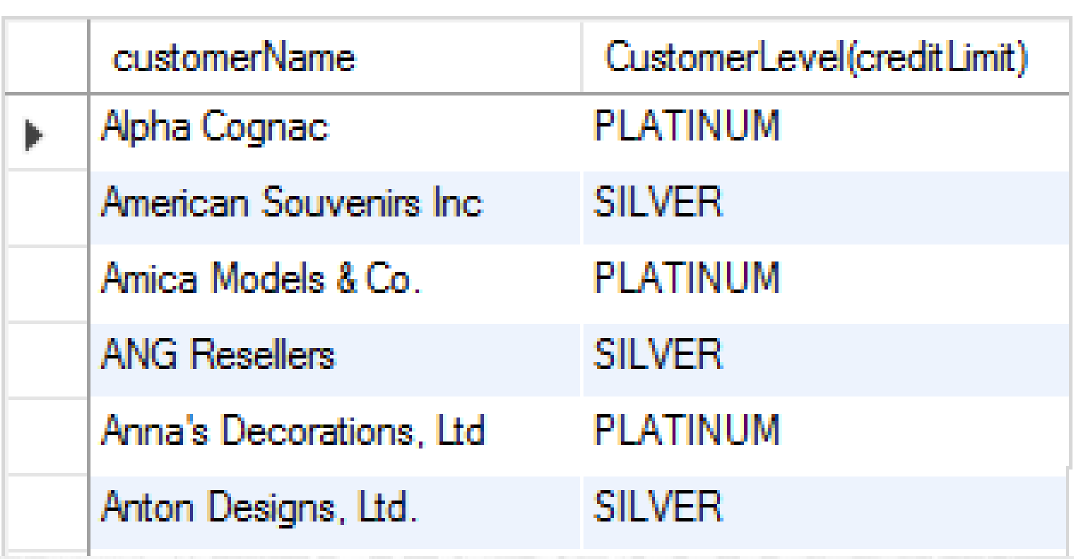
# Example 2 (Cont..)

- **Calling function:**
- we can call the CustomerLevel() in a SELECT statement as follows:



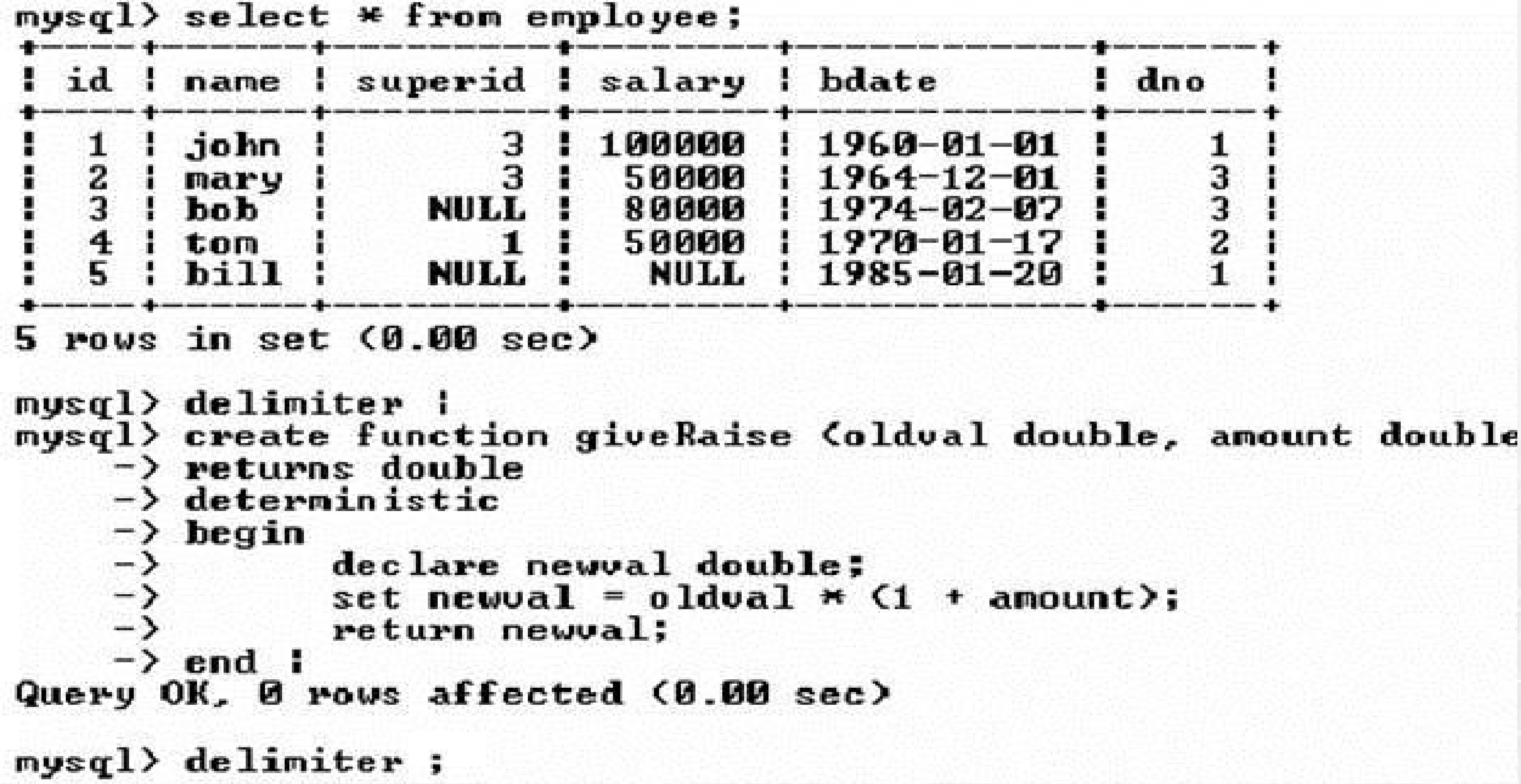
```
SELECT
    customerName,
    CustomerLevel(creditLimit)
FROM
    customers
ORDER BY
    customerName;
```

**Output:**



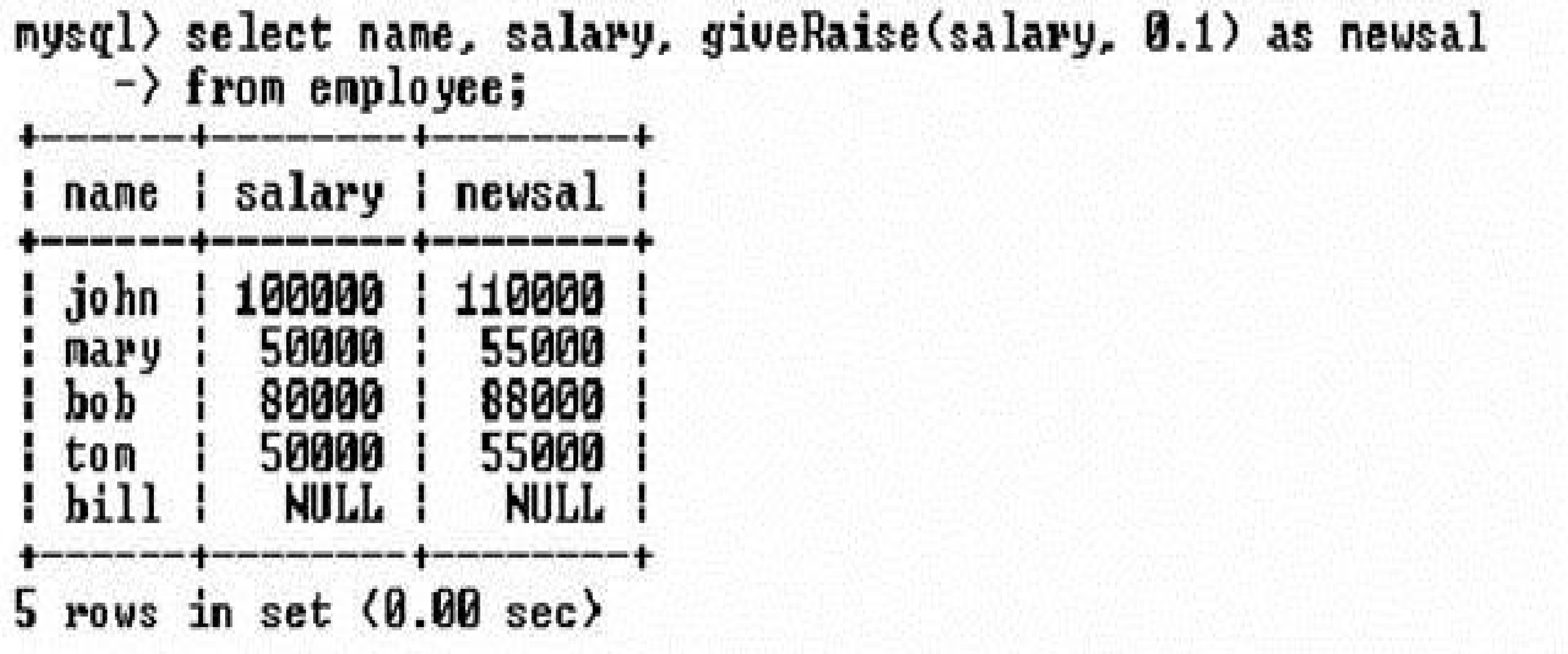
|  | customerName | CustomerLevel(creditLimit) |
|---|---|---|
| ▶ | Alpha Cognac | PLATINUM |
|  | American Souvenirs Inc | SILVER |
|  | Amica Models & Co. | PLATINUM |
|  | ANG Resellers | SILVER |
|  | Anna's Decorations, Ltd | PLATINUM |
|  | Anton Designs, Ltd. | SILVER |

# Example 3

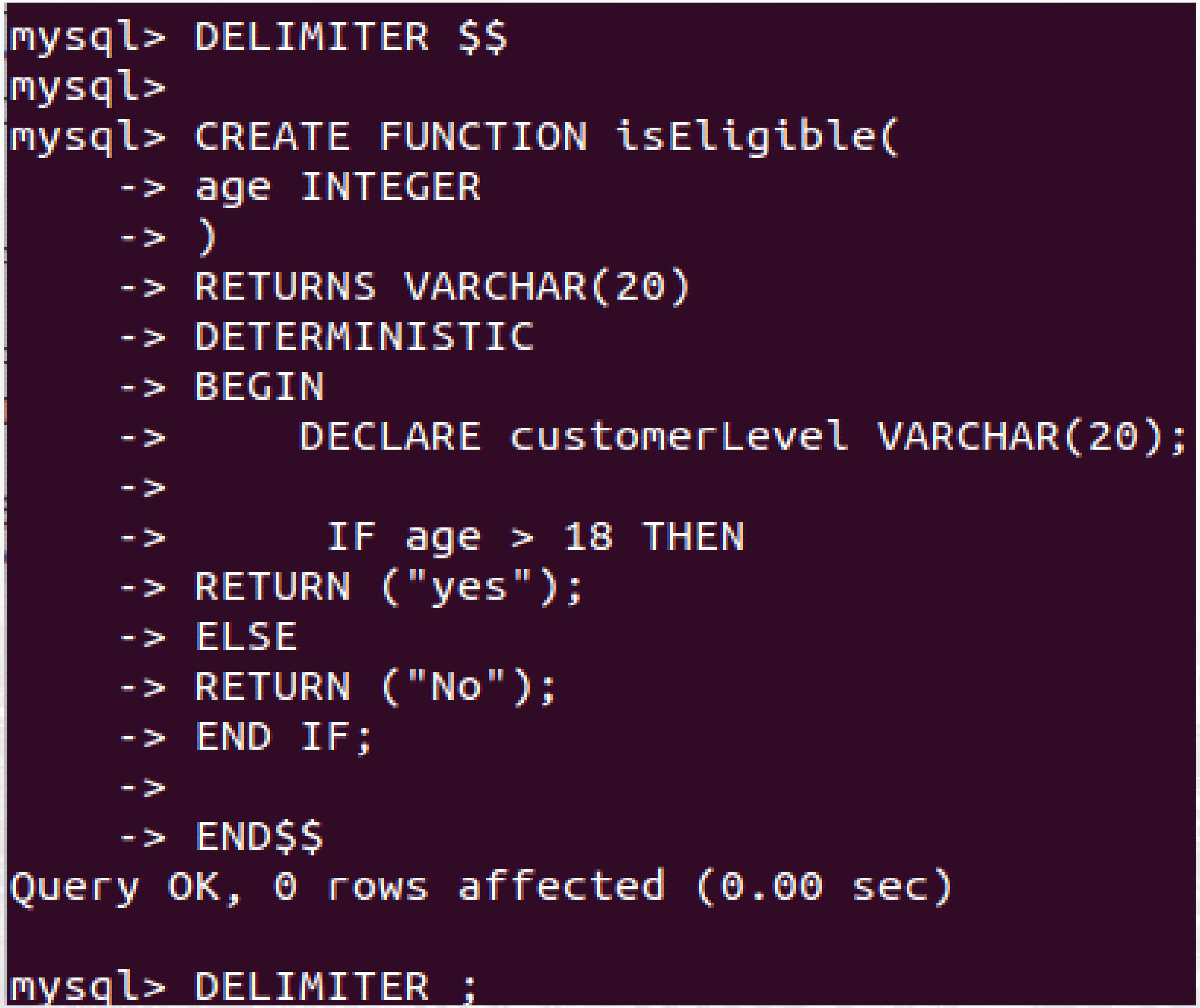


```
mysql> select * from employee;
+----+------+---------+--------+------------+-----+
| id | name | superid | salary | bdate      | dno |
+----+------+---------+--------+------------+-----+
|  1 | john |       3 | 100000 | 1960-01-01 |   1 |
|  2 | mary |       3 |  50000 | 1964-12-01 |   3 |
|  3 | 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 ;
```

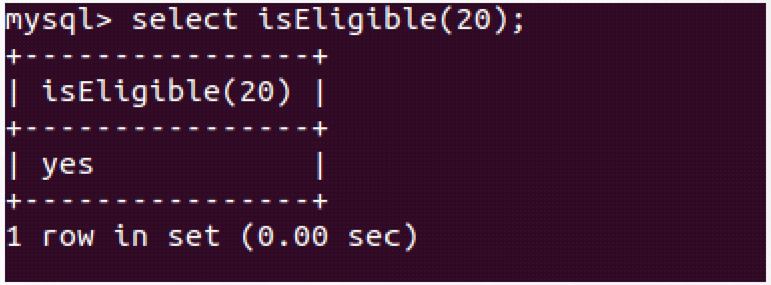
# Example 3 (cont..)



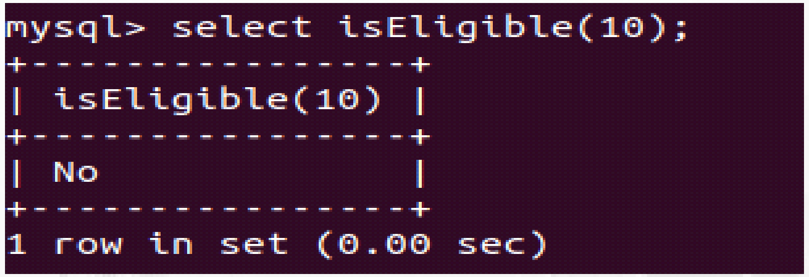
```
mysql> select name, salary, giveRaise(salary, 0.1) as newsal
    -> from employee;
+------+--------+--------+
| name | salary | newsal |
+------+--------+--------+
| john | 100000 | 110000 |
| mary |  50000 |  55000 |
| bob  |  80000 |  88000 |
| tom  |  50000 |  55000 |
| bill |   NULL |   NULL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



```
mysql> DELIMITER $$
mysql>
mysql> CREATE FUNCTION isEligible(
    -> age INTEGER
    -> )
    -> RETURNS VARCHAR(20)
    -> DETERMINISTIC
    -> BEGIN
    ->     DECLARE customerLevel VARCHAR(20);
    ->
    ->      IF age > 18 THEN
    -> RETURN ("yes");
    -> ELSE
    -> RETURN ("No");
    -> END IF;
    ->
    -> END$$
Query OK, 0 rows affected (0.00 sec)

mysql> DELIMITER ;
```

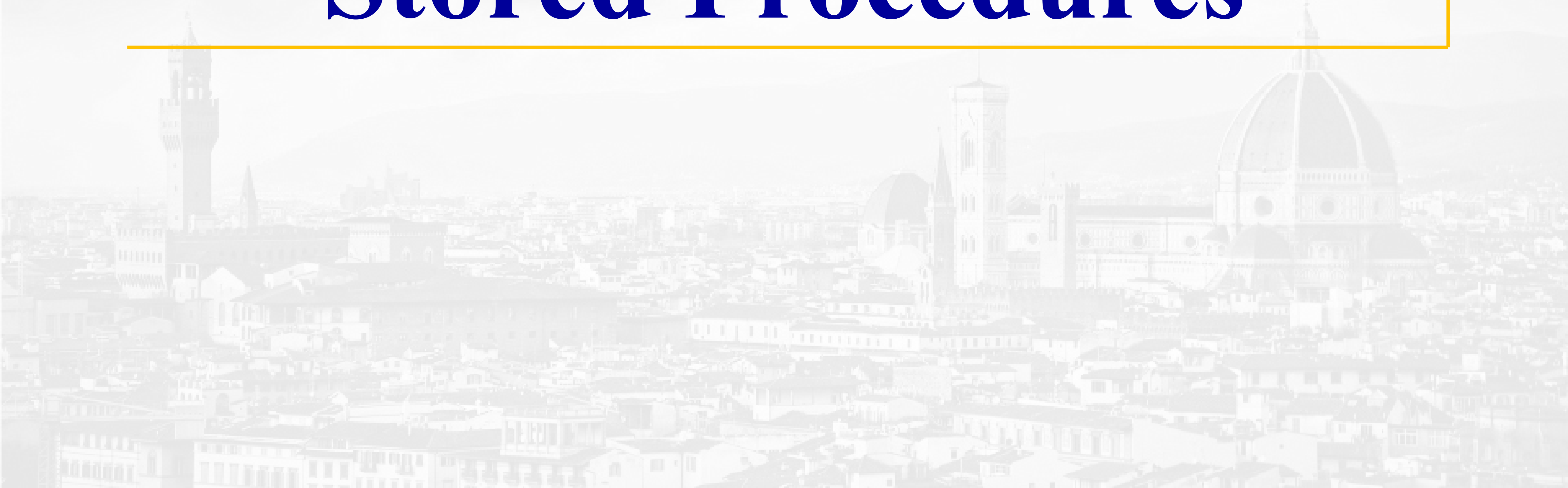


```
mysql> select isEligible(20);
+----------------+
| isEligible(20) |
+----------------+
| yes            |
+----------------+
1 row in set (0.00 sec)
```

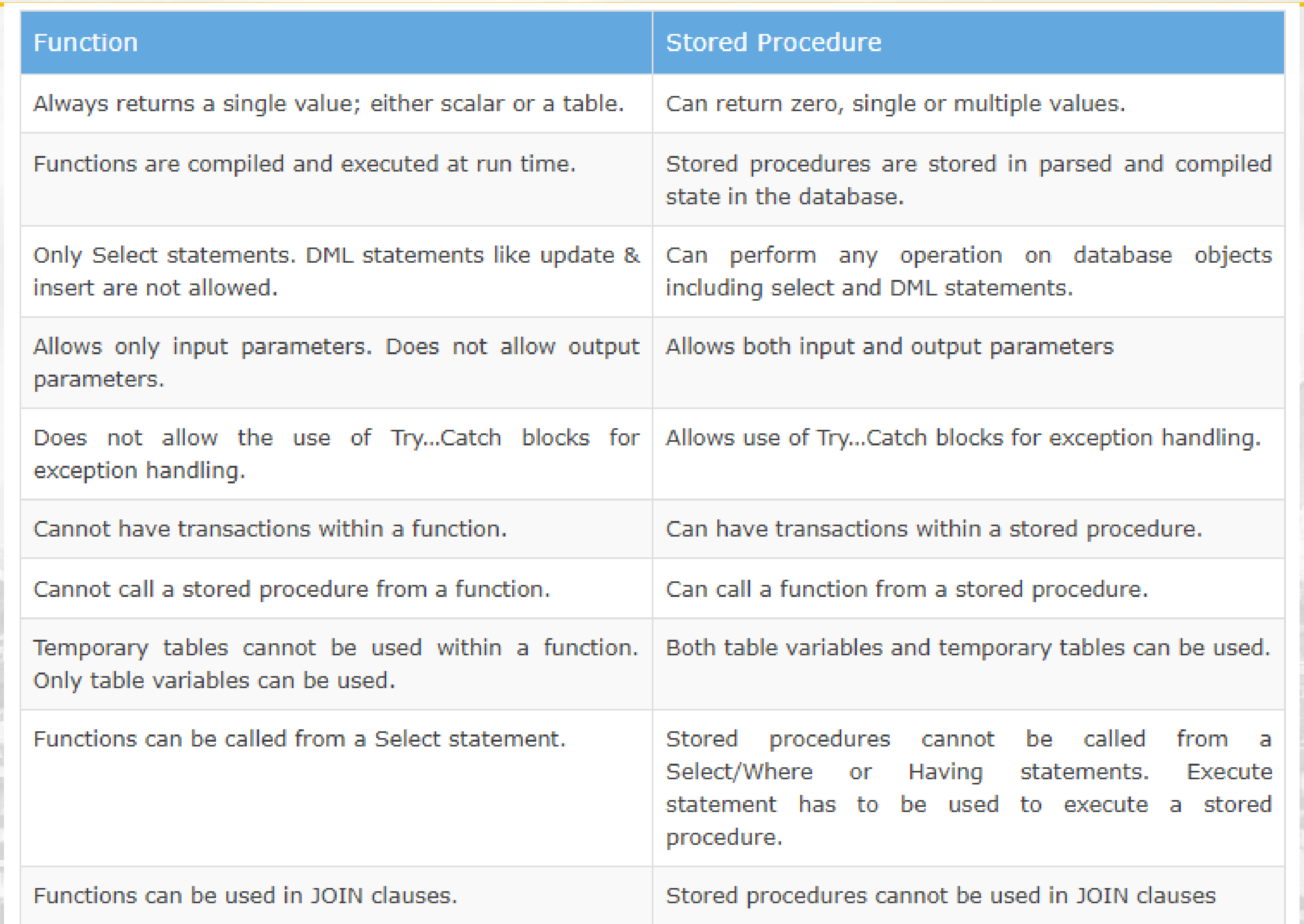


```
mysql> select isEligible(10);
+----------------+
| isEligible(10) |
+----------------+
| No             |
+----------------+
1 row in set (0.00 sec)
```

# Stored Procedures



# Stored Function Vs Stored Procedure



| Function | Stored Procedure |
|---|---|
| Always returns a single value; either scalar or a table. | Can return zero, single or multiple values. |
| Functions are compiled and executed at run time. | Stored procedures are stored in parsed and compiled state in the database. |
| Only Select statements. DML statements like update & insert are not allowed. | Can perform any operation on database objects including select and DML statements. |
| Allows only input parameters. Does not allow output parameters. | Allows both input and output parameters |
| Does not allow the use of Try...Catch blocks for exception handling. | Allows use of Try...Catch blocks for exception handling. |
| Cannot have transactions within a function. | Can have transactions within a stored procedure. |
| Cannot call a stored procedure from a function. | Can call a function from a stored procedure. |
| Temporary tables cannot be used within a function. Only table variables can be used. | Both table variables and temporary tables can be used. |
| Functions can be called from a Select statement. | Stored procedures cannot be called from a Select/Where or Having statements. Execute statement has to be used to execute a stored procedure. |
| Functions can be used in JOIN clauses. | Stored procedures cannot be used in JOIN clauses |

# 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_spec$_1$, param_spec$_2$,param_spec$_n$ )
begin
     -- execution code
end;
```

where each param_spec is of the form:

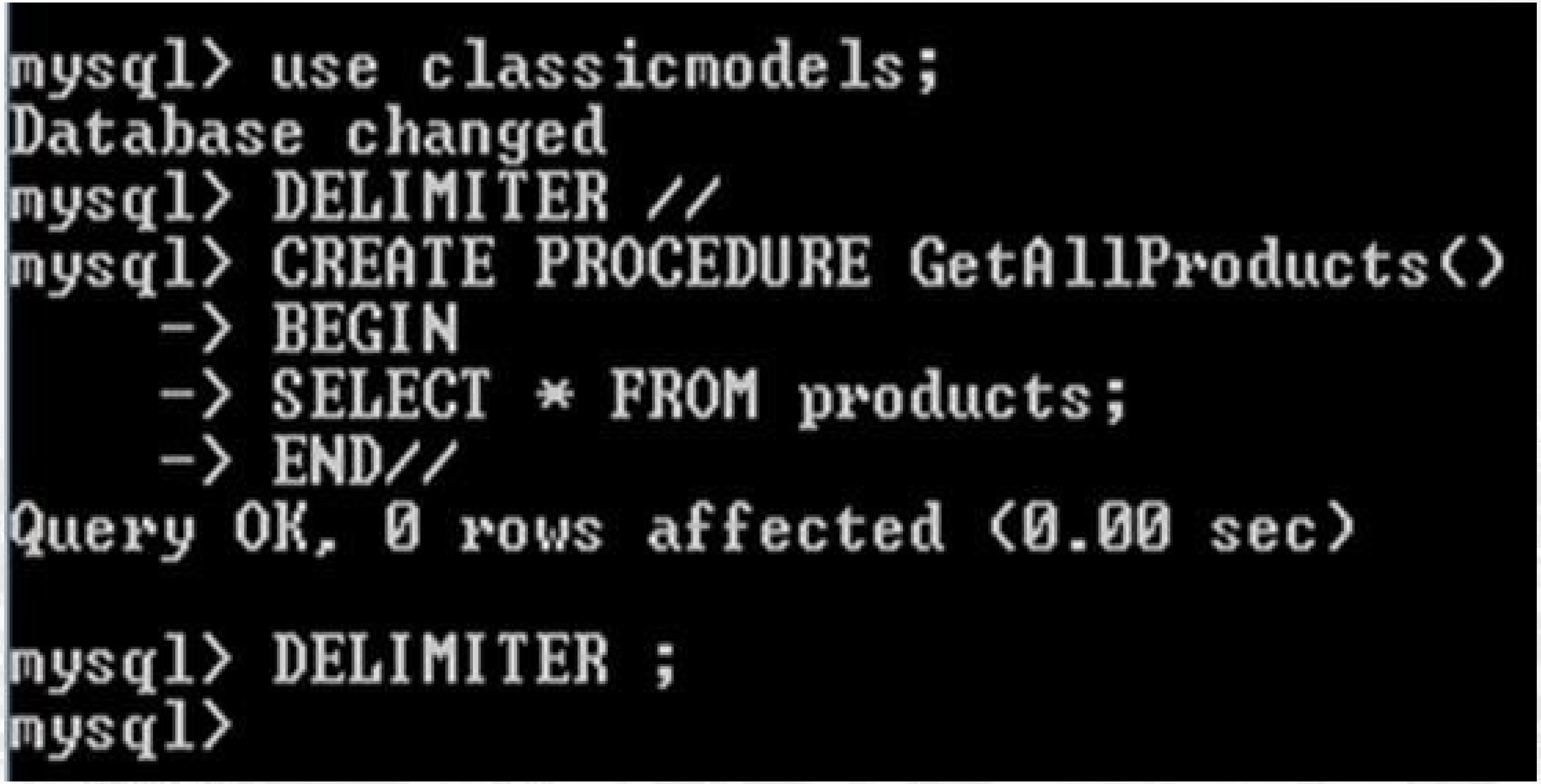
[in | out | inout] <param_name> <param_type>

- in mode: allows you to pass values into the procedure,
- out mode: allows you to pass value back from procedure to the calling program, initial value in the procedure is taken as null .

  Inout mode : allows you to pass value back from procedure to the calling program, initial value in the procedure is taken from the caller value

# Example 1 – No parameters

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



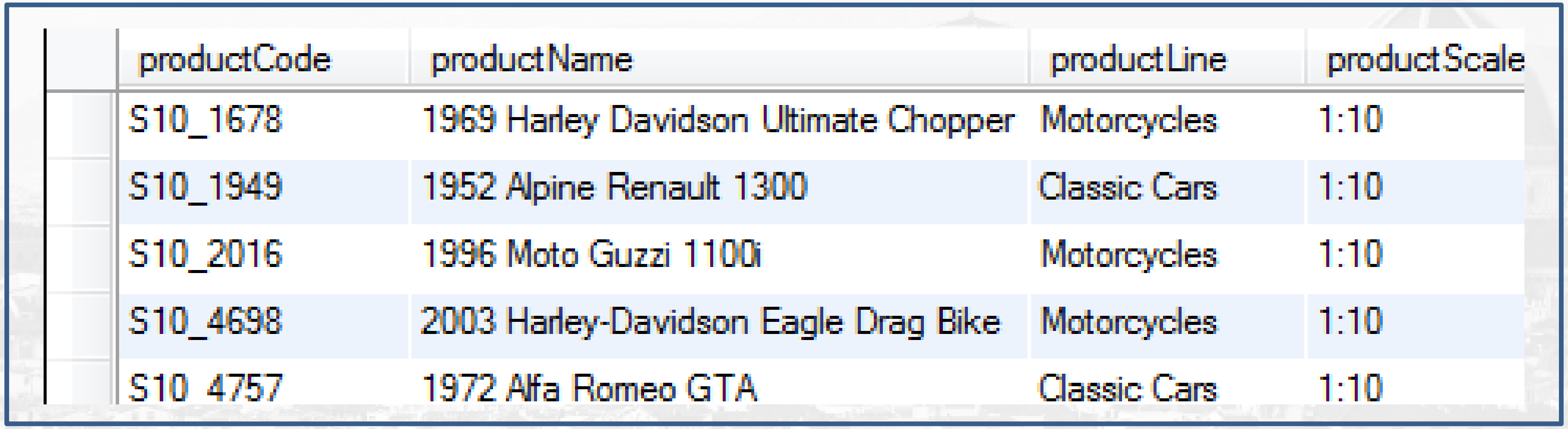
```
mysql> use classicmodels;
Database changed
mysql> DELIMITER //
mysql> CREATE PROCEDURE GetAllProducts()
    -> BEGIN
    -> SELECT * FROM products;
    -> END//
Query OK, 0 rows affected (0.00 sec)

mysql> DELIMITER ;
mysql>
```

# Example 1 (Cont..)

- **Calling Procedure:**

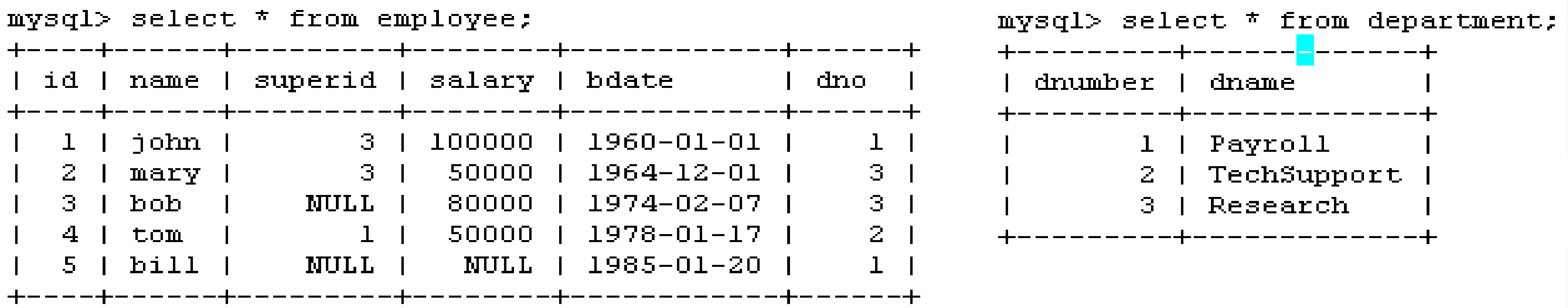
```
CALL GetAllProducts();
```

- **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 |

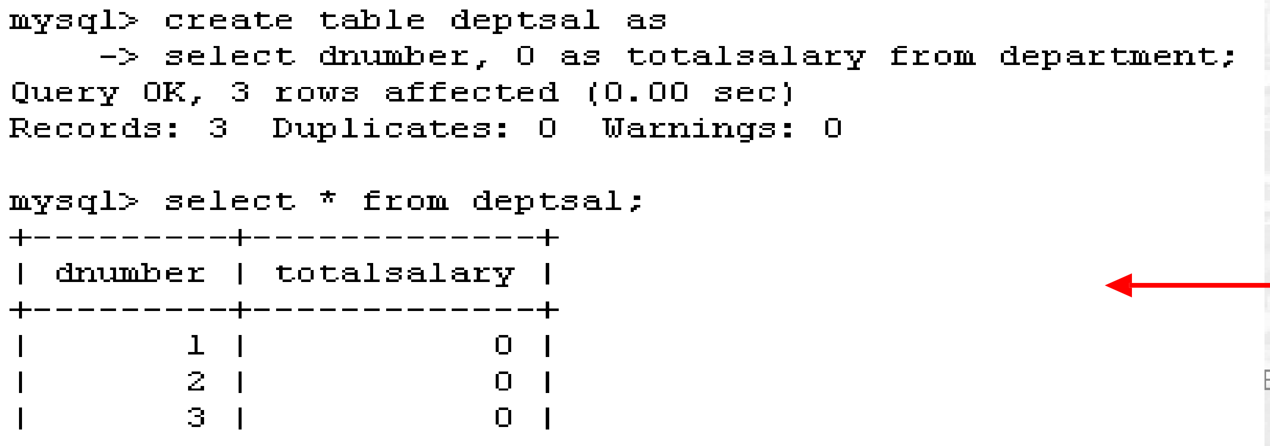
# Example 2 ( with IN parameter)



```
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    |
+---------+-------------+
```

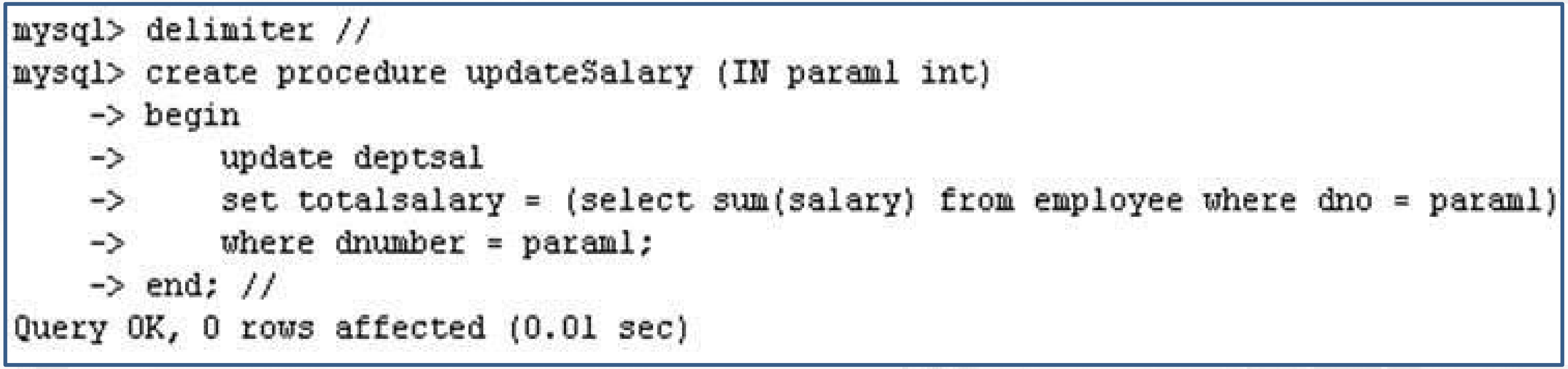
- Suppose we want to keep track of the total salaries of employees working for each department



```
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..)

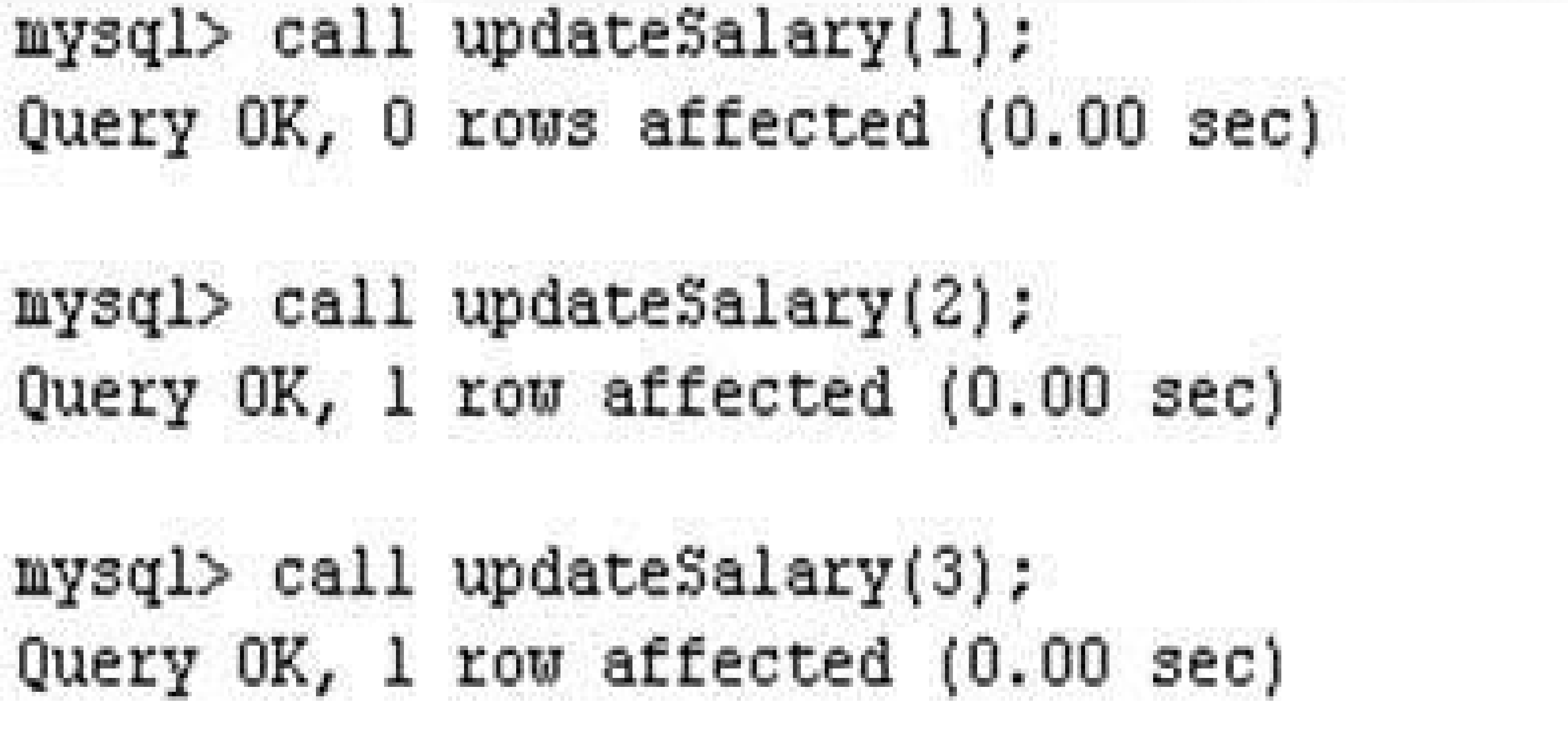


```
mysql> delimiter //
mysql> create procedure updateSalary (IN param1 int)
    -> begin
    ->     update deptsal
    ->     set totalsalary = (select sum(salary) from employee where dno = param1)
    ->     where dnumber = param1;
    -> end; //
Query OK, 0 rows affected (0.01 sec)
```

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..)

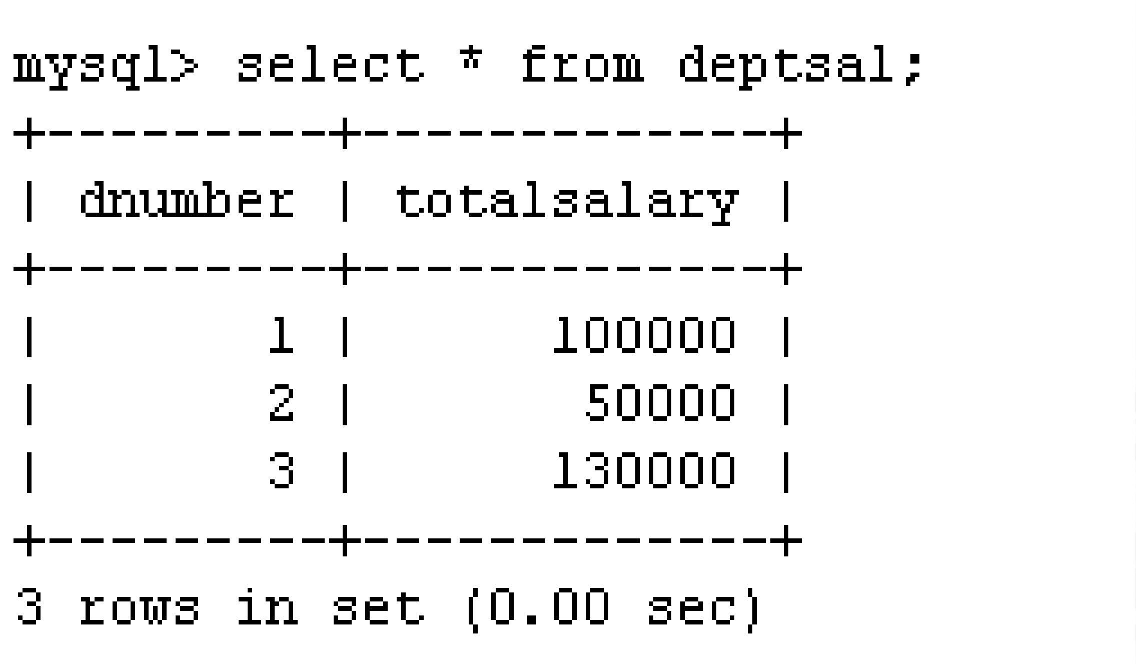
**Step 3: Call the procedure to update the totalsalary for each department**



```
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)
```

- To see the result type the following command

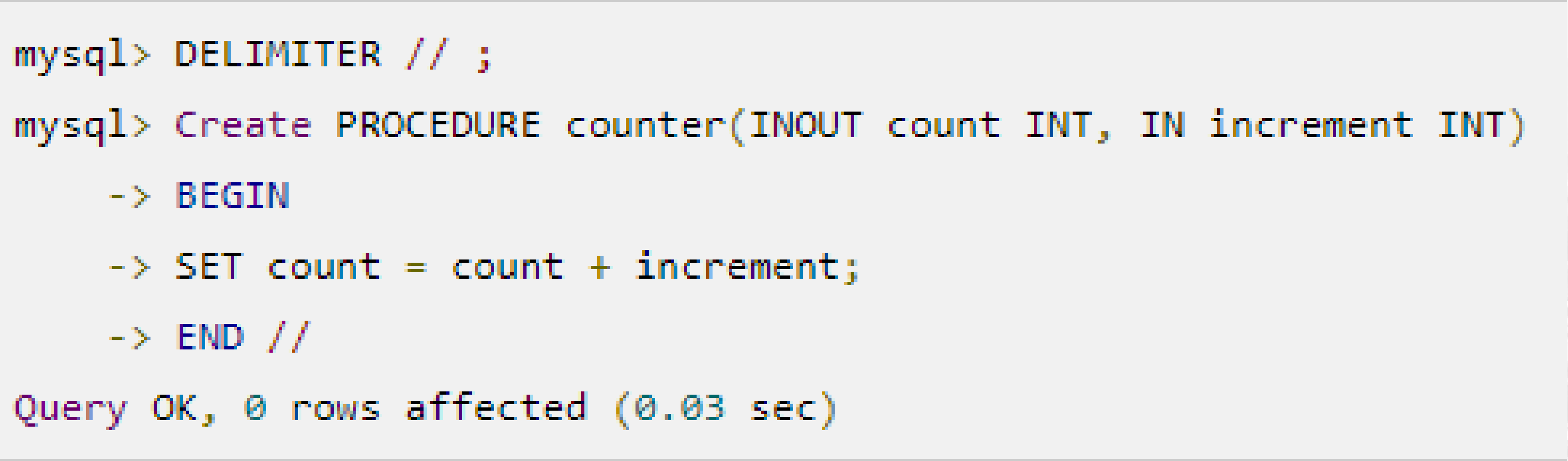
```
mysql< SELECT @M$$
```

- **Output:**

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

# Example 4 (with INOUT Parameter)

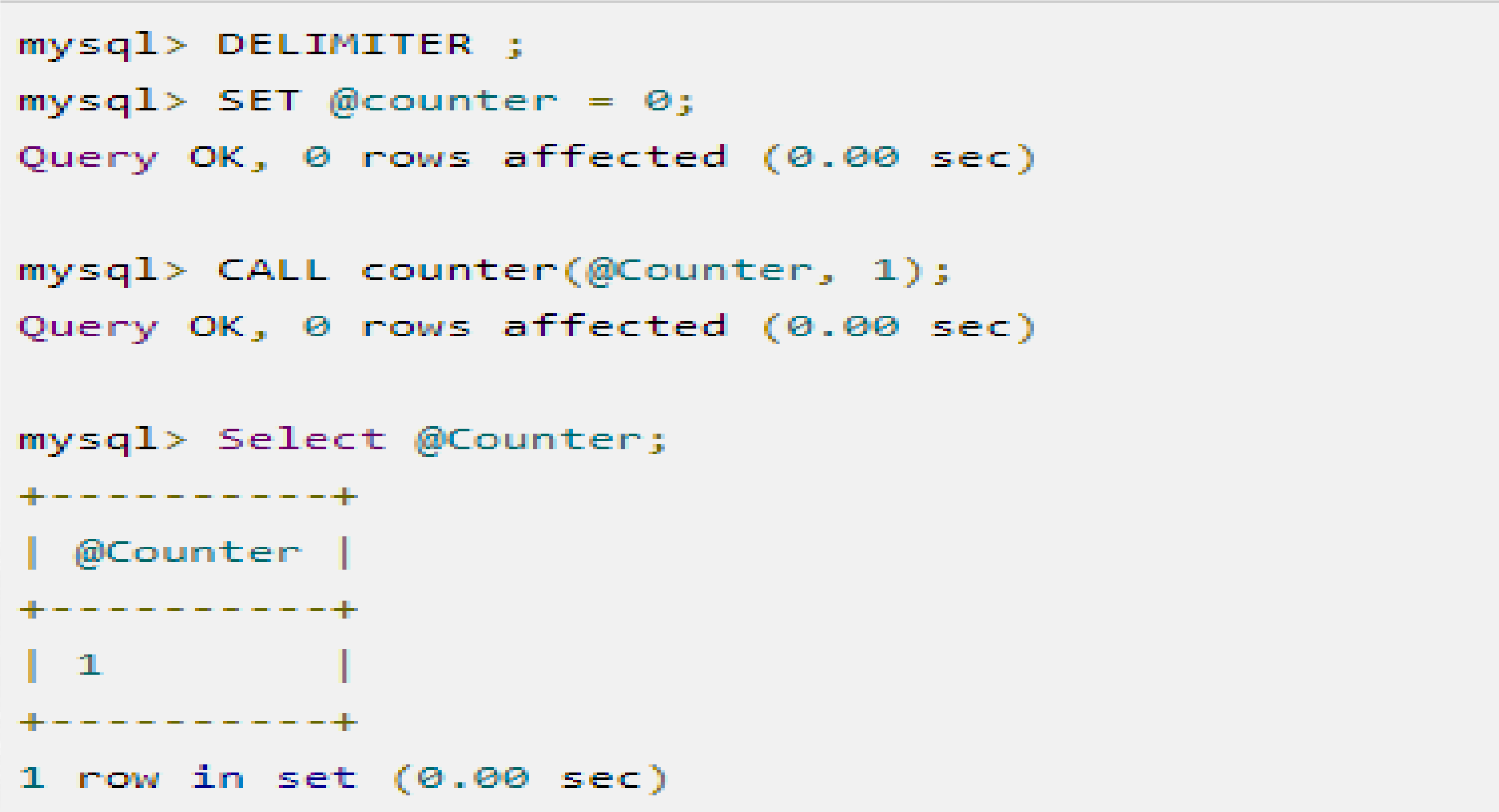
- The following example shows a simple stored procedure that uses an INOUT parameter.
- ‘count’ is the INOUT parameter, which can store and return values and ‘increment’ is the IN parameter, which accepts the values from user.



```
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..)

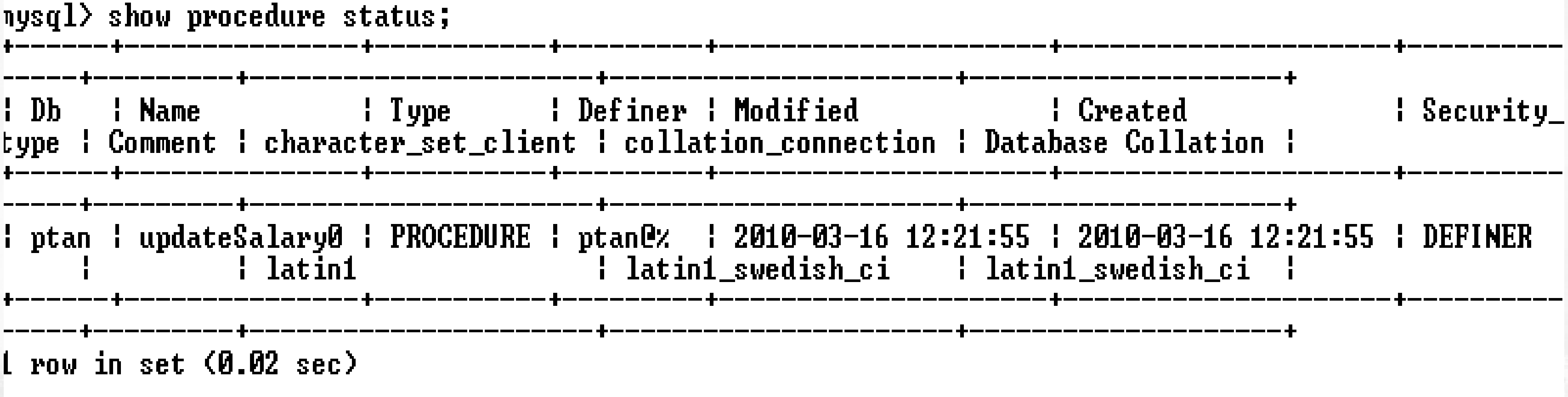
**Function Call:**



```
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)
```

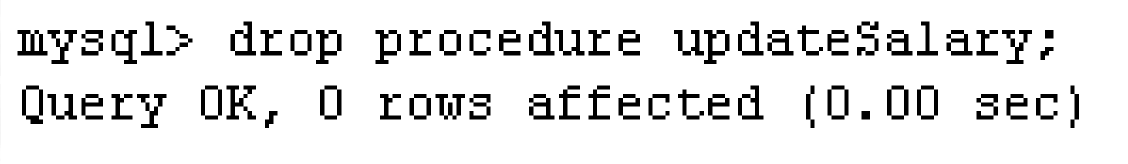
# Stored Procedures (Cont..)

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



```
nysql> 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  |
+------+---------------+-----------+---------+---------------------+---------------------+----------
-----+---------+----------------------+----------------------+--------------------+
l 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.

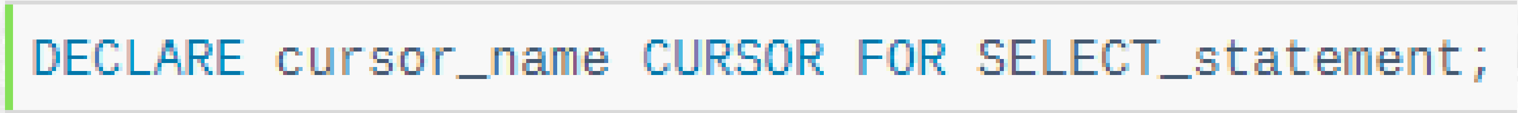
```
loop_label:       LOOP
IF          x > 10 THEN
      LEAVE
loop_label; END  IF;
SET        x = x + 1;
IF          (x mod 2)
THEN ITERATE
loop_label; ELSE
              SET       str = CONCAT(str,x,',');
END       IF;
        END LOOP;
```

# 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:

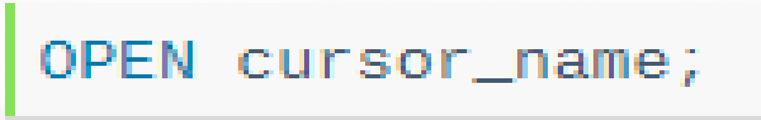


```
DECLARE cursor_name CURSOR FOR SELECT_statement;
```

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

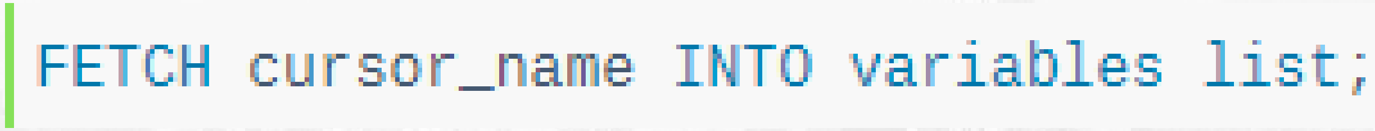
# Cursors

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



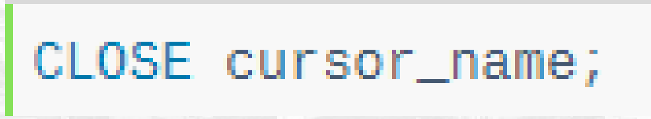
```
OPEN cursor_name;
```

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;
```

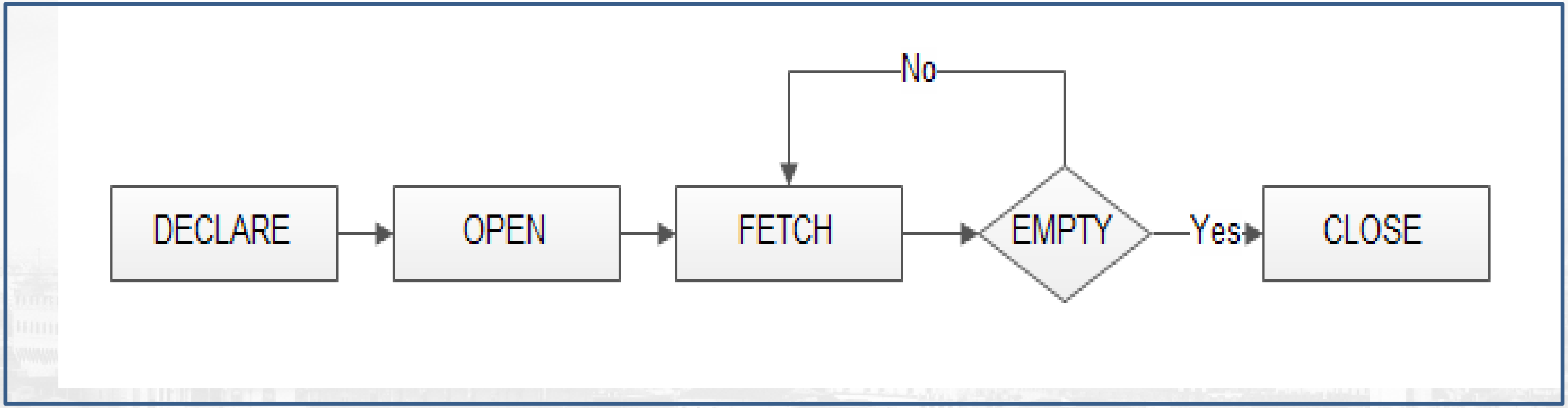
4. Finally, call the CLOSE statement to deactivate the cursor and release the memory associated with it as follows:



```
CLOSE cursor_name;
```

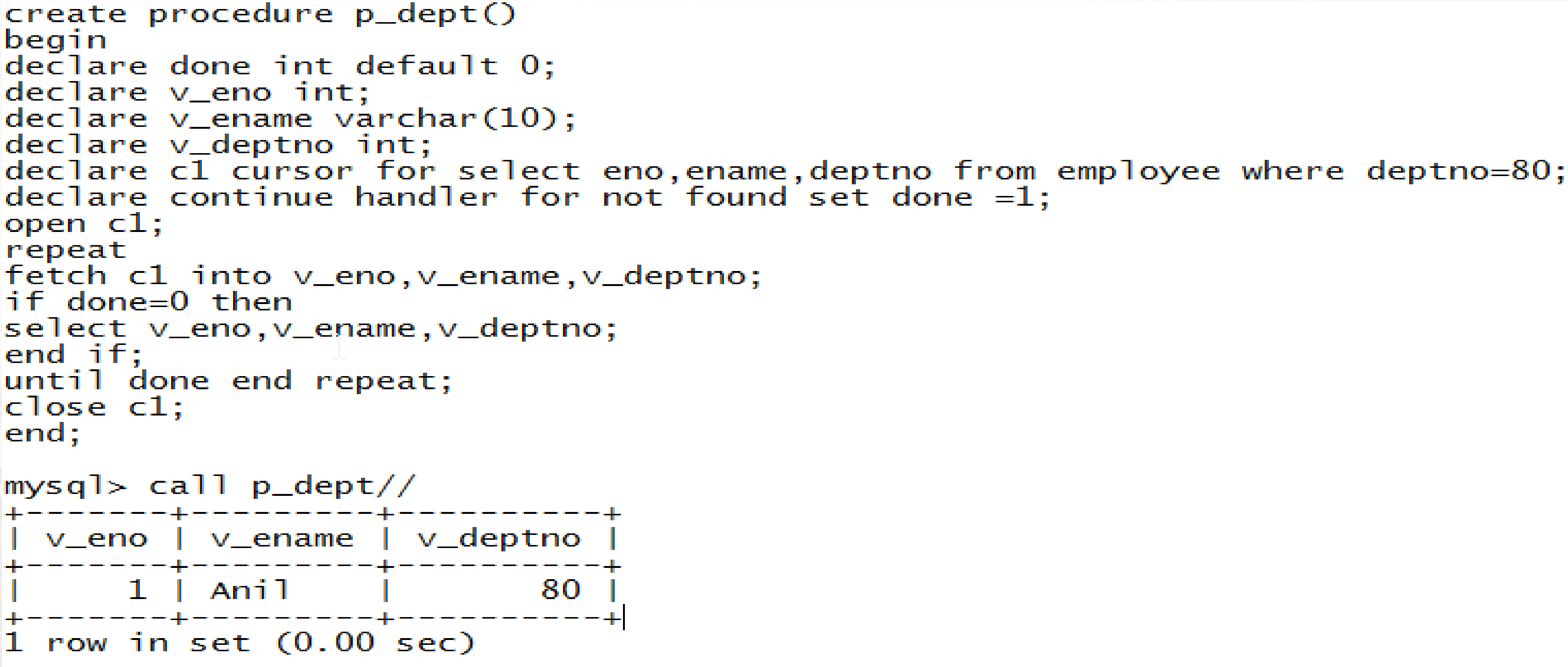
# Cursors

The following diagram illustrates how MySQL cursor works.



# Example 1 - Cursors

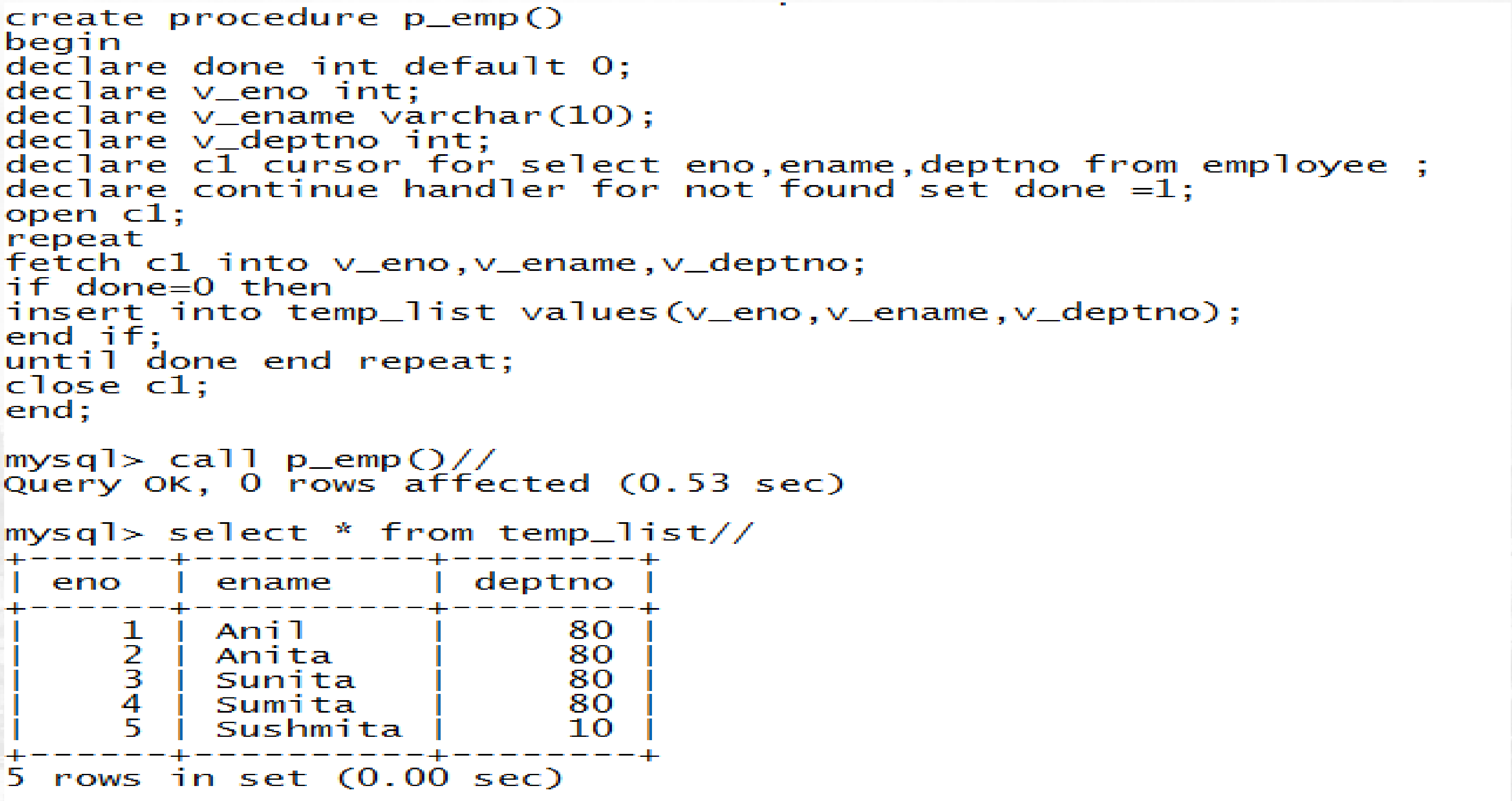
1) Retrieve employees one by one and print out a list of those employees currently working in the DEPARTMENT_ID = 80



```
create procedure p_dept()
begin
declare done int default 0;
declare v_eno int;
declare v_ename varchar(10);
declare v_deptno int;
declare c1 cursor for select eno,ename,deptno from employee where deptno=80;
declare continue handler for not found set done =1;
open c1;
repeat
fetch c1 into v_eno,v_ename,v_deptno;
if done=0 then
select v_eno,v_ename,v_deptno;
end if;
until done end repeat;
close c1;
end;

mysql> call p_dept//
+-------+----------+----------+
| v_eno | v_ename  | v_deptno |
+-------+----------+----------+
|     1 | Anil     |       80 |
+-------+----------+----------+
1 row in set (0.00 sec)
```

# Example 2

2) **Use a cursor to retrieve employee numbers and names from employee table and populate a database table, TEMP_LIST, with this information.**

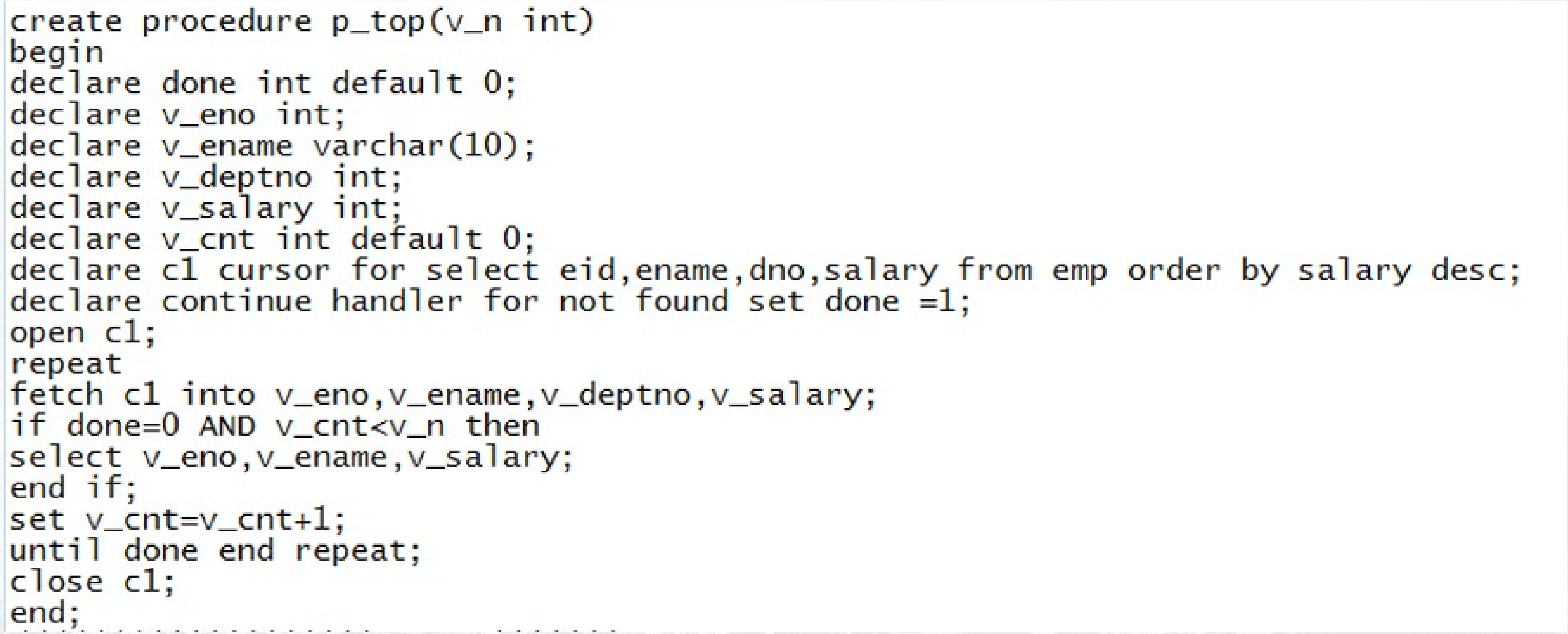


```
create procedure p_emp()
begin
declare done int default 0;
declare v_eno int;
declare v_ename varchar(10);
declare v_deptno int;
declare c1 cursor for select eno,ename,deptno from employee ;
declare continue handler for not found set done =1;
open c1;
repeat
fetch c1 into v_eno,v_ename,v_deptno;
if done=0 then
insert into temp_list values(v_eno,v_ename,v_deptno);
end if;
until done end repeat;
close c1;
end;

mysql> call p_emp()//
Query OK, 0 rows affected (0.53 sec)

mysql> select * from temp_list//
+-------+-----------+---------+
| eno   | ename     | deptno  |
+-------+-----------+---------+
|     1 | Anil      |      80 |
|     2 | Anita     |      80 |
|     3 | Sunita    |      80 |
|     4 | Sumita    |      80 |
|     5 | Sushmita  |      10 |
+-------+-----------+---------+
5 rows in set (0.00 sec)
```

# Example 3

3. Create a PL/SQL block that determines the top employees with respect to salaries. Accept a number n from the user where n represents the number of top n earners from the EMPLOYEES table. For example, to view the top five earners, enter 5. Test a variety of special cases, such as n = 0 or where n is greater than the number of employees in the EMPLOYEES table. The output shown represents the five highest salaries in the EMPLOYEES table.

# Cont..

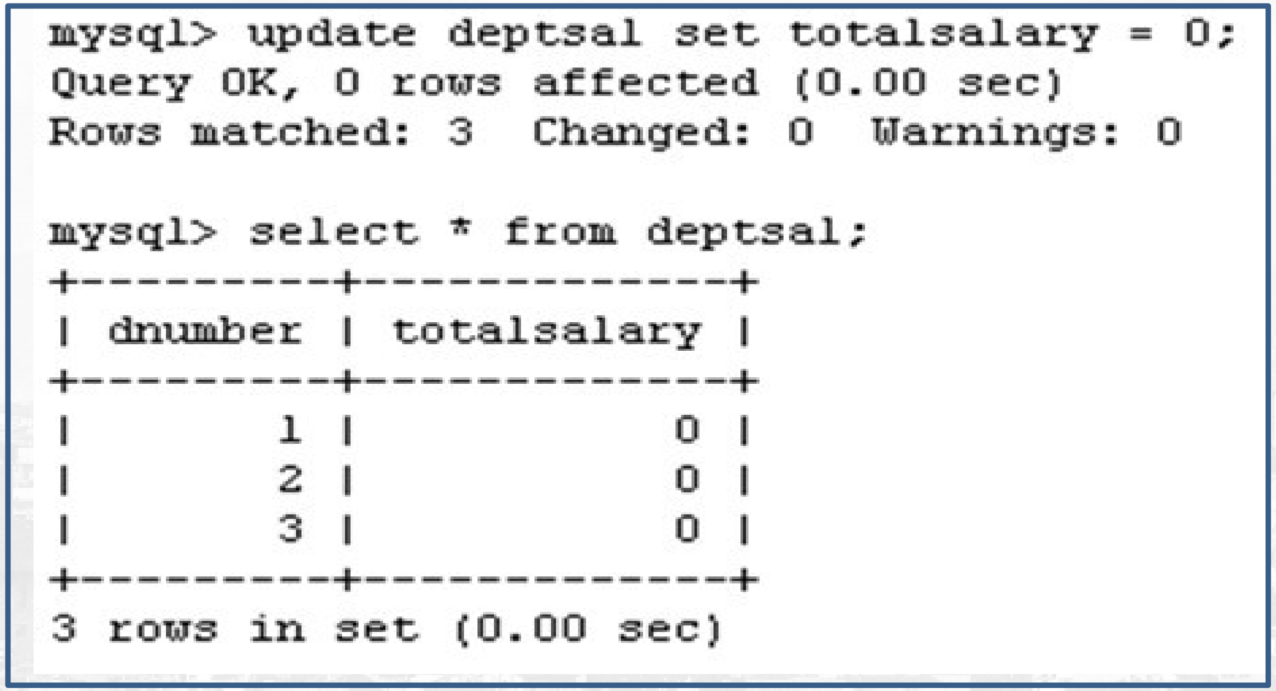


```
create procedure p_top(v_n int)
begin
declare done int default 0;
declare v_eno int;
declare v_ename varchar(10);
declare v_deptno int;
declare v_salary int;
declare v_cnt int default 0;
declare c1 cursor for select eid,ename,dno,salary from emp order by salary desc;
declare continue handler for not found set done =1;
open c1;
repeat
fetch c1 into v_eno,v_ename,v_deptno,v_salary;
if done=0 AND v_cnt<v_n then
select v_eno,v_ename,v_salary;
end if;
set v_cnt=v_cnt+1;
until done end repeat;
close c1;
end;
```

# Example 4

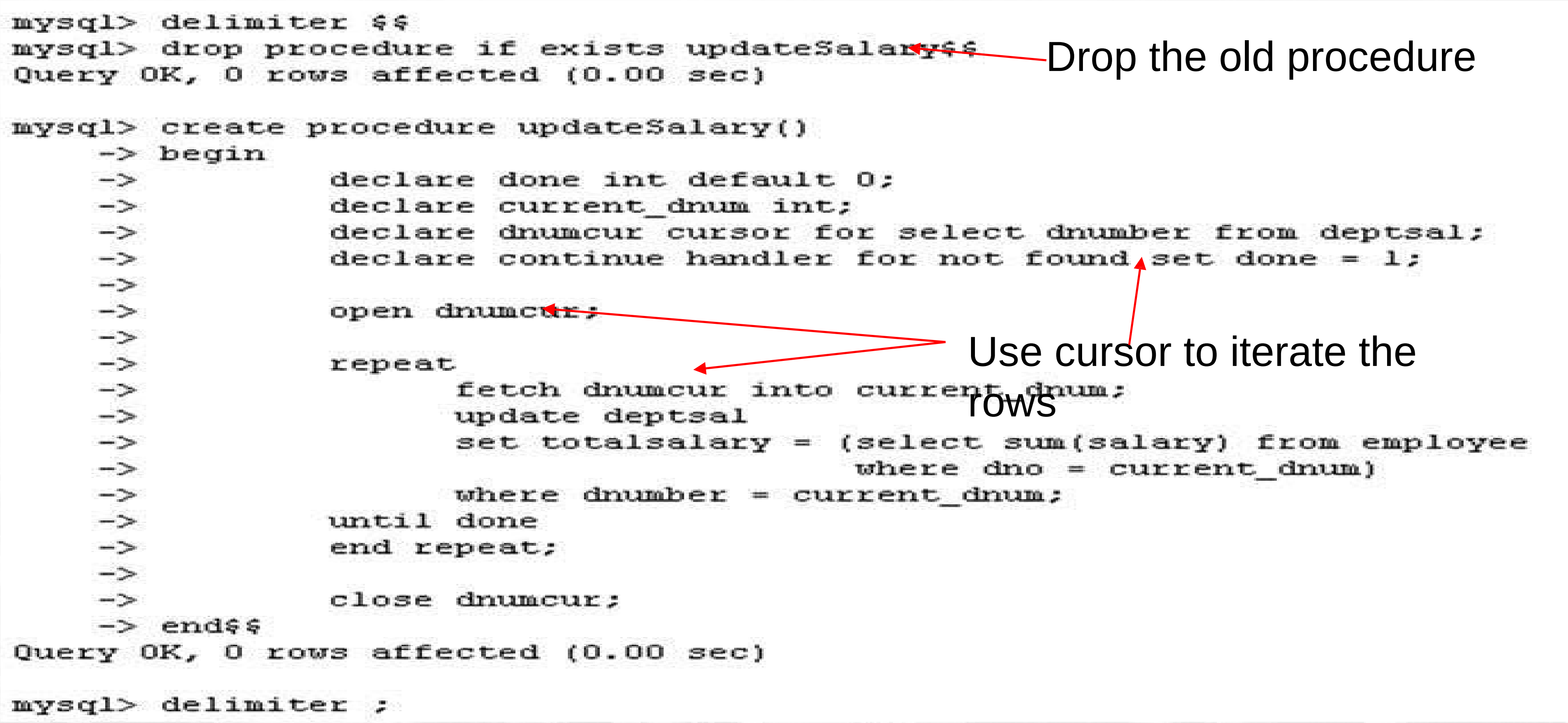
4. **Update all the rows in deptsal simultaneously.**

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)
```

# Cont..



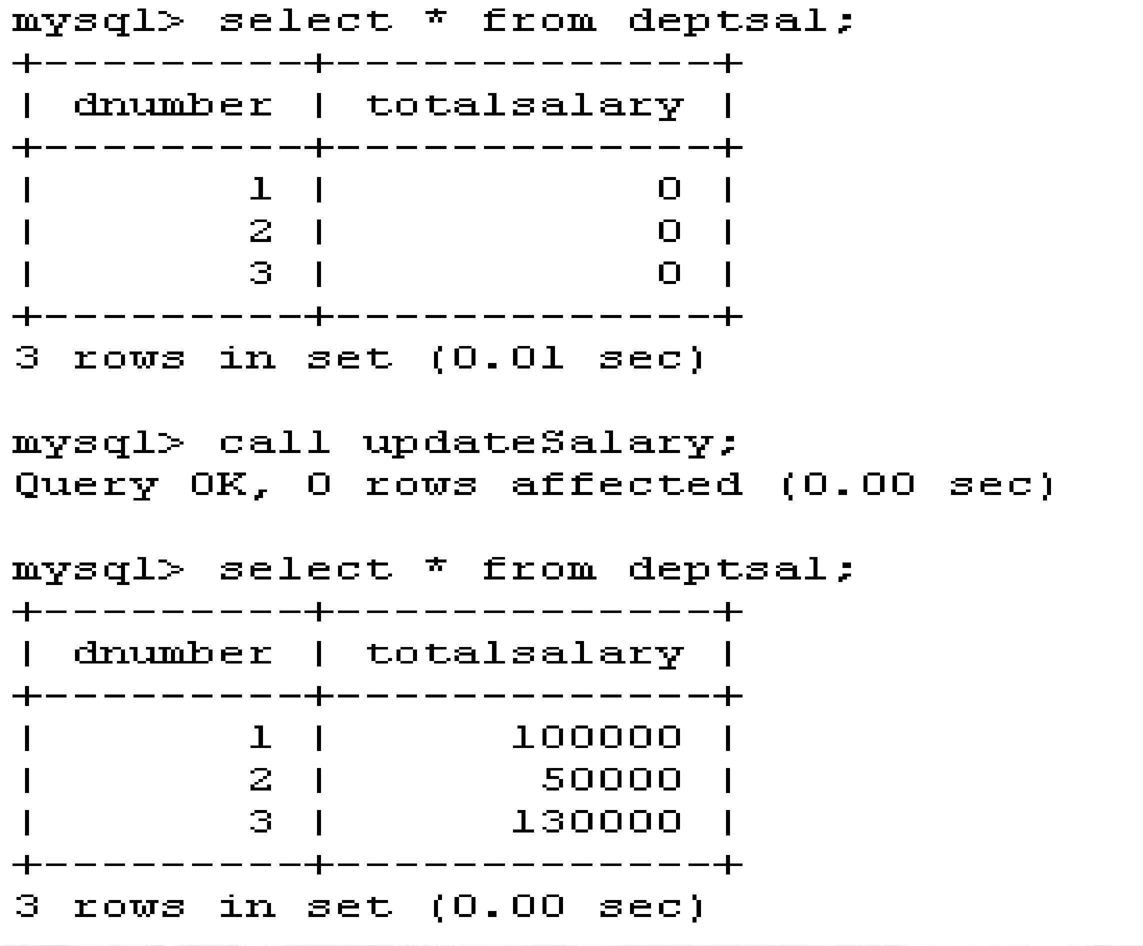
```
mysql> delimiter $$
mysql> drop procedure if exists updateSalary$$
Query OK, 0 rows affected (0.00 sec)

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

# Cont..

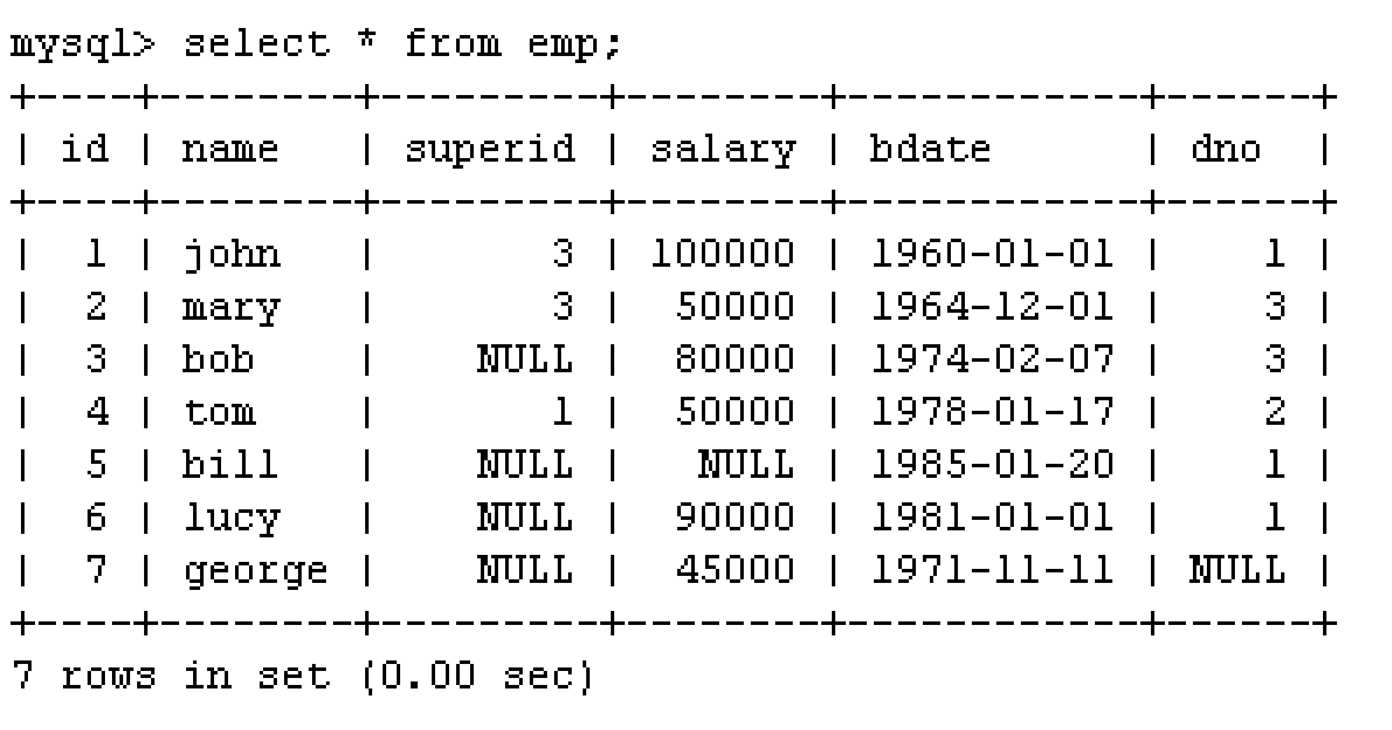
- Call procedure :



```
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)
```

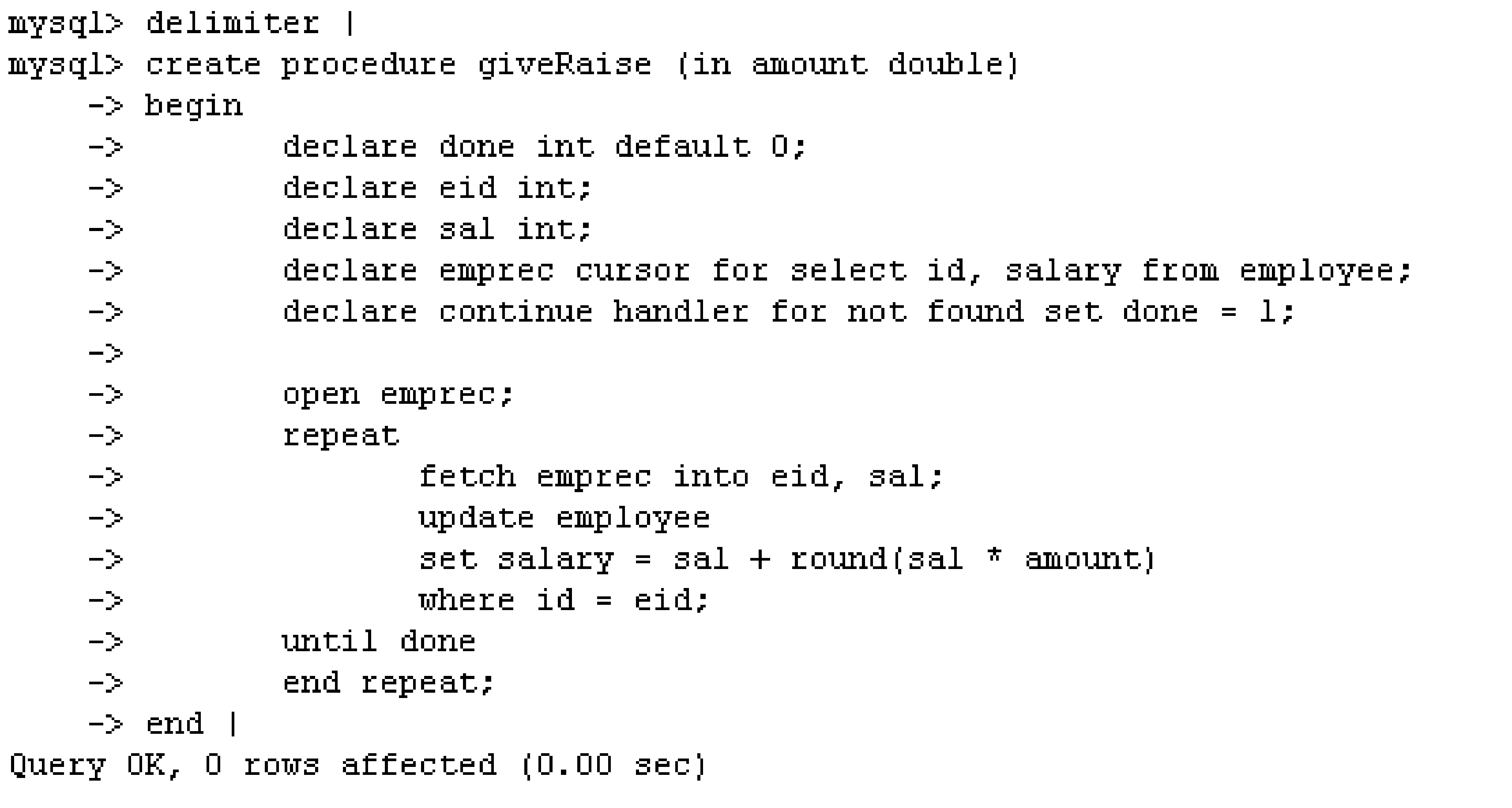
# Example 5

5. **Create a procedure to give a rise to all employees**



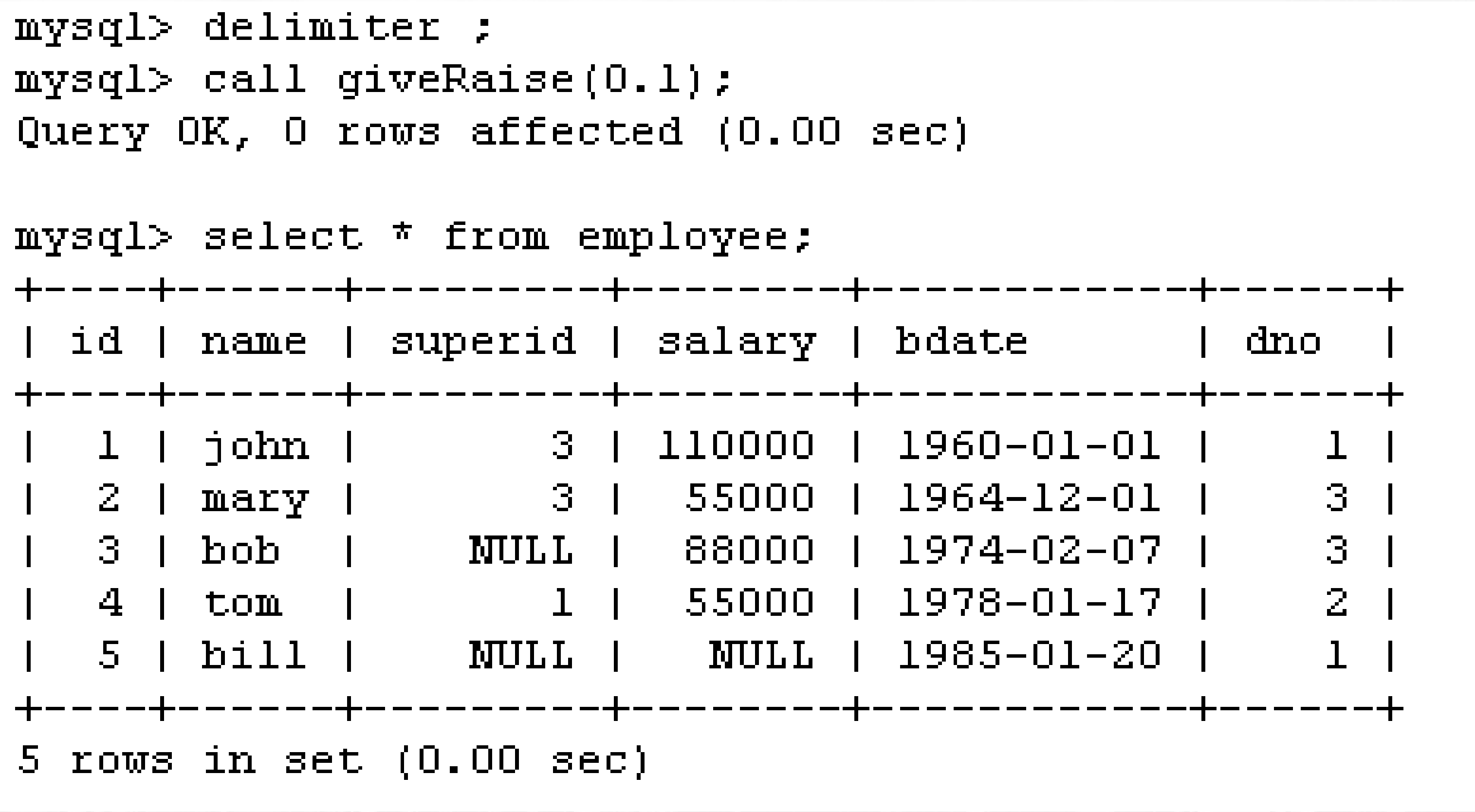
```
mysql> select * from emp;
+----+--------+---------+--------+------------+------+
| id | name   | superid | salary | bdate      | dno  |
+----+--------+---------+--------+------------+------+
|  1 | john   |       3 | 100000 | 1960-01-01 |    1 |
|  2 | mary   |       3 |  50000 | 1964-12-01 |    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)
```

# 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)
```

# 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)
```

# Triggers

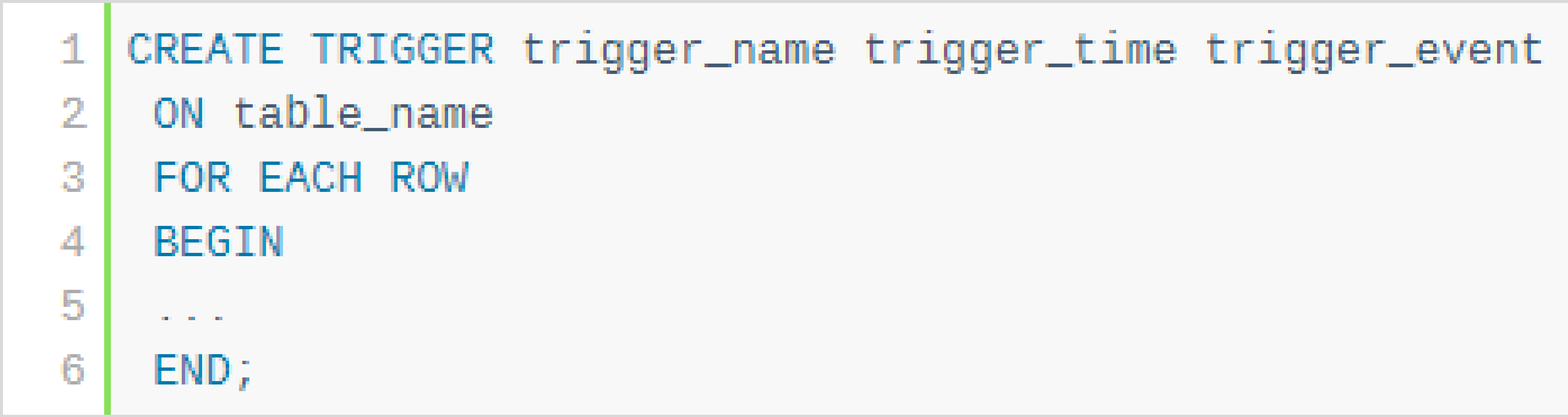
# Triggers

- 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.

# MySQL Trigger Syntax



```
CREATE TRIGGER trigger_name trigger_time trigger_event
 ON table_name
 FOR EACH ROW
 BEGIN
 ...
 END;
```

# Cont..

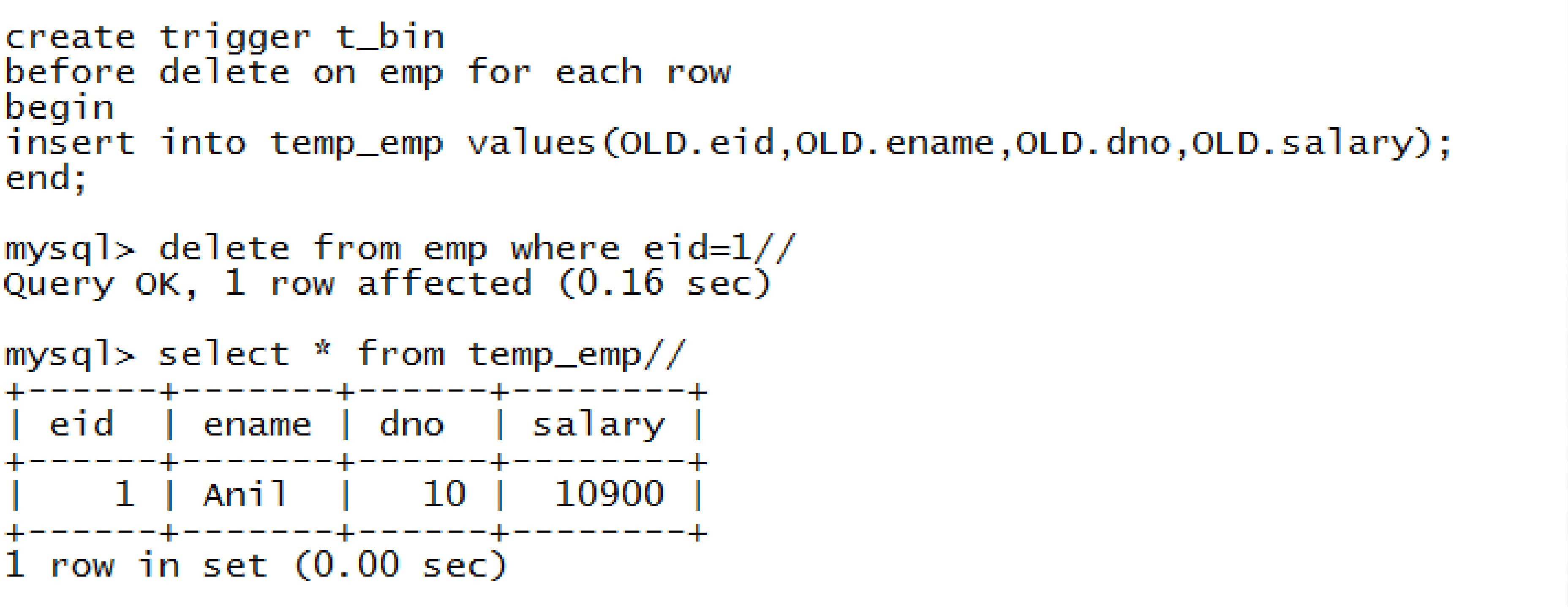
- In a trigger defined for INSERT, you can use NEW keyword only. You cannot use the OLD keyword.
- However, in the trigger defined for DELETE, there is no new row so you can use the OLD keyword only.
- In the UPDATE trigger, OLD refers to the row before it is updated and NEW refers to the row after it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

# Example 1 - Trigger

1. Create a trigger to simulate Recycle Bin for employee table. If any row gets deleted from Emp, same row must get stored in temp_emp

**Emp(Eno,Ename,Salary)**

**temp_emp(Eno,Ename,Salary)**

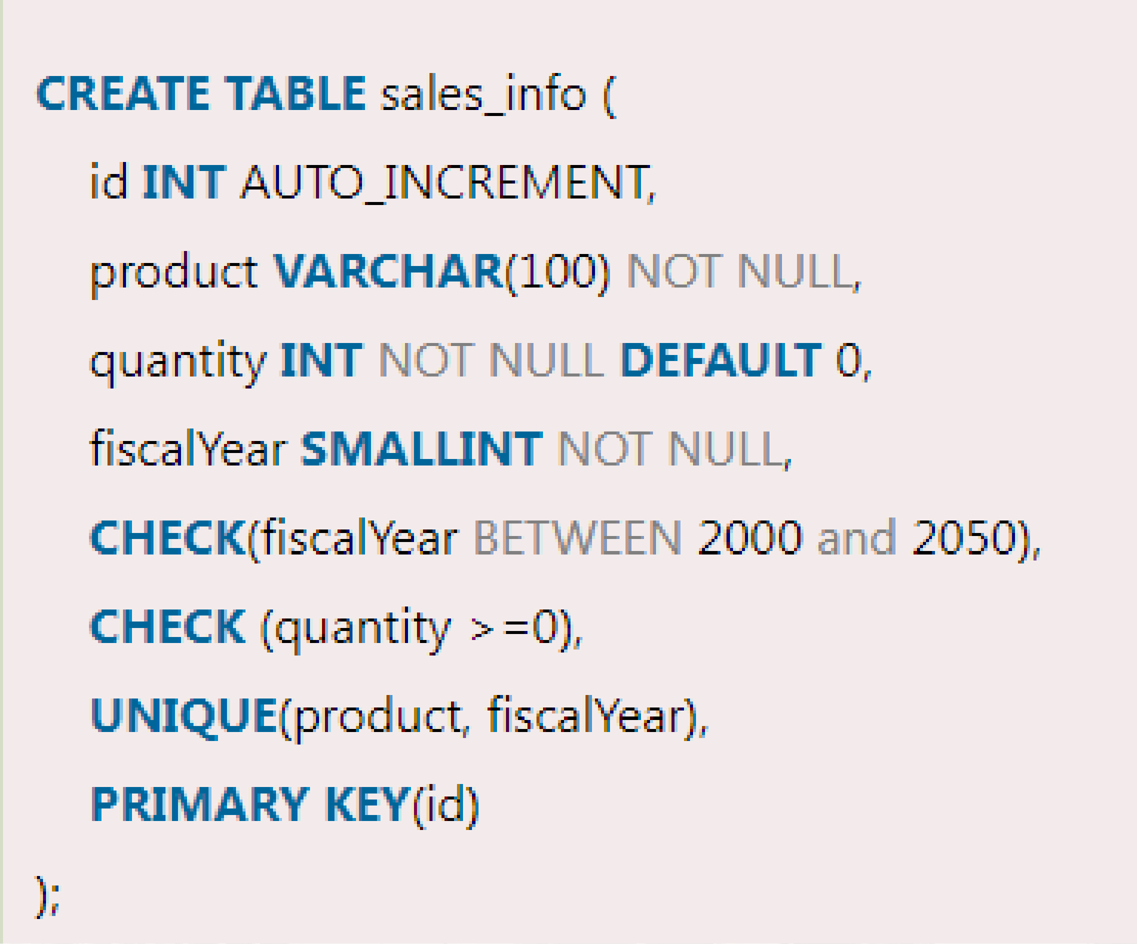


```
create trigger t_bin
before delete on emp for each row
begin
insert into temp_emp values(OLD.eid,OLD.ename,OLD.dno,OLD.salary);
end;

mysql> delete from emp where eid=1//
Query OK, 1 row affected (0.16 sec)

mysql> select * from temp_emp//
+------+--------+------+--------+
| eid  | ename  | dno  | salary |
+------+--------+------+--------+
|    1 | Anil   |   10 |  10900 |
+------+--------+------+--------+
1 row in set (0.00 sec)
```

# Example 2

2. **Create a BEFORE UPDATE trigger that is invoked before a change is made to the table.**

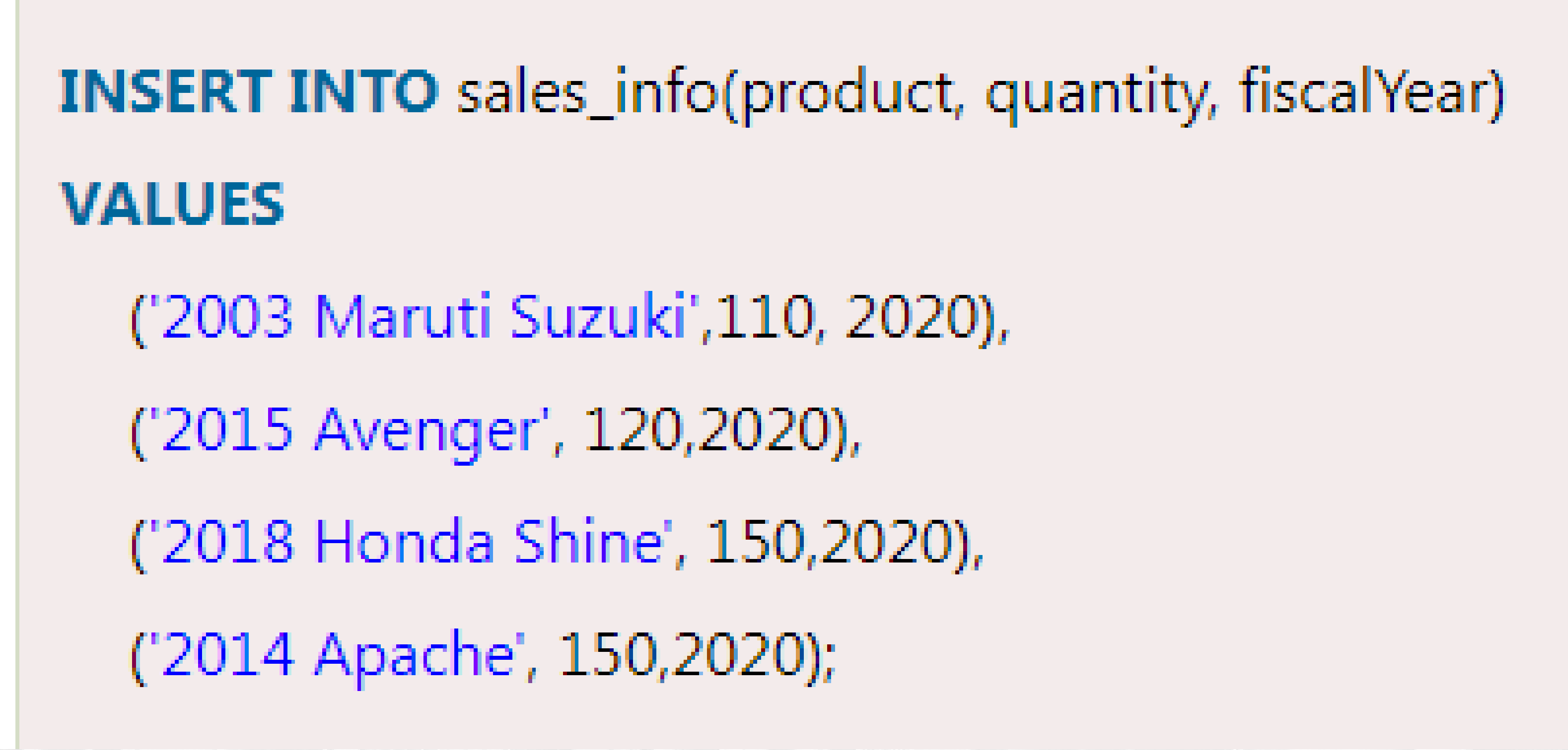
   Suppose we have created a table named **sales_info** as follows:



```
CREATE TABLE sales_info (
    id INT AUTO_INCREMENT,
    product VARCHAR(100) NOT NULL,
    quantity INT NOT NULL DEFAULT 0,
    fiscalYear SMALLINT NOT NULL,
    CHECK(fiscalYear BETWEEN 2000 and 2050),
    CHECK (quantity >=0),
    UNIQUE(product, fiscalYear),
    PRIMARY KEY(id)
);
```

# Contd..

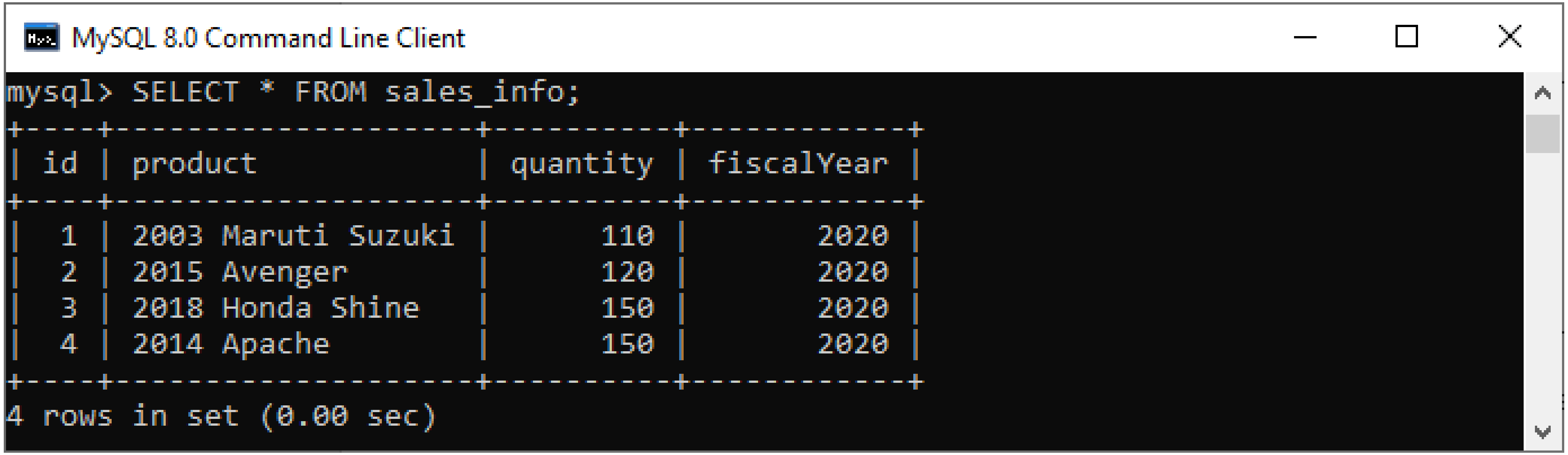
Next, we will insert some records into the sales_info table as follows:



```
INSERT INTO sales_info(product, quantity, fiscalYear)
VALUES
    ('2003 Maruti Suzuki',110, 2020),
    ('2015 Avenger', 120,2020),
    ('2018 Honda Shine', 150,2020),
    ('2014 Apache', 150,2020);
```

# Contd..

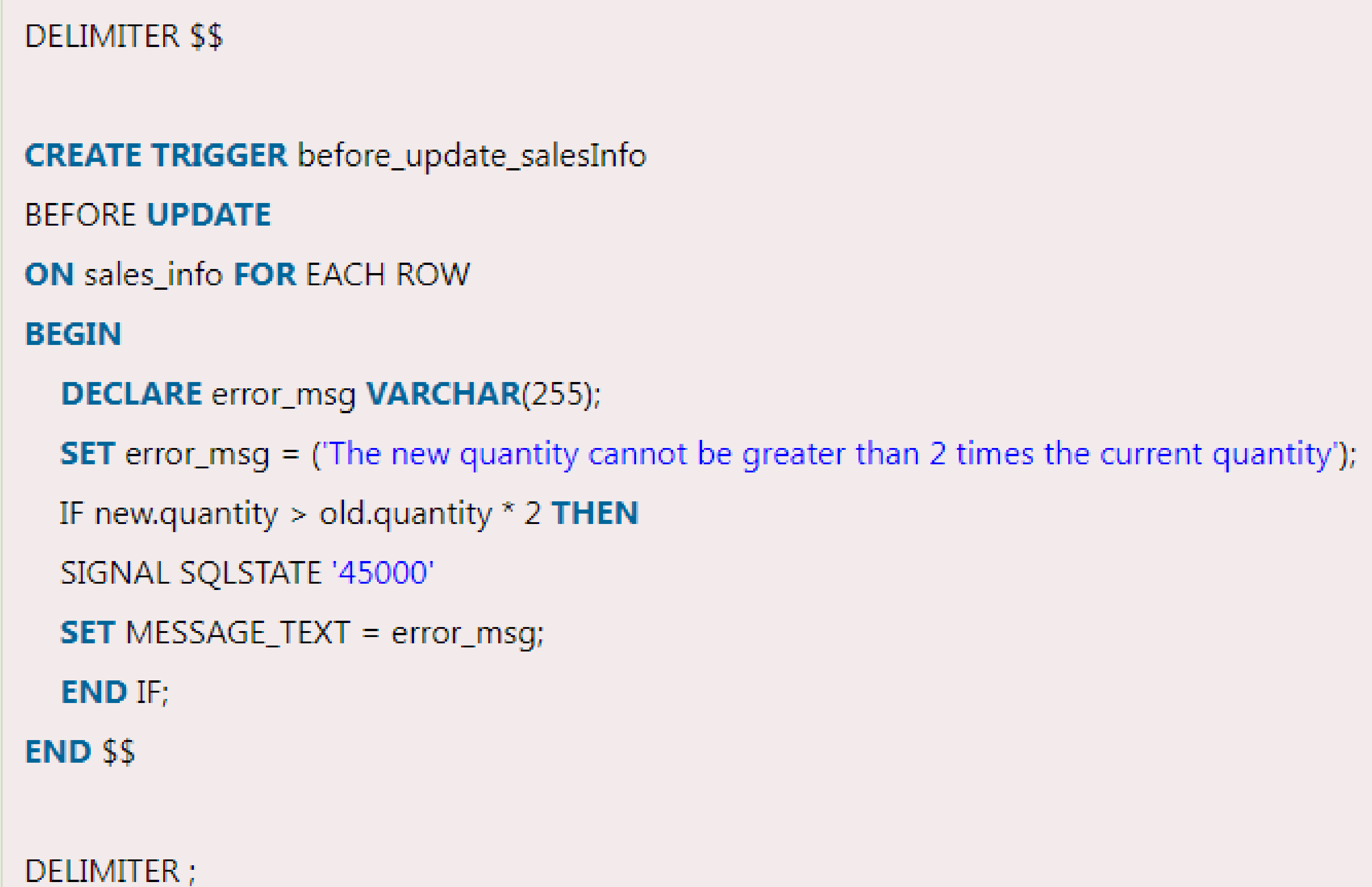
Then, execute the **SELECT statement** to see the table data as follows:



```
mysql> SELECT * FROM sales_info;
+----+---------------------+----------+------------+
| id | product             | quantity | fiscalYear |
+----+---------------------+----------+------------+
|  1 | 2003 Maruti Suzuki  |      110 |       2020 |
|  2 | 2015 Avenger        |      120 |       2020 |
|  3 | 2018 Honda Shine    |      150 |       2020 |
|  4 | 2014 Apache         |      150 |       2020 |
+----+---------------------+----------+------------+
4 rows in set (0.00 sec)
```

# Contd..

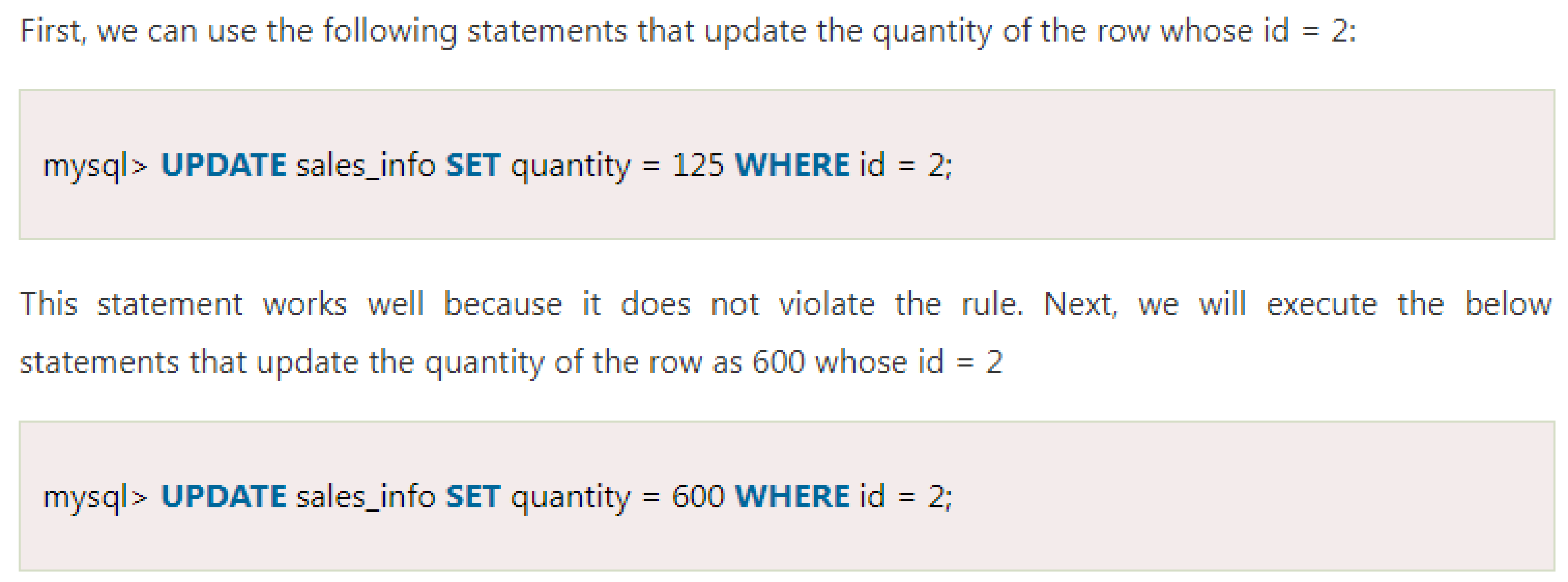
Next, we will use a **CREATE TRIGGER** statement to create a BEFORE UPDATE trigger. This trigger is invoked automatically before an update event occurs in the table.



```
DELIMITER $$


CREATE TRIGGER before_update_salesInfo
BEFORE UPDATE
ON sales_info FOR EACH ROW
BEGIN
   DECLARE error_msg VARCHAR(255);
   SET error_msg = ('The new quantity cannot be greater than 2 times the current quantity');
   IF new.quantity > old.quantity * 2 THEN
   SIGNAL SQLSTATE '45000'
   SET MESSAGE_TEXT = error_msg;
   END IF;
END $$


DELIMITER ;
```

# Contd..

The trigger produces an error message and stops the updation if we update the value in the quantity column to a new value two times greater than the current value.



First, we can use the following statements that update the quantity of the row whose id = 2:

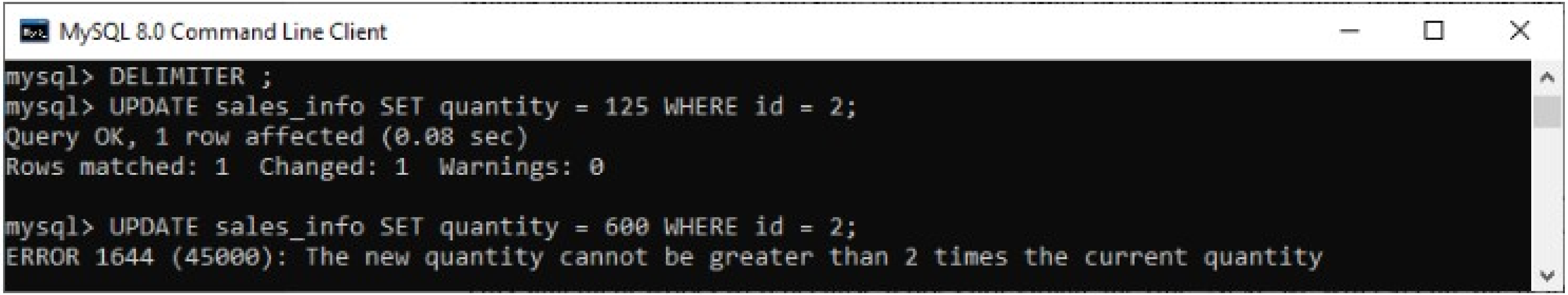
```
mysql> UPDATE sales_info SET quantity = 125 WHERE id = 2;
```

This statement works well because it does not violate the rule. Next, we will execute the below statements that update the quantity of the row as 600 whose id = 2

```
mysql> UPDATE sales_info SET quantity = 600 WHERE id = 2;
```

# Contd..

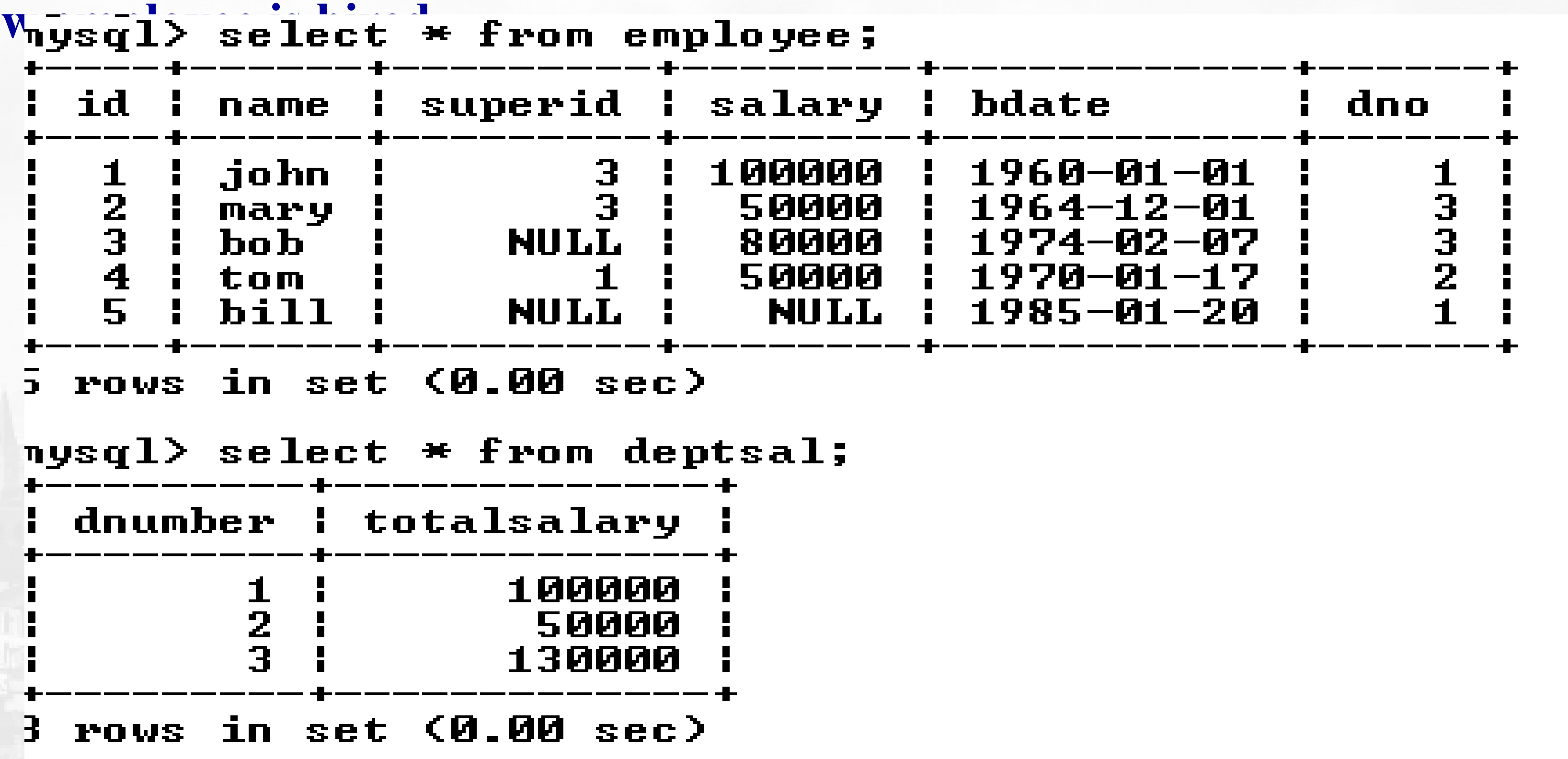
It will give the error as follows because it violates the rule. See the below output.



```
mysql> DELIMITER ;
mysql> UPDATE sales_info SET quantity = 125 WHERE id = 2;
Query OK, 1 row affected (0.08 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> UPDATE sales_info SET quantity = 600 WHERE id = 2;
ERROR 1644 (45000): The new quantity cannot be greater than 2 times the current quantity
```

# Example 3

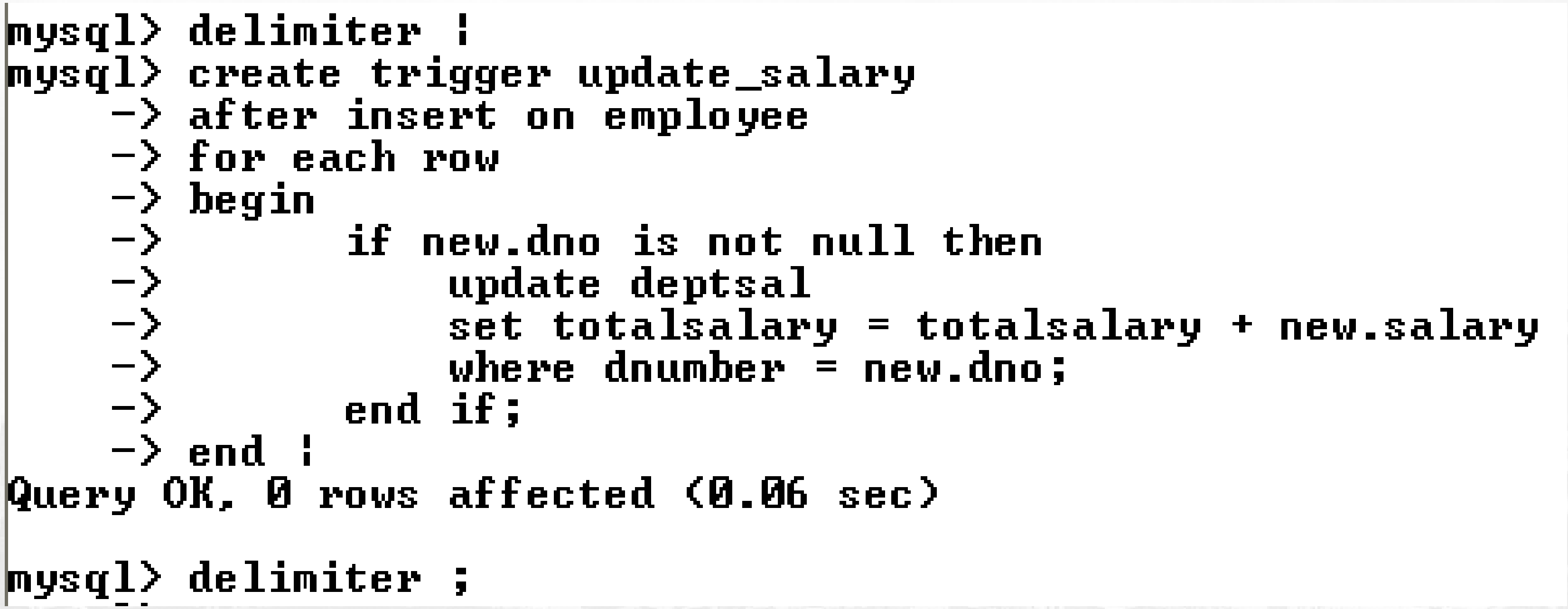
**3. We want to create a trigger to update the total salary of a department when a new employee is hired.**



```
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)
```

# Cont..

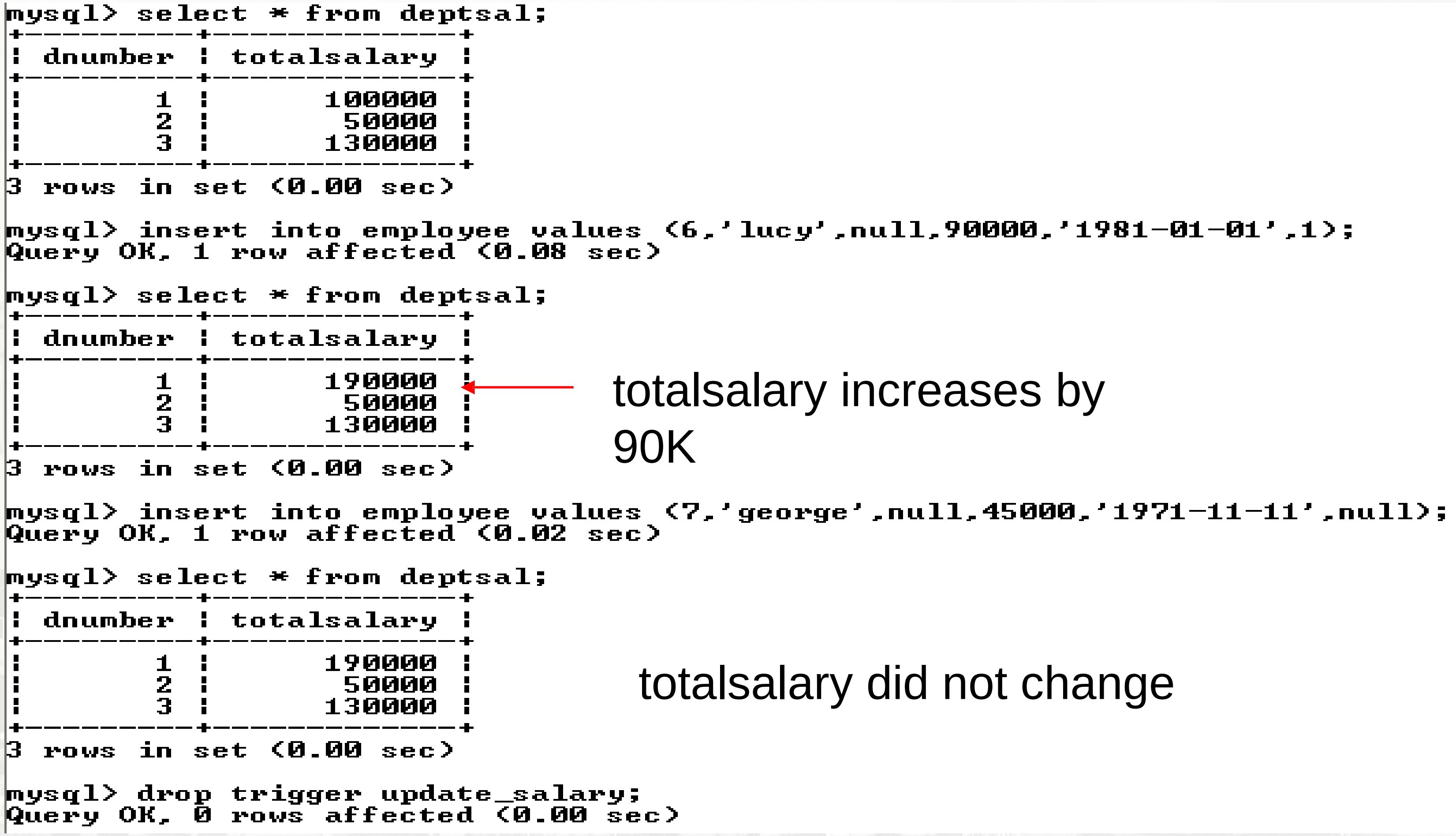
**Create a trigger to update the total salary of a department when a new employee is hired.**



```
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

# Cont..



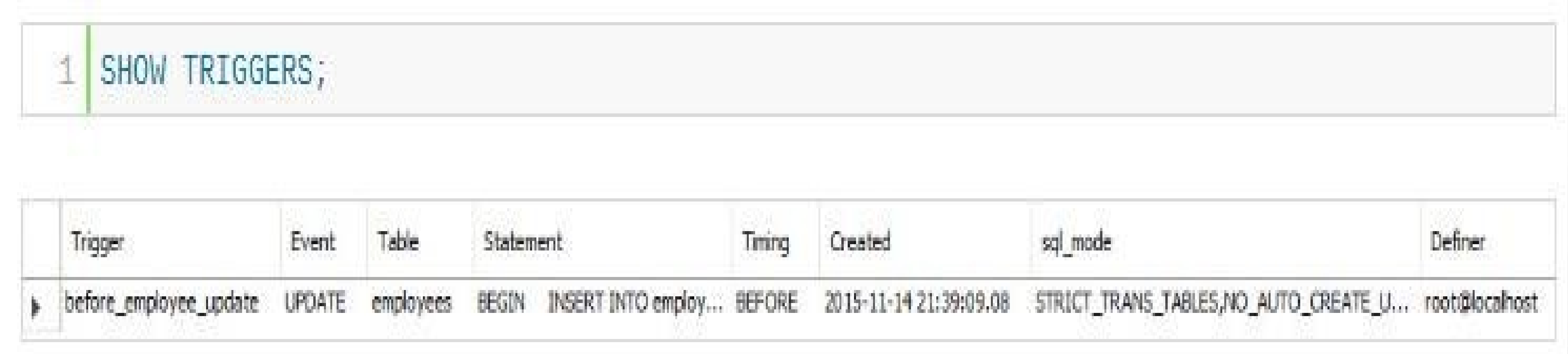
```
mysql> select * from deptsal;
+---------+-------------+
| dnumber | totalsalary |
+---------+-------------+
|       1 |      100000 |
|       2 |       50000 |
|       3 |      130000 |
+---------+-------------+
3 rows in set (0.00 sec)

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)
```

totalsalary increases by 90K

totalsalary did not change

# Trigger

- To list all the triggers we have created: mysql> show triggers;



```
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 |

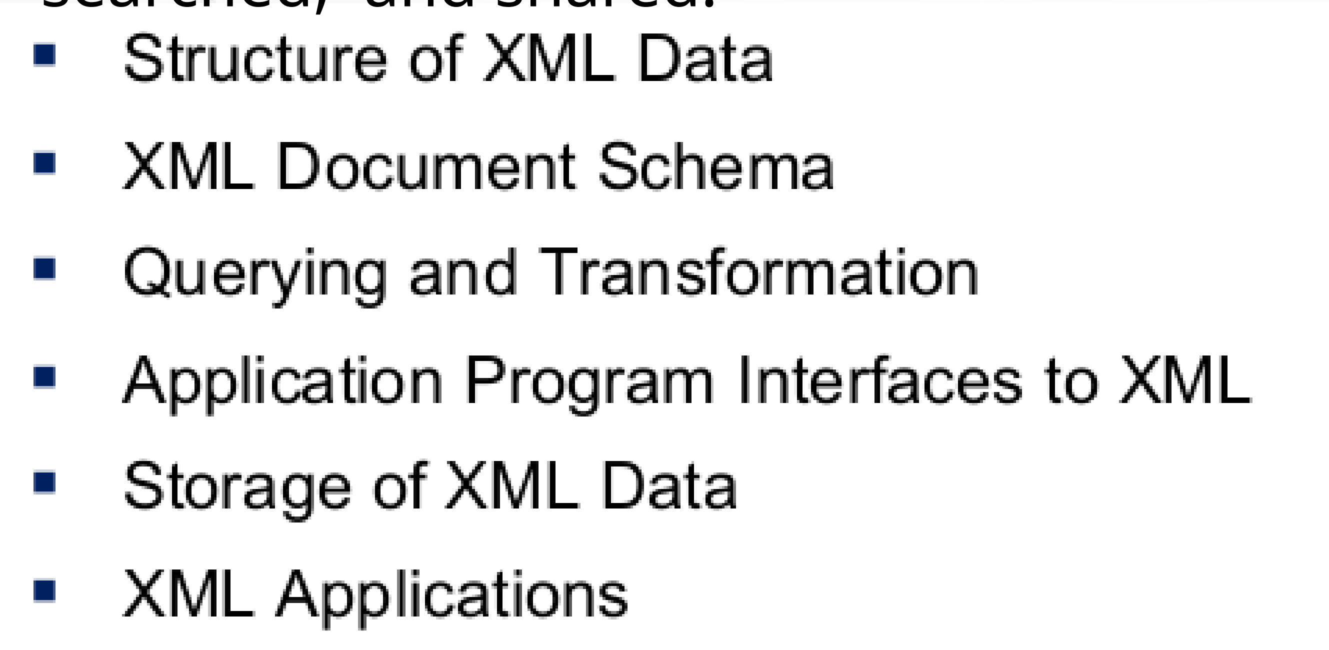
- To drop a trigger
  mysql> drop trigger <trigger name>

# Complex Data Types

# XML (Extensible Markup Language)

XML is a markup language similar to HTML, but without predefined tags to use.  Instead, you define your own tags designed specifically for your needs.

This is a powerful way to store data in a format that can be stored, searched,  and shared.

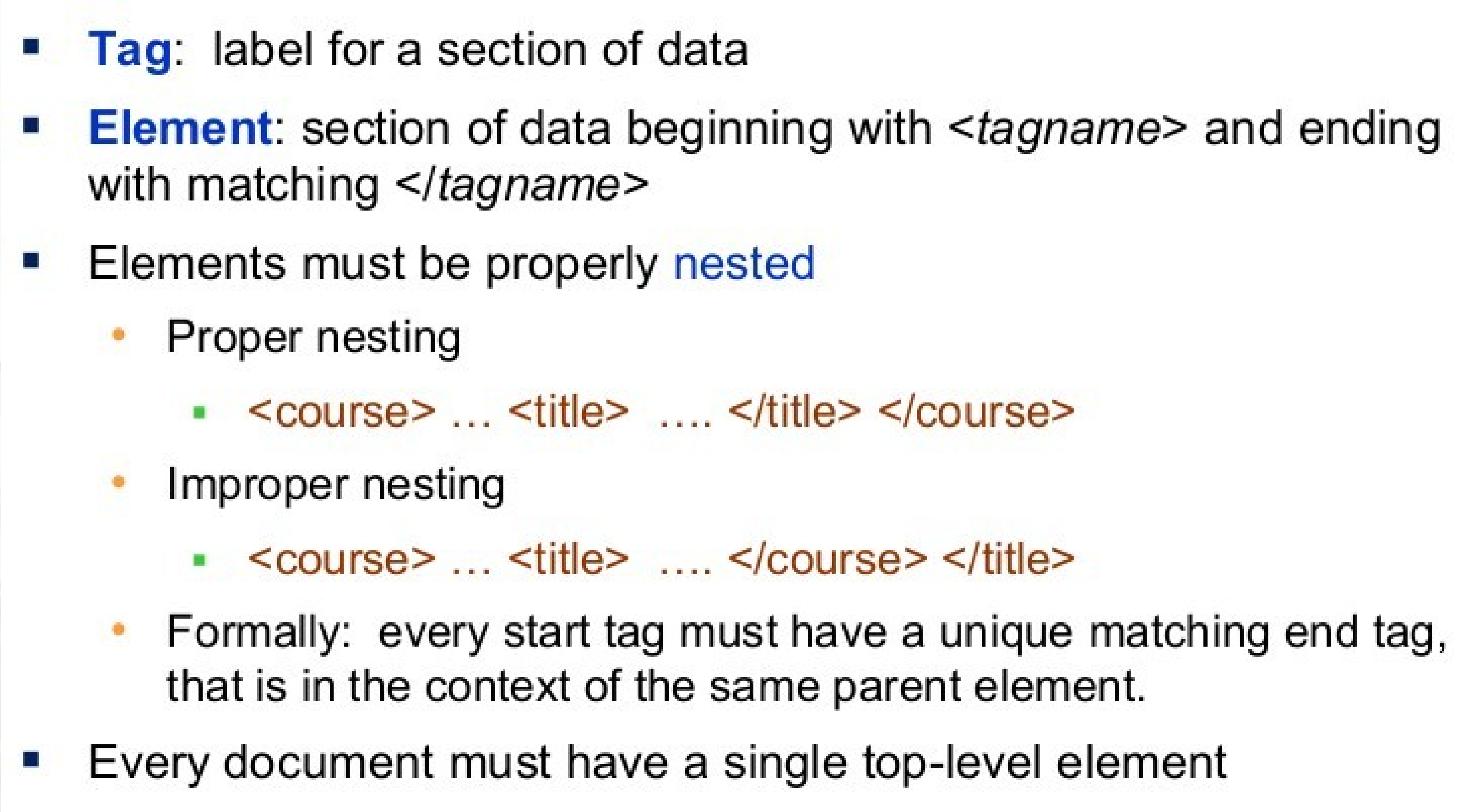


- Structure of XML Data
- XML Document Schema
- Querying and Transformation
- Application Program Interfaces to XML
- Storage of XML Data
- XML Applications

- The ability to specify new tags, and to create nested tag structures make XML a great way to exchange **data**, not just documents.
  - Much of the use of XML has been in data exchange applications, not as a replacement for HTML
- Tags make data (relatively) self-documenting
  - E.g.

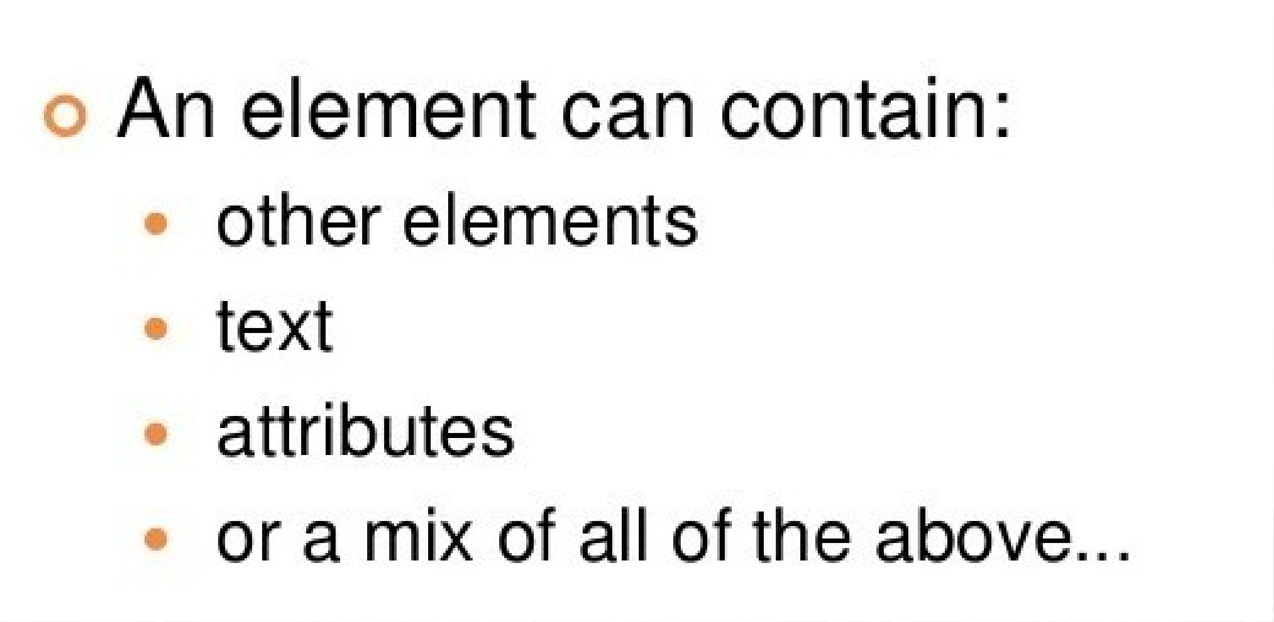
```
<university>
      <department>
        <dept_name> Comp. Sci. </dept_name>
        <building> Taylor </building>
        <budget> 100000 </budget>
     </department>
     <course>
         <course_id> CS-101 </course_id>
         <title> Intro. to Computer Science </title>
         <dept_name> Comp. Sci </dept_name>
         <credits> 4 </credits>
      </course>
</university>
```

# Structure of XML data



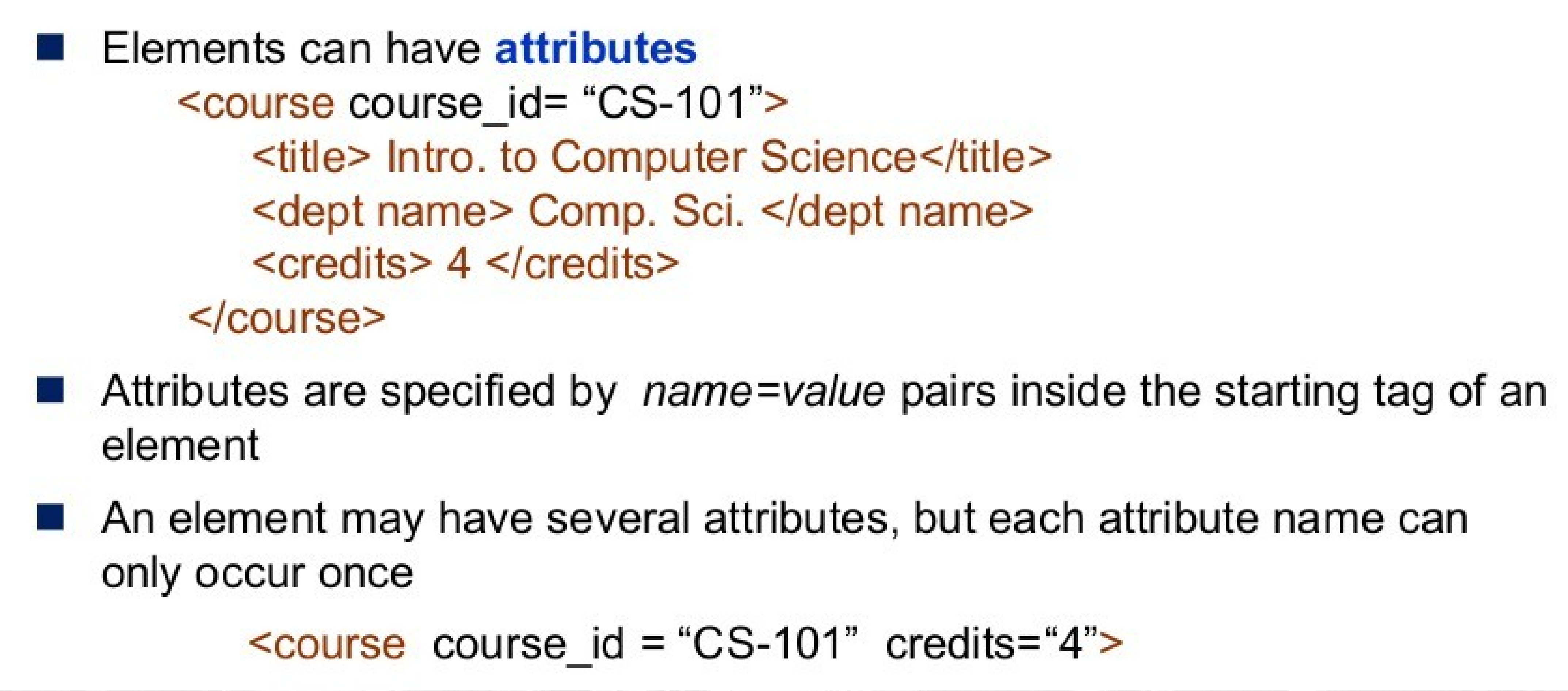
- **Tag**: label for a section of data
- **Element**: section of data beginning with <*tagname*> and ending with matching </*tagname*>
- Elements must be properly nested
  - Proper nesting
    - <course> … <title> …. </title> </course>
  - Improper nesting
    - <course> … <title> …. </course> </title>
  - Formally: every start tag must have a unique matching end tag, that is in the context of the same parent element.
- Every document must have a single top-level element

# XML Element



- An element can contain:
  - other elements
  - text
  - attributes
  - or a mix of all of the above...

# Attributes



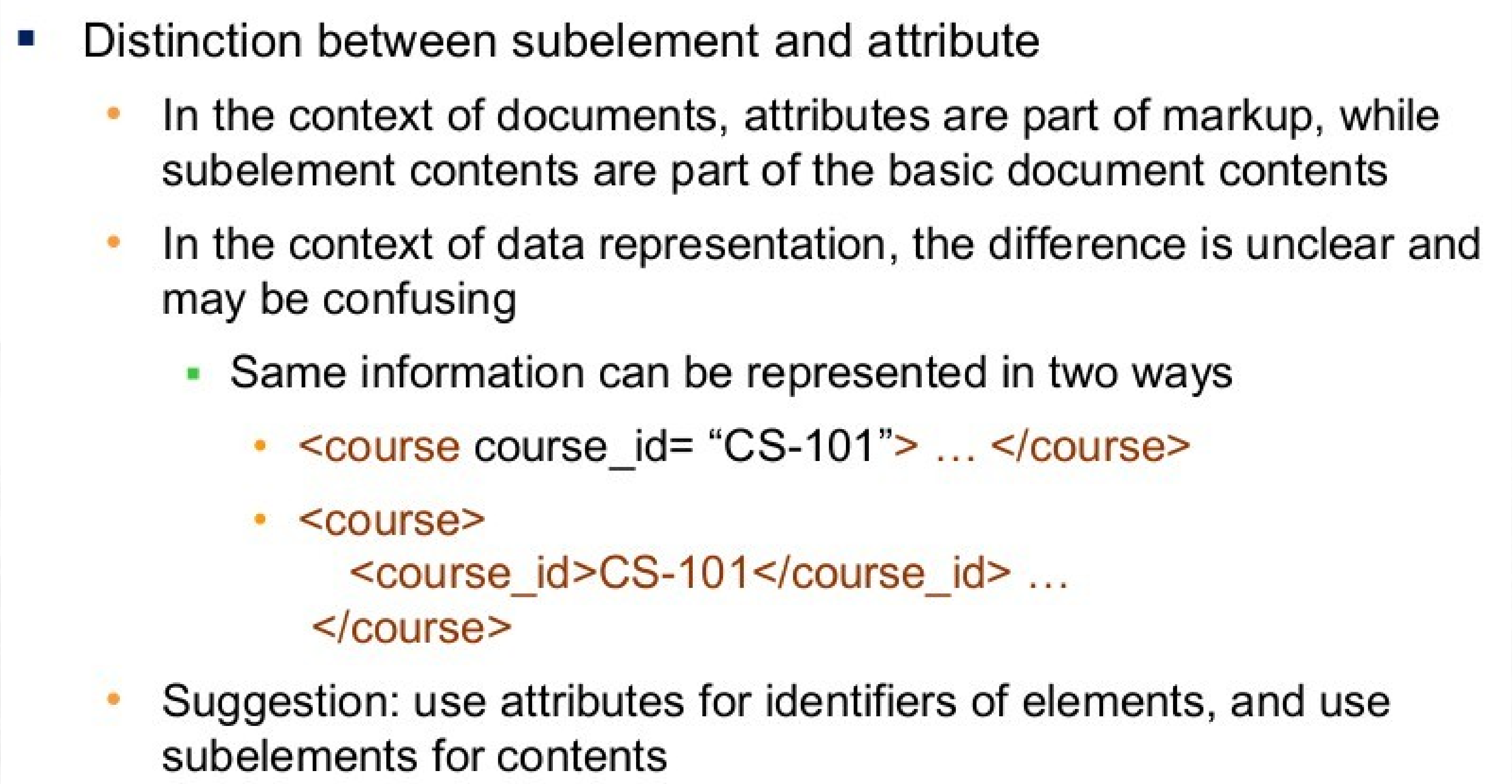
- Elements can have **attributes**

```
<course course_id= “CS-101”>
        <title> Intro. to Computer Science</title>
        <dept name> Comp. Sci. </dept name>
        <credits> 4 </credits>
 </course>
```

- Attributes are specified by *name=value* pairs inside the starting tag of an element
- An element may have several attributes, but each attribute name can only occur once

```
<course  course_id = “CS-101”  credits=“4”>
```

# Attributes vs. Subelements



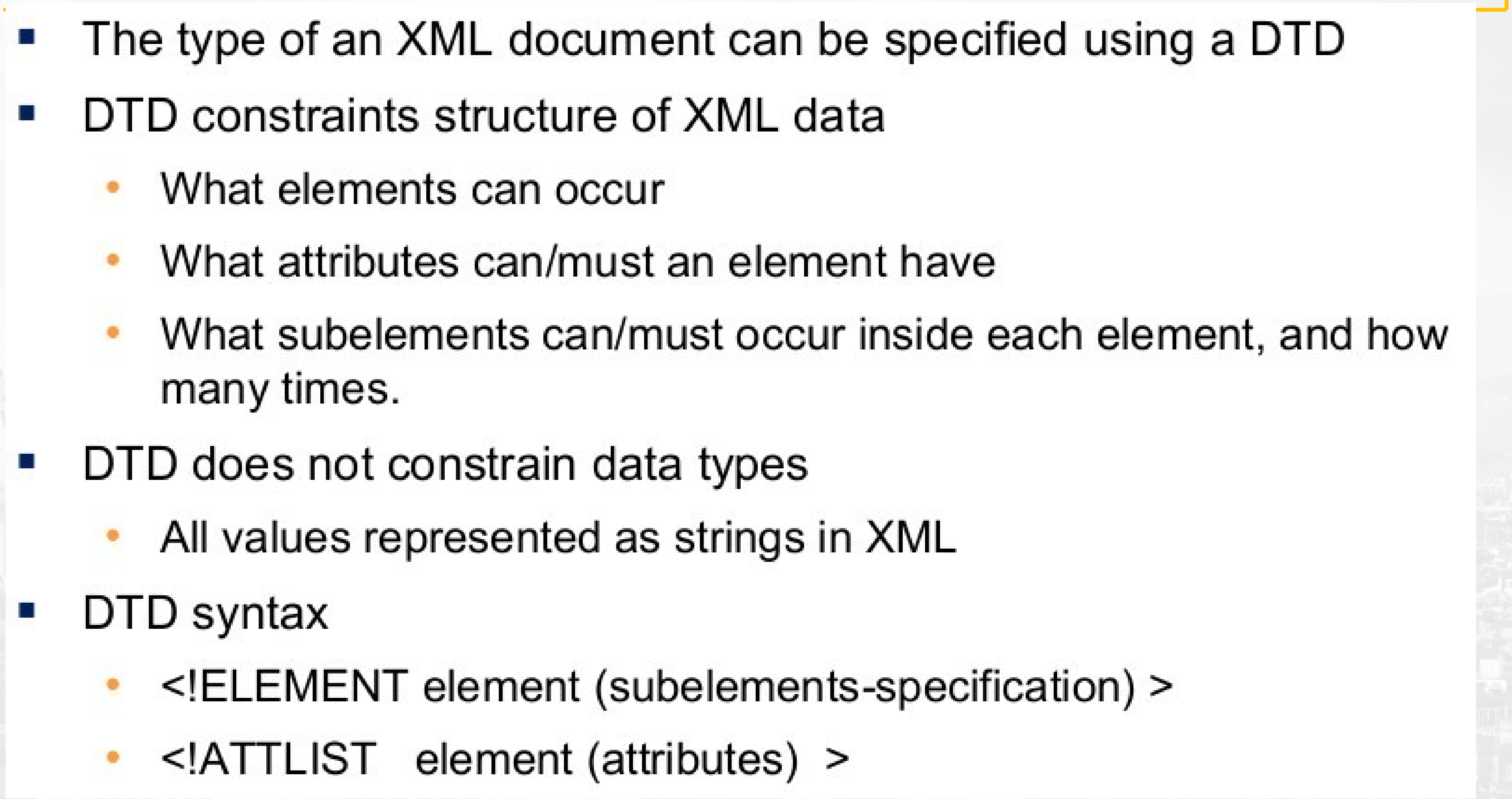
- Distinction between subelement and attribute
  - In the context of documents, attributes are part of markup, while subelement contents are part of the basic document contents
  - In the context of data representation, the difference is unclear and may be confusing
    - Same information can be represented in two ways
      - <course course_id= “CS-101”> … </course>
      - <course>  
        <course_id>CS-101</course_id> …  
        </course>
  - Suggestion: use attributes for identifiers of elements, and use subelements for contents

# Namespaces

- XML data has to be exchanged between organizations
- Same tag name may have different meaning in different organizations, causing confusion on exchanged documents
- Specifying a unique string as an element name avoids confusion
- Better solution: use unique-name:element-name
- Avoid using long unique names all over document by using XML Namespaces

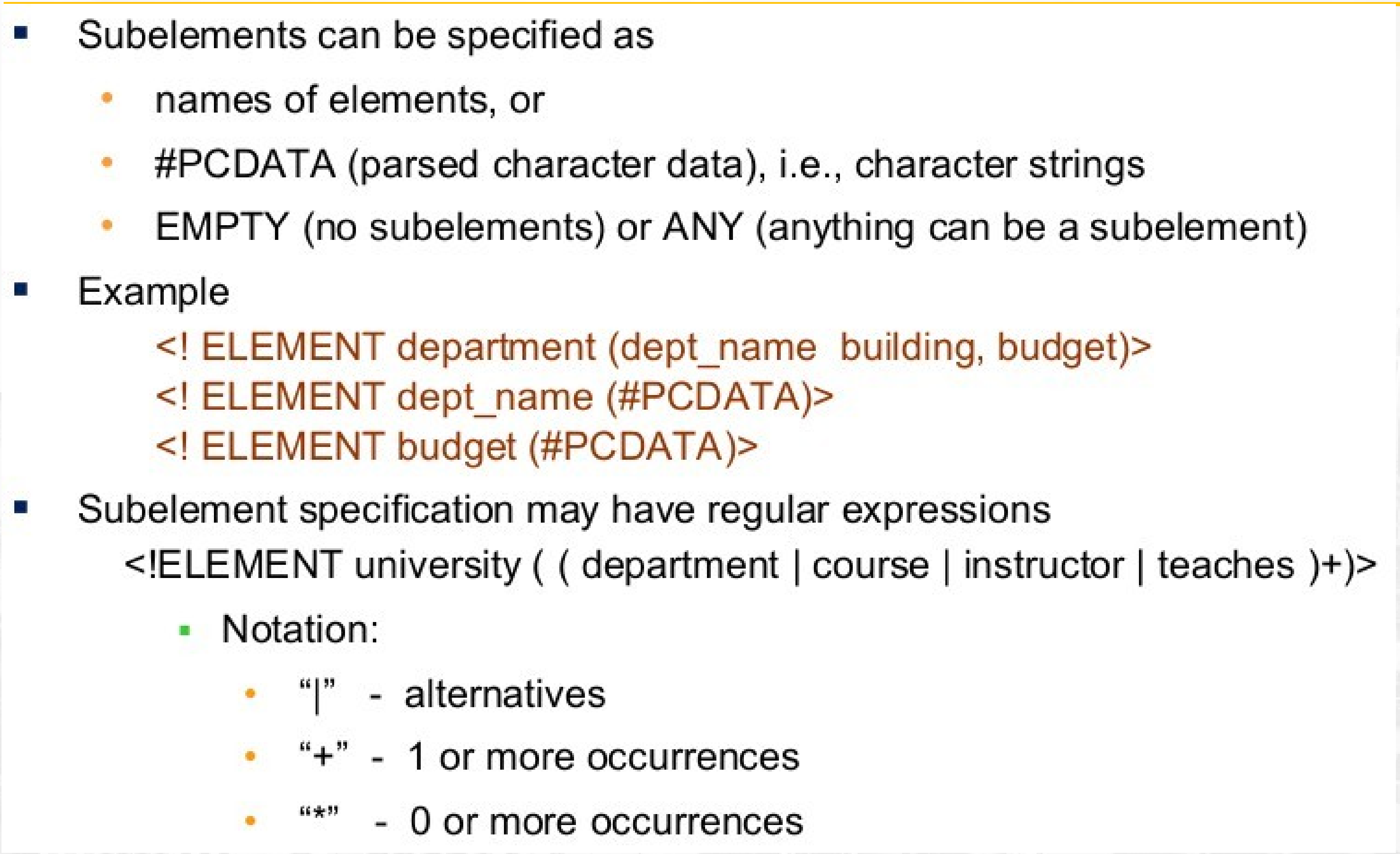
```
<university xmlns:yale=“http://www.yale.edu”>
      …
       <yale:course>
           <yale:course_id> CS-101 </yale:course_id>
           <yale:title> Intro. to Computer Science</yale:title>
           <yale:dept_name> Comp. Sci. </yale:dept_name>
           <yale:credits> 4 </yale:credits>
       </yale:course>
      …
</university>
```

# Document Type Definition (DTD)



- The type of an XML document can be specified using a DTD
- DTD constraints structure of XML data
  - What elements can occur
  - What attributes can/must an element have
  - What subelements can/must occur inside each element, and how many times.
- DTD does not constrain data types
  - All values represented as strings in XML
- DTD syntax
  - <!ELEMENT element (subelements-specification) >
  - <!ATTLIST element (attributes) >

# Element Specification in DTD



- Subelements can be specified as
  - names of elements, or
  - #PCDATA (parsed character data), i.e., character strings
  - EMPTY (no subelements) or ANY (anything can be a subelement)
- Example

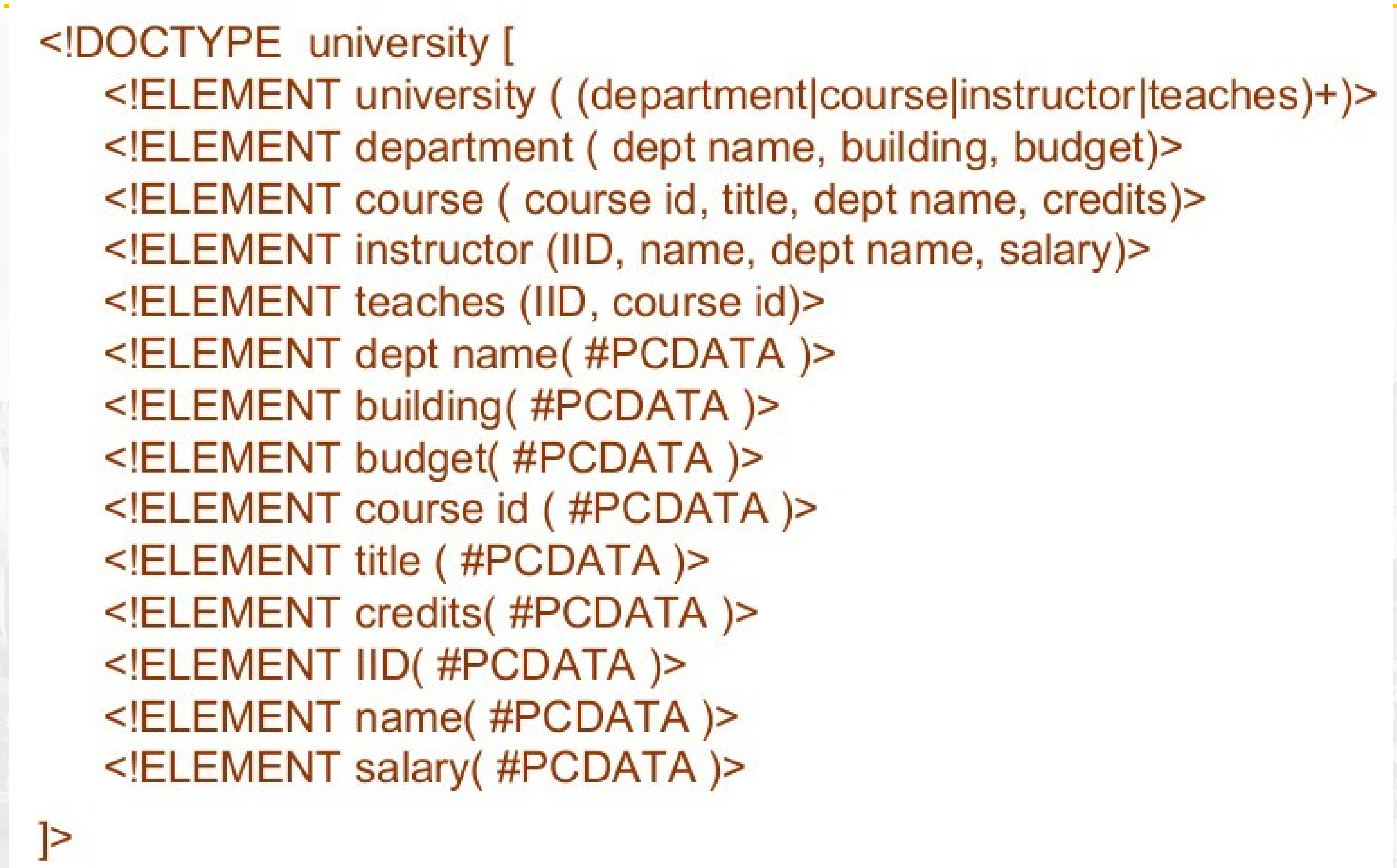
```
<! ELEMENT department (dept_name  building, budget)>
<! ELEMENT dept_name (#PCDATA)>
<! ELEMENT budget (#PCDATA)>
```

- Subelement specification may have regular expressions

```
<!ELEMENT university ( ( department | course | instructor | teaches )+)>
```

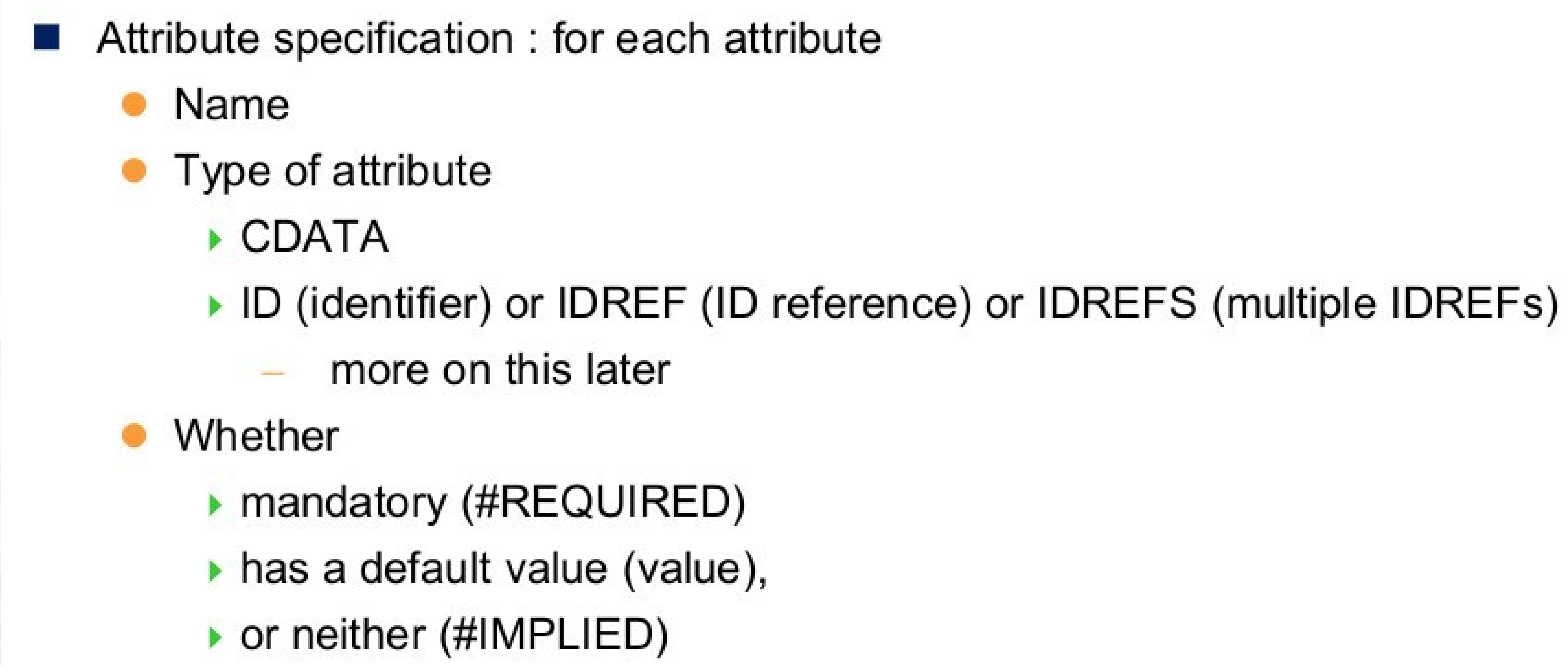
  - Notation:
    - “|”  -  alternatives
    - “+”  -  1 or more occurrences
    - “*”  -  0 or more occurrences

# University DTD



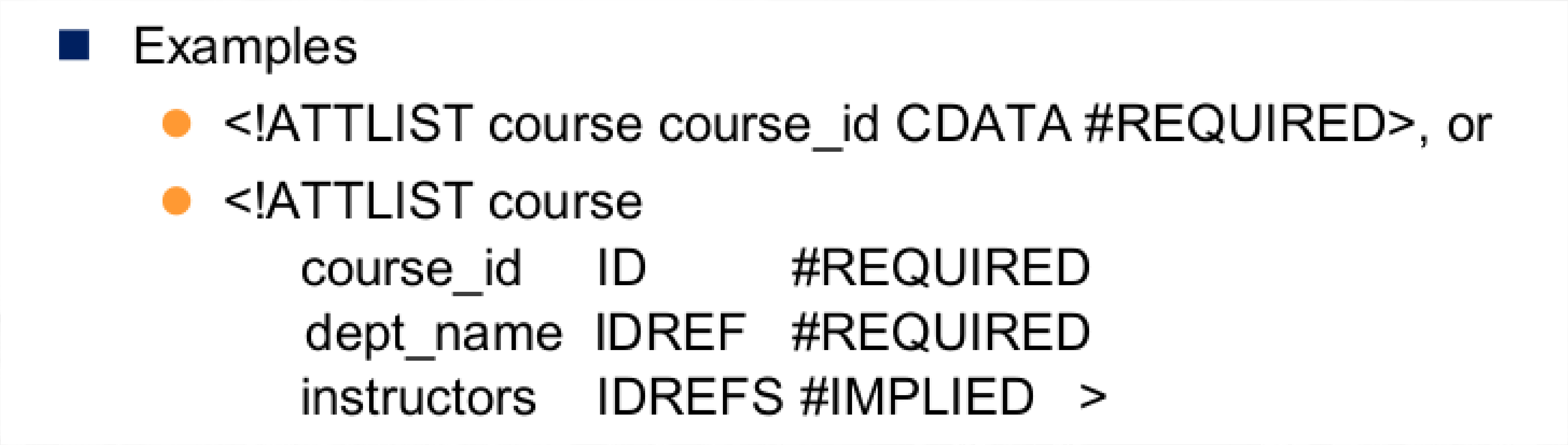
```
<!DOCTYPE  university [
     <!ELEMENT university ( (department|course|instructor|teaches)+)>
     <!ELEMENT department ( dept name, building, budget)>
     <!ELEMENT course ( course id, title, dept name, credits)>
     <!ELEMENT instructor (IID, name, dept name, salary)>
     <!ELEMENT teaches (IID, course id)>
     <!ELEMENT dept name( #PCDATA )>
     <!ELEMENT building( #PCDATA )>
     <!ELEMENT budget( #PCDATA )>
     <!ELEMENT course id ( #PCDATA )>
     <!ELEMENT title ( #PCDATA )>
     <!ELEMENT credits( #PCDATA )>
     <!ELEMENT IID( #PCDATA )>
     <!ELEMENT name( #PCDATA )>
     <!ELEMENT salary( #PCDATA )>

]>
```

# Attribute Specification in DTD



- Attribute specification : for each attribute
  - Name
  - Type of attribute
    - CDATA
    - ID (identifier) or IDREF (ID reference) or IDREFS (multiple IDREFs)
      - more on this later
  - Whether
    - mandatory (#REQUIRED)
    - has a default value (value),
    - or neither (#IMPLIED)

# Attribute Specification in DTD : examples



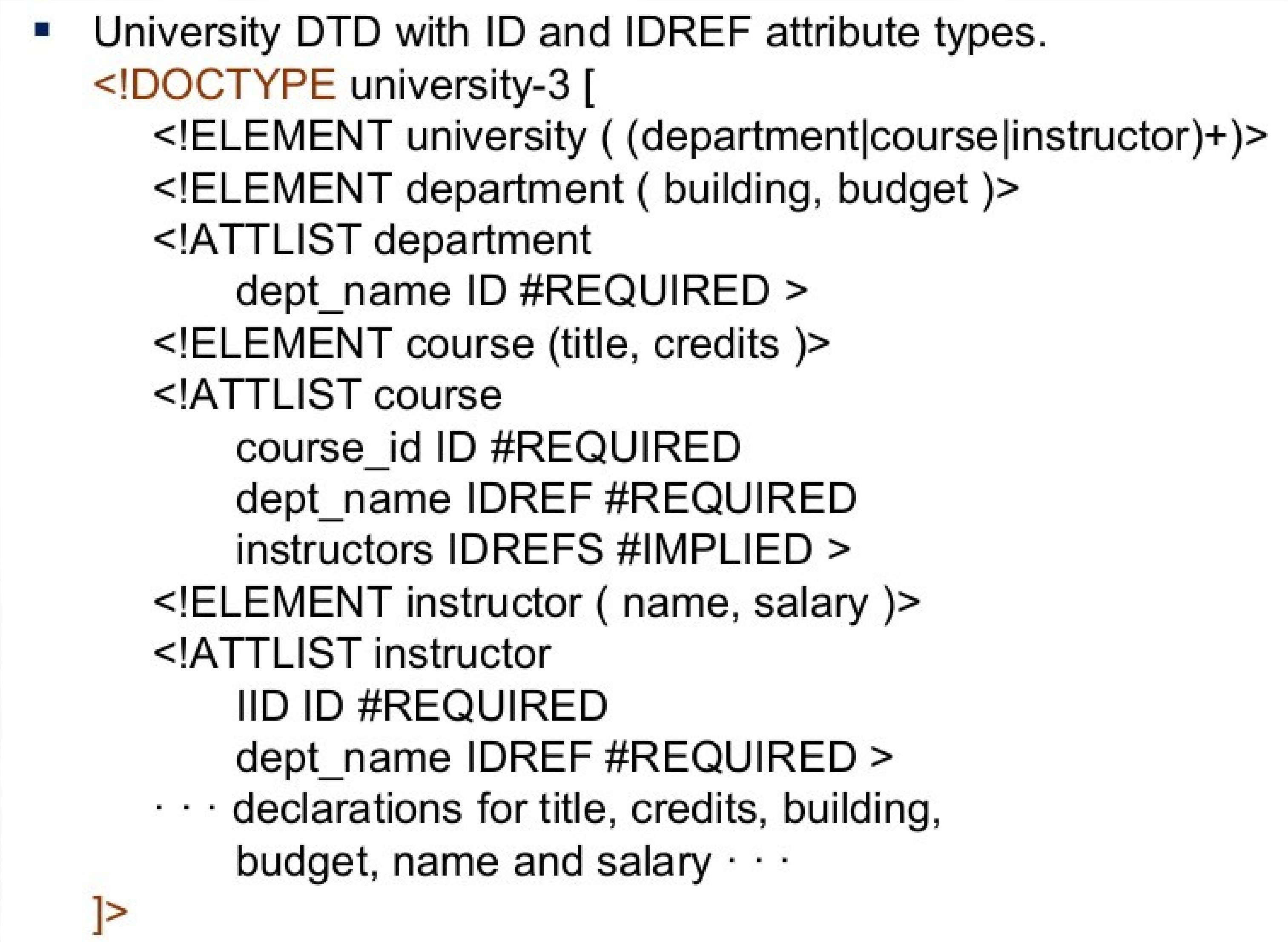
- Examples
  - <!ATTLIST course course_id CDATA #REQUIRED>, or
  - <!ATTLIST course

```
      course_id     ID          #REQUIRED
      dept_name   IDREF     #REQUIRED
      instructors    IDREFS #IMPLIED   >
```

# IDs and IDREFs

- An element can have at most one attribute of type ID
- The ID attribute value of each element in an XML document must be distinct
  - Thus the ID attribute value is an object identifier
- An attribute of type IDREF must contain the ID value of an element in the same document
- An attribute of type IDREFS contains a set of (0 or more) ID values.  Each ID value must contain the ID value of an element in the same document

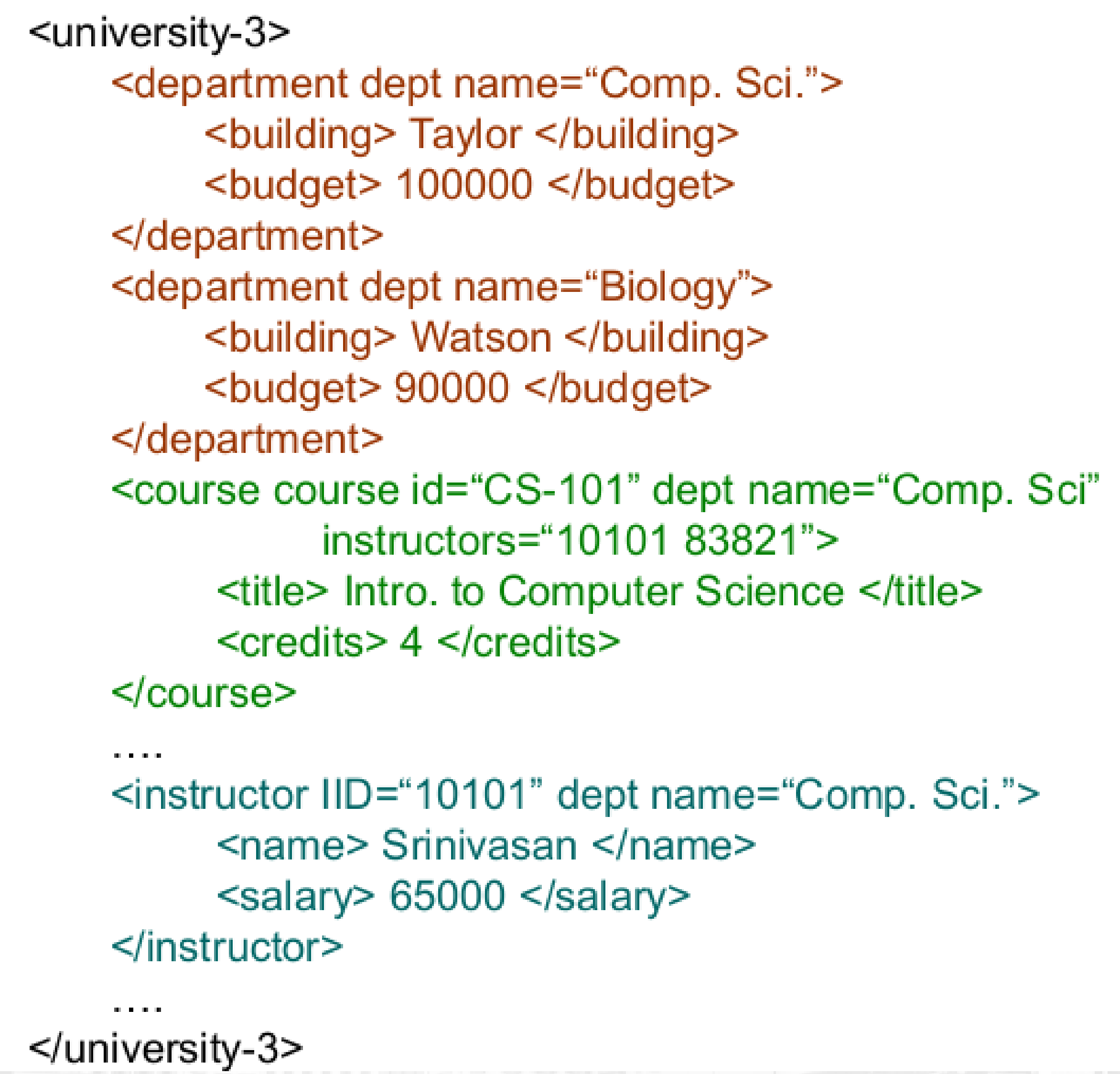
# University DTD with Attributes



- University DTD with ID and IDREF attribute types.

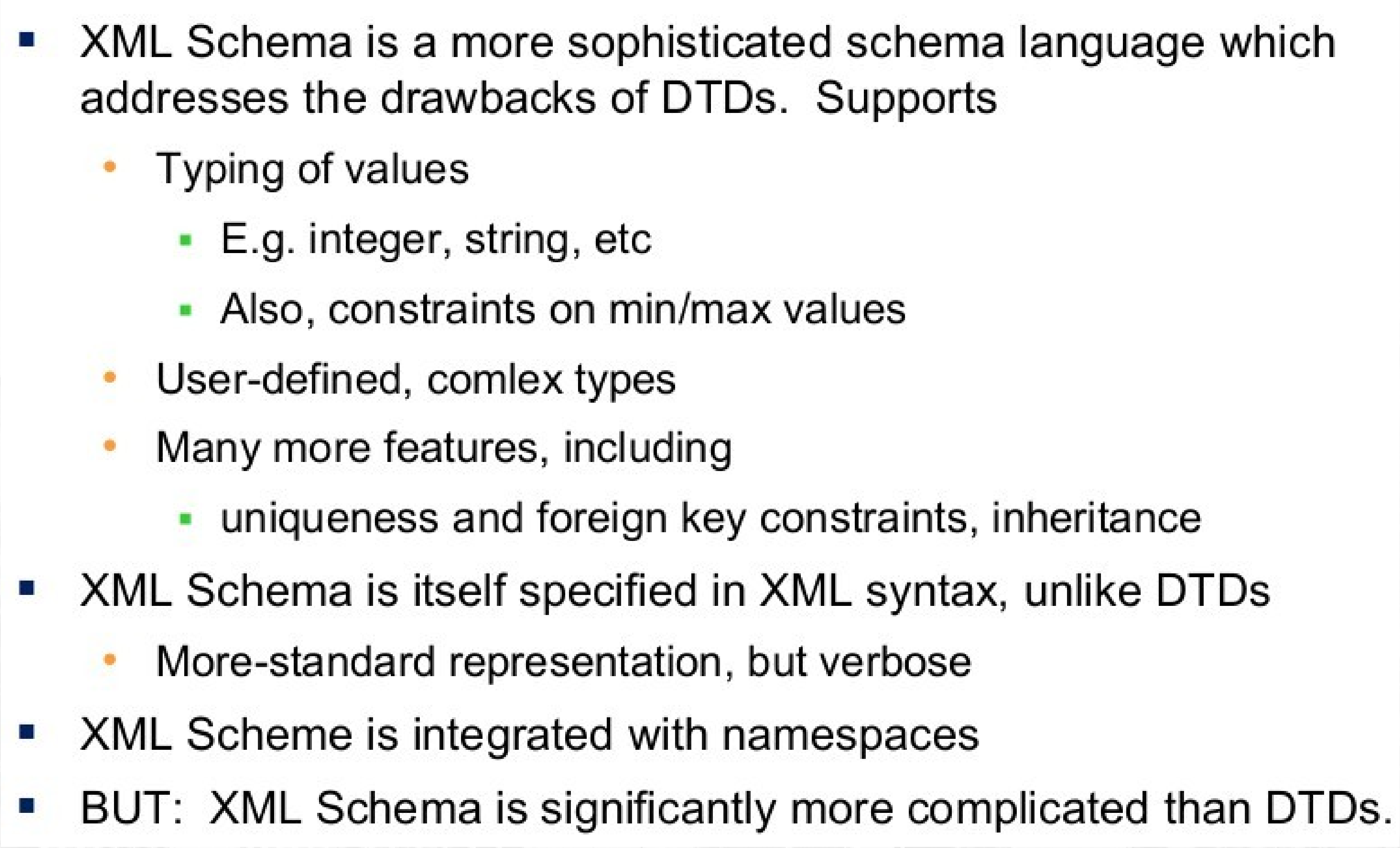
```
<!DOCTYPE university-3 [
    <!ELEMENT university ( (department|course|instructor)+)>
    <!ELEMENT department ( building, budget )>
    <!ATTLIST department
          dept_name ID #REQUIRED >
    <!ELEMENT course (title, credits )>
    <!ATTLIST course
          course_id ID #REQUIRED
          dept_name IDREF #REQUIRED
          instructors IDREFS #IMPLIED >
    <!ELEMENT instructor ( name, salary )>
    <!ATTLIST instructor
          IID ID #REQUIRED
          dept_name IDREF #REQUIRED >
    · · · declarations for title, credits, building,
          budget, name and salary · · ·
]>
```

# XML data with ID and IDREF attributes



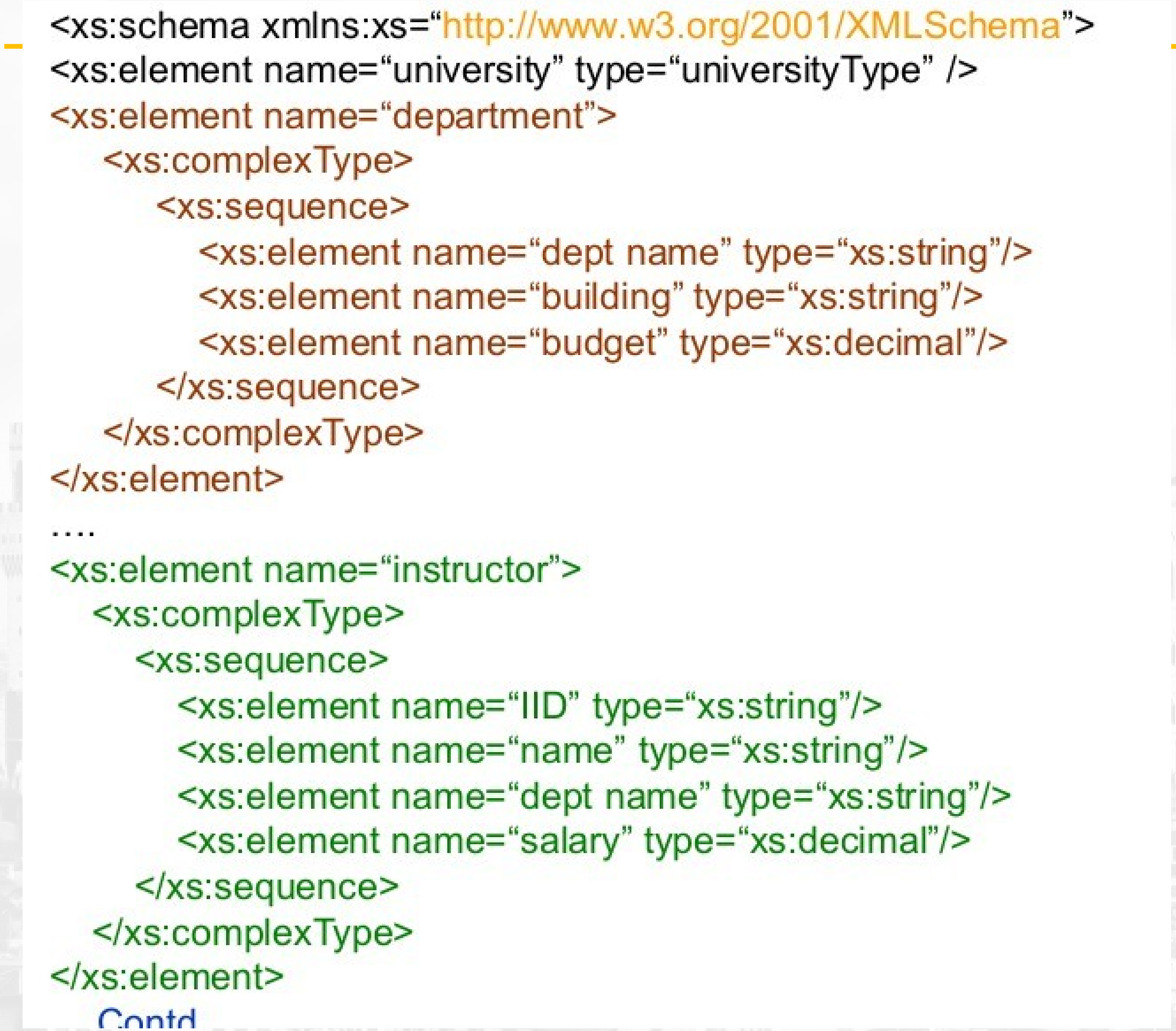
```
<university-3>
        <department dept name="Comp. Sci.">
                <building> Taylor </building>
                <budget> 100000 </budget>
        </department>
        <department dept name="Biology">
                <building> Watson </building>
                <budget> 90000 </budget>
        </department>
        <course course id="CS-101" dept name="Comp. Sci"
                        instructors="10101 83821">
                 <title> Intro. to Computer Science </title>
                 <credits> 4 </credits>
        </course>
        ….
        <instructor IID="10101" dept name="Comp. Sci.">
                 <name> Srinivasan </name>
                 <salary> 65000 </salary>
        </instructor>
        ….
</university-3>
```

# XML Schema



- XML Schema is a more sophisticated schema language which addresses the drawbacks of DTDs.  Supports
  - Typing of values
    - E.g. integer, string, etc
    - Also, constraints on min/max values
  - User-defined, comlex types
  - Many more features, including
    - uniqueness and foreign key constraints, inheritance
- XML Schema is itself specified in XML syntax, unlike DTDs
  - More-standard representation, but verbose
- XML Scheme is integrated with namespaces
- BUT:  XML Schema is significantly more complicated than DTDs.

# XML Schema Version of Univ. DTD



```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
<xs:element name="university" type="universityType" />
<xs:element name="department">
    <xs:complexType>
        <xs:sequence>
           <xs:element name="dept name" type="xs:string"/>
           <xs:element name="building" type="xs:string"/>
           <xs:element name="budget" type="xs:decimal"/>
        </xs:sequence>
    </xs:complexType>
</xs:element>
….
<xs:element name="instructor">
   <xs:complexType>
      <xs:sequence>
         <xs:element name="IID" type="xs:string"/>
         <xs:element name="name" type="xs:string"/>
         <xs:element name="dept name" type="xs:string"/>
         <xs:element name="salary" type="xs:decimal"/>
      </xs:sequence>
   </xs:complexType>
</xs:element>
    Contd
```

# XML Schema Version of Univ. DTD (Cont.)

```
….
<xs:complexType name=“UniversityType”>
    <xs:sequence>
        <xs:element ref=“department” minOccurs=“0” maxOccurs=“unbounded”/>
        <xs:element ref=“course” minOccurs=“0” maxOccurs=“unbounded”/>
        <xs:element ref=“instructor” minOccurs=“0” maxOccurs=“unbounded”/>
        <xs:element ref=“teaches” minOccurs=“0” maxOccurs=“unbounded”/>
    </xs:sequence>
</xs:complexType>
</xs:schema>
```

- Choice of “xs:” was ours -- any other namespace prefix could be chosen
- Element “university” has type “universityType”, which is defined separately
    - xs:complexType is used later to create the named complex type “UniversityType”

# More features of XML Schema

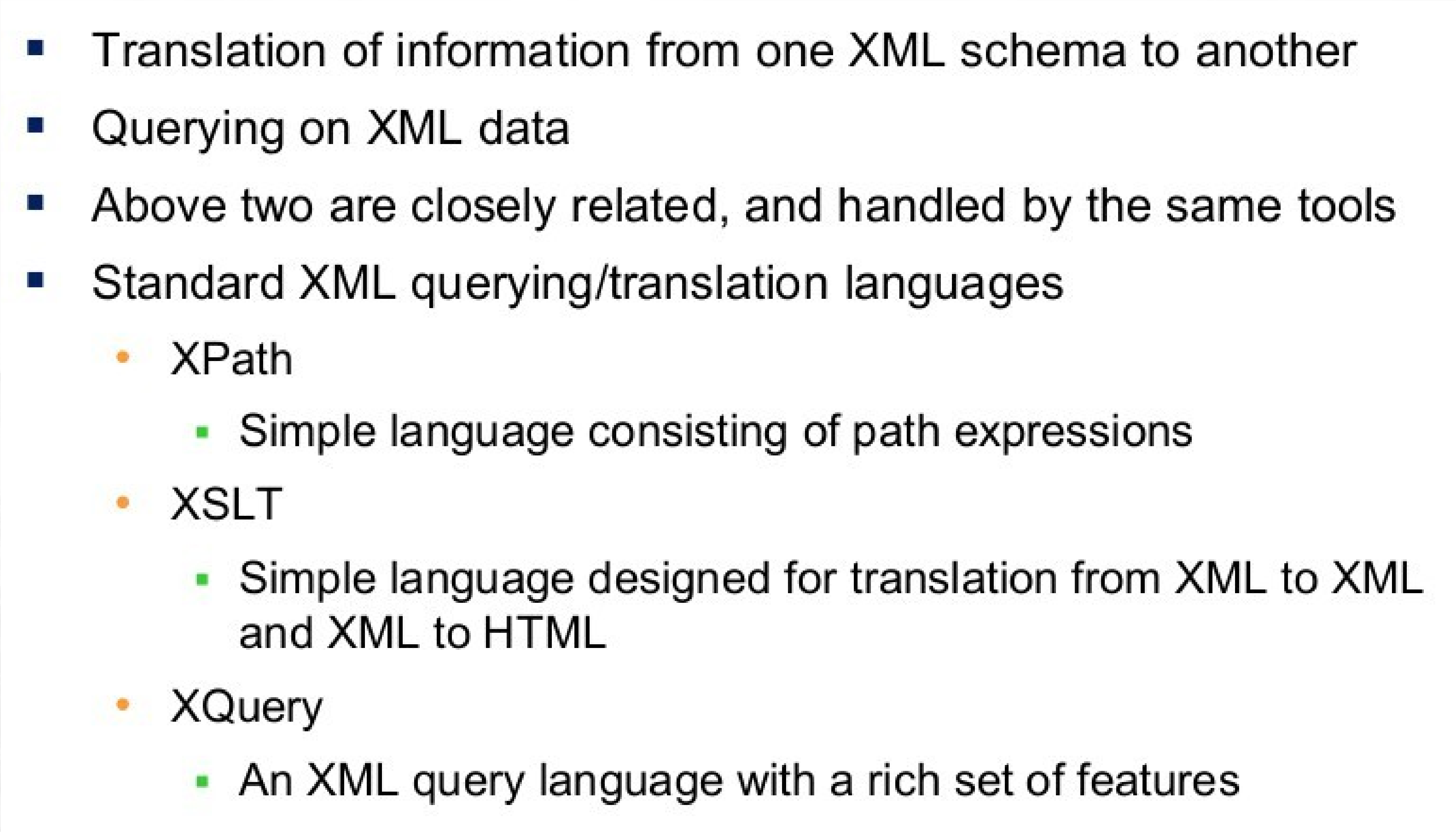
- Attributes specified by xs:attribute tag:
  - <xs:attribute name = “dept_name”/>
  - adding the attribute use = “required” means value must be specified
- Key constraint: “department names form a key for department elements under the root university element:

```
<xs:key name = “deptKey”>
        <xs:selector xpath = “/university/department”/>
        <xs:field xpath = “dept_name”/>
<\xs:key>
```

- Foreign key constraint from course to department:

```
<xs:keyref name = “courseDeptFKey” refer=“deptKey”>
        <xs:selector xpath = “/university/course”/>
        <xs:field xpath = “dept_name”/>
<\xs:keyref>
```

# Querying and Transforming XML Data

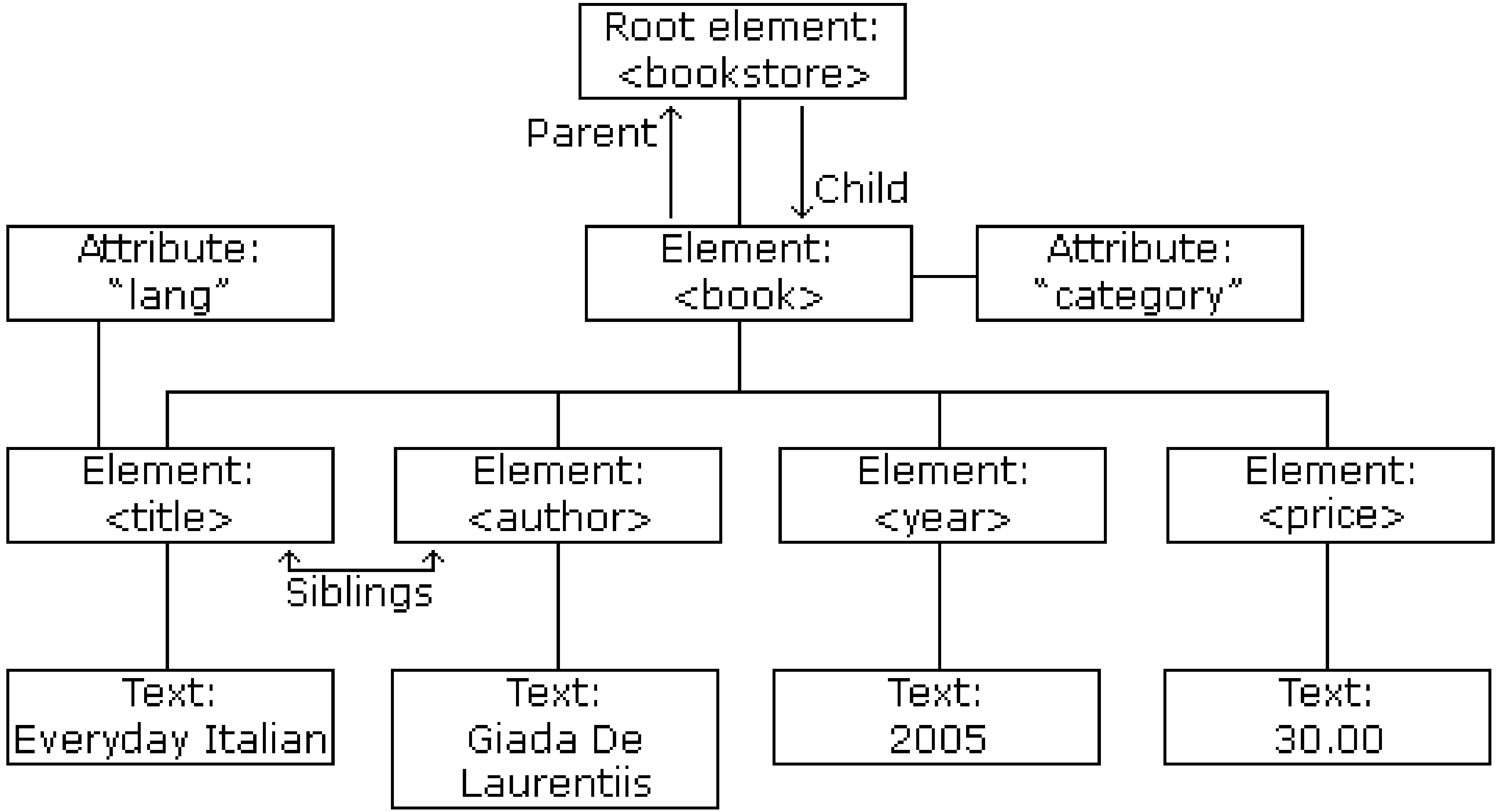


- Translation of information from one XML schema to another
- Querying on XML data
- Above two are closely related, and handled by the same tools
- Standard XML querying/translation languages
  - XPath
    - Simple language consisting of path expressions
  - XSLT
    - Simple language designed for translation from XML to XML and XML to HTML
  - XQuery
    - An XML query language with a rich set of features

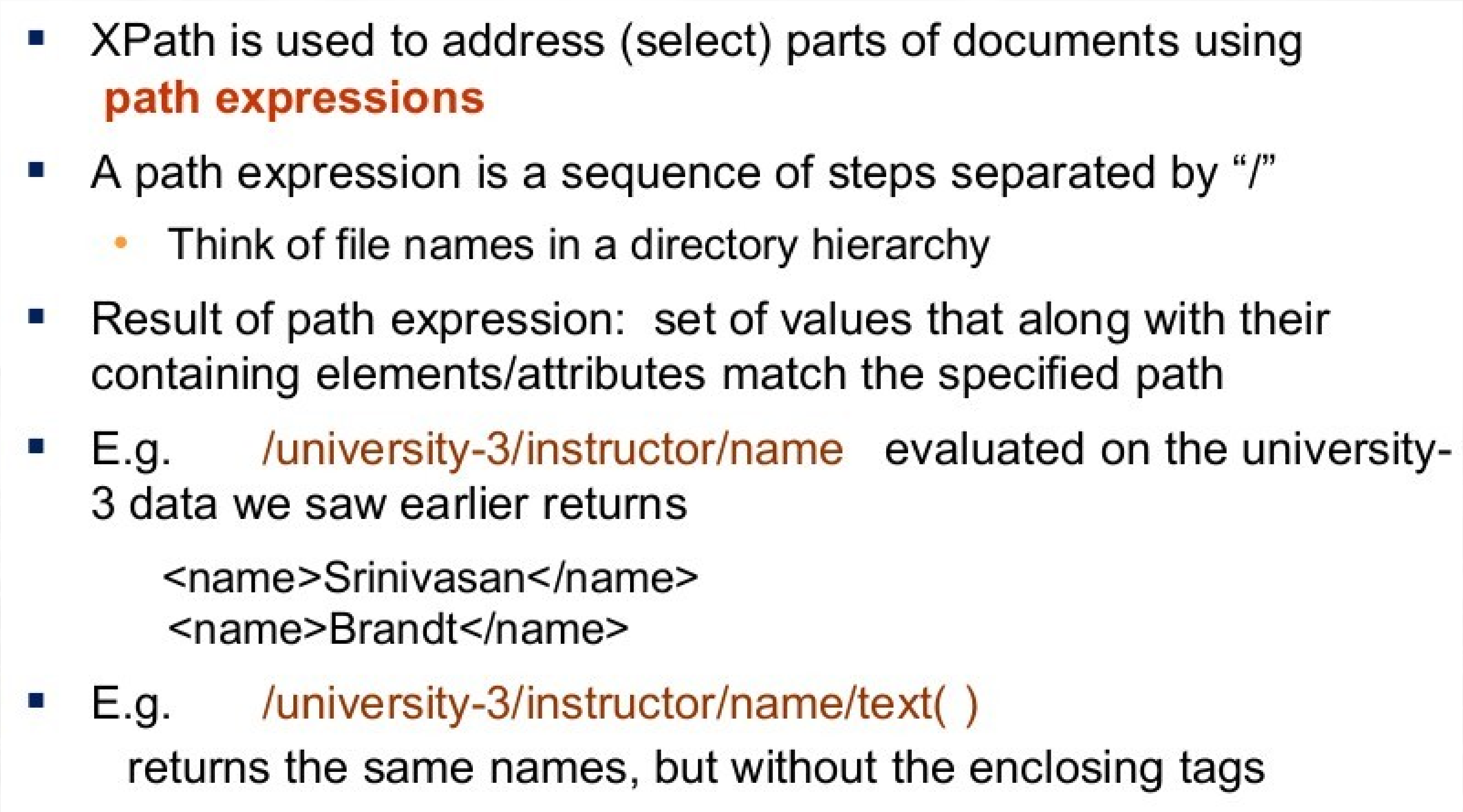
# Tree Model of XML Data

- Query and transformation languages are based on a **tree model** of XML data
- An XML document is modeled as a tree, with **nodes** corresponding to elements and attributes
  - Element nodes have child nodes, which can be attributes or subelements
  - Text in an element is modeled as a text node child of the element
  - Children of a node are ordered according to their order in the XML document
  - Element and attribute nodes (except for the root node) have a single parent, which is an element node
  - The root node has a single child, which is the root element of the document

# Tree Representation - Example



# XPath

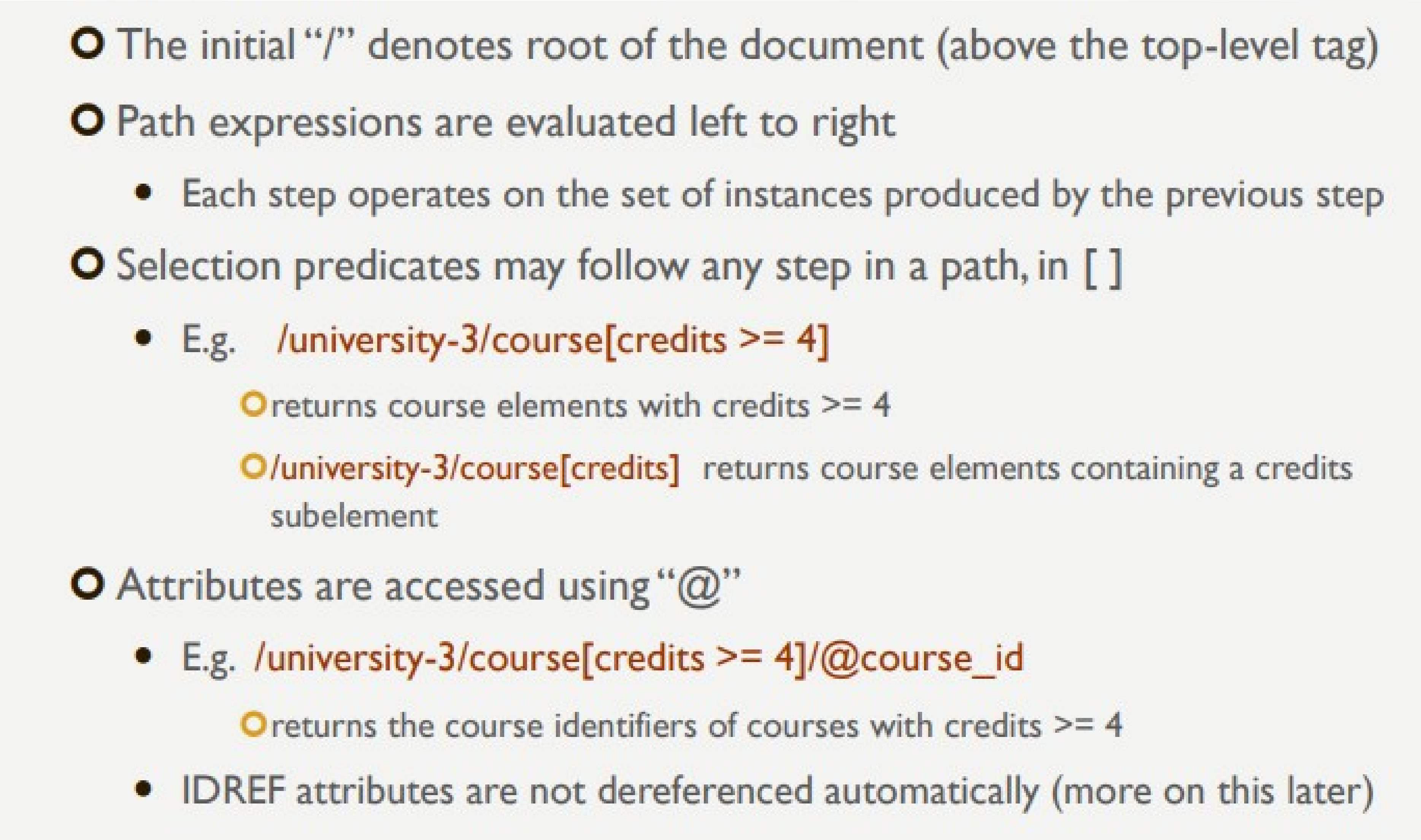


- XPath is used to address (select) parts of documents using **path expressions**
- A path expression is a sequence of steps separated by “/”
  - Think of file names in a directory hierarchy
- Result of path expression: set of values that along with their containing elements/attributes match the specified path
- E.g. /university-3/instructor/name evaluated on the university-3 data we saw earlier returns

  <name>Srinivasan</name>
  <name>Brandt</name>
- E.g. /university-3/instructor/name/text( )

  returns the same names, but without the enclosing tags

# XPath (Cont.)



- The initial "/" denotes root of the document (above the top-level tag)
- Path expressions are evaluated left to right
  - Each step operates on the set of instances produced by the previous step
- Selection predicates may follow any step in a path, in [ ]
  - E.g. /university-3/course[credits >= 4]
    - returns course elements with credits >= 4
    - /university-3/course[credits] returns course elements containing a credits subelement
- Attributes are accessed using "@"
  - E.g. /university-3/course[credits >= 4]/@course_id
    - returns the course identifiers of courses with credits >= 4
  - IDREF attributes are not dereferenced automatically (more on this later)

# Functions in XPath

- XPath provides several functions
  - The function count() at the end of a path counts the number of elements in the set generated by the path
    - E.g. /university-2/instructor[count(./teaches/course)> 2]
      - Returns instructors teaching more than 2 courses (on university-2 schema)
  - Also function for testing position (1, 2, ..) of node w.r.t. siblings
- Boolean connectives and and or and function not() can be used in predicates
- IDREFs can be referenced using function id()
  - id() can also be applied to sets of references such as IDREFS and even to strings containing multiple references separated by blanks
  - E.g. /university-3/course/id(@dept_name)
    - returns all department elements referred to from the dept_name attribute of course elements.

# More XPath Features

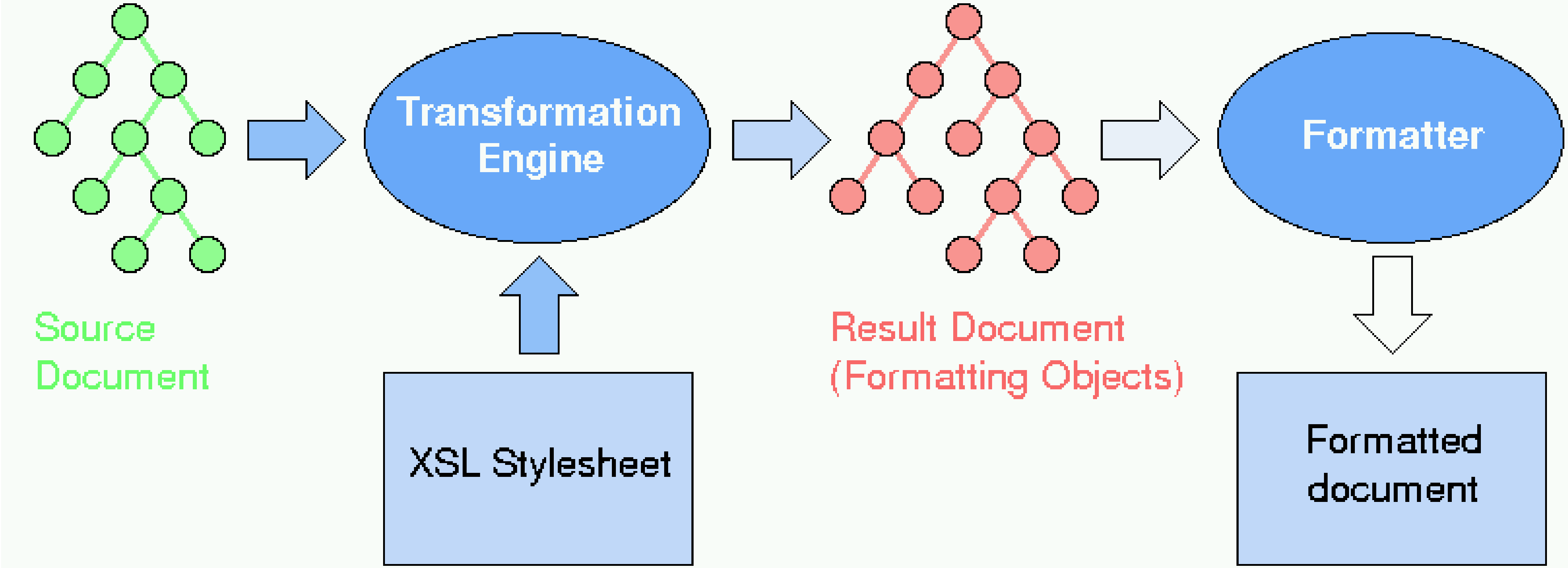
- Operator “|” used to implement union
  - E.g. /university-3/course[@dept name=“Comp. Sci”] | /university-3/course[@dept name=“Biology”]
    - Gives union of Comp. Sci. and Biology courses
    - However, “|” cannot be nested inside other operators.
- “//” can be used to skip multiple levels of nodes
  - E.g. /university-3//name
    - finds any name element *anywhere* under the /university-3 element, regardless of the element in which it is contained.
- A step in the path can go to parents, siblings, ancestors and descendants of the nodes generated by the previous step, not just to the children
  - “//”, described above, is a short from for specifying “all descendants”
  - “..” specifies the parent.
- doc(name) returns the root of a named document

# Extensible Stylesheet Language (XSL)

XSL is a language for expressing
stylesheets

- support for browsing, printing, and aural
- rendering  formatting highly structured
- documents (XML)
  performing complex publishing tasks: tables of contents,
- indexes,  reports,…
- addressing accessibility and internationalization issues
  written in XML

# XSL Architecture

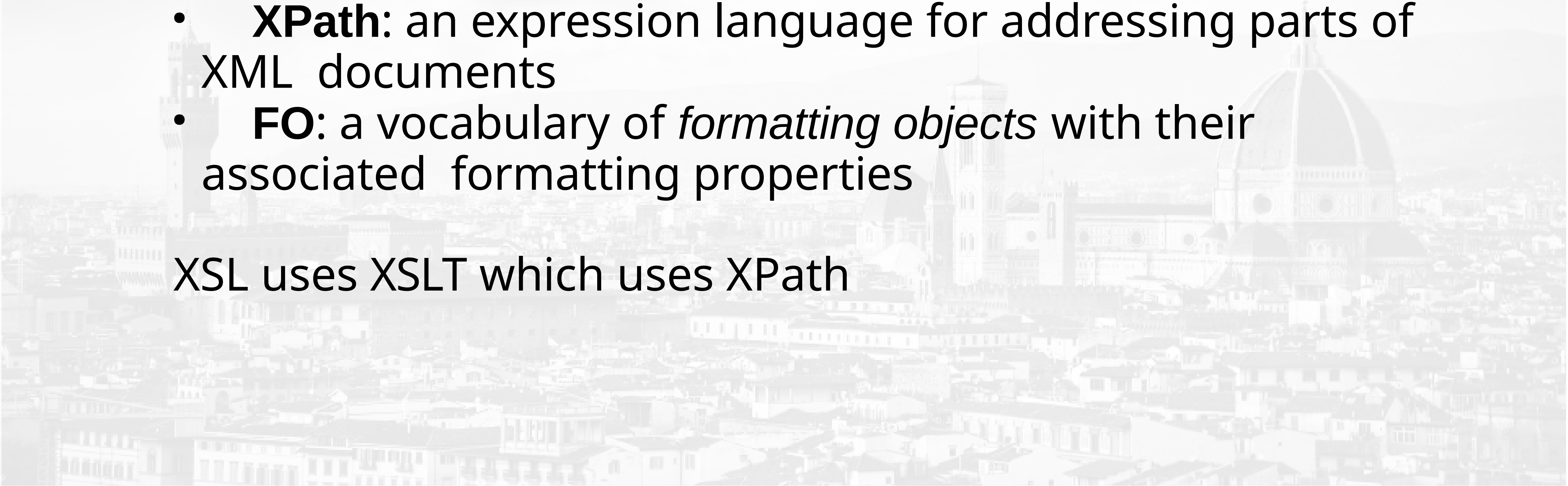


# XSL Components

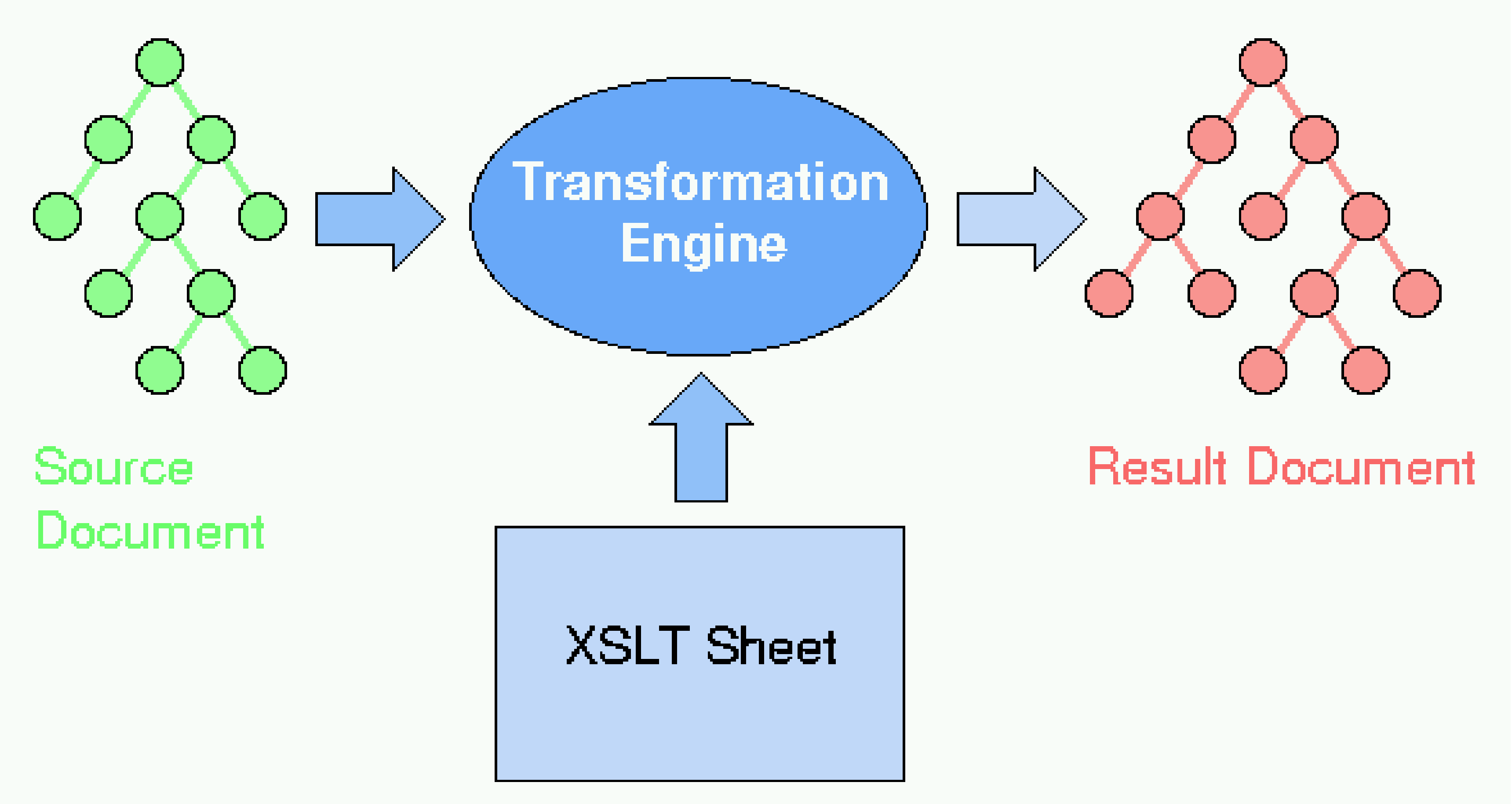
XSL is constituted of three main components:

- **XSLT**: a transformation language
- **XPath**: an expression language for addressing parts of XML documents
- **FO**: a vocabulary of *formatting objects* with their associated formatting properties

XSL uses XSLT which uses XPath



# XSL Transformations

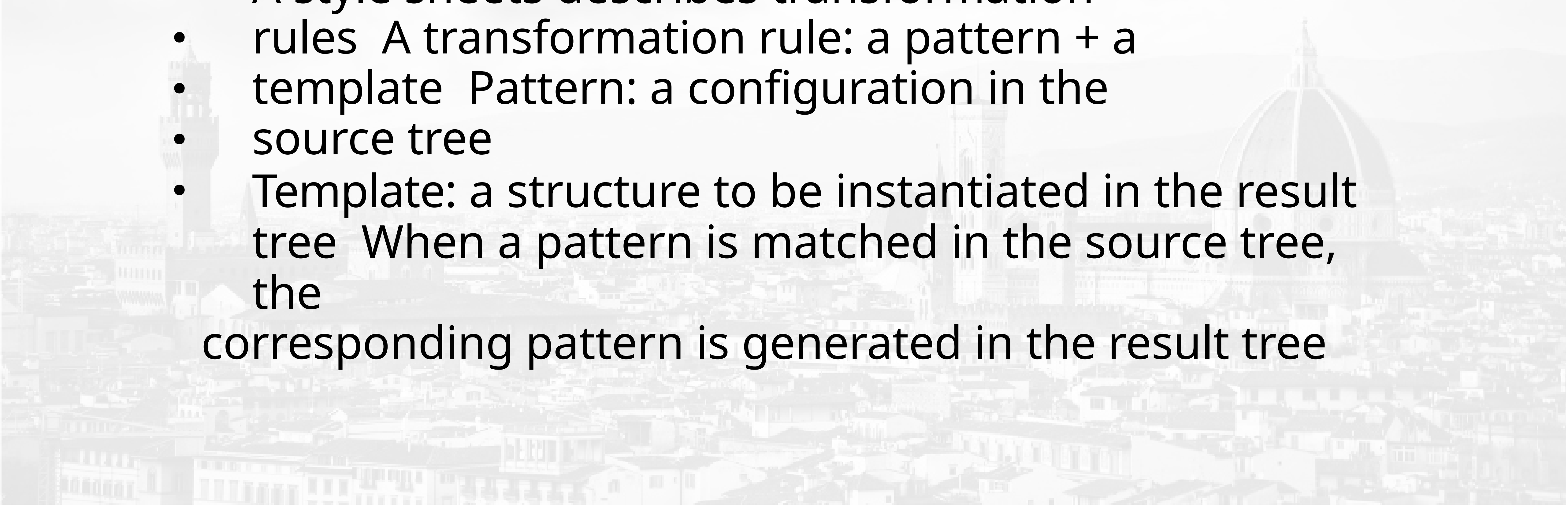


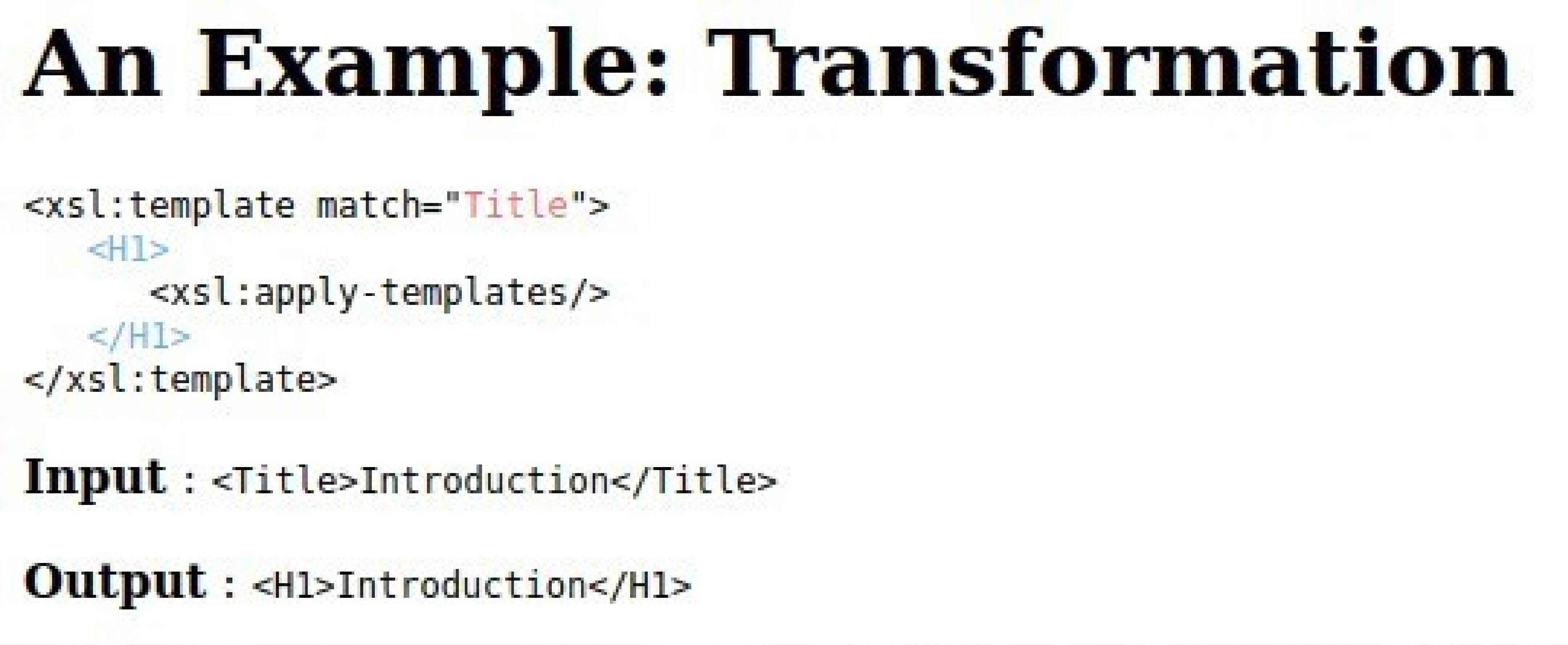
# XSLT - Basic Principle

**Patterns** and **Templates**

- A style sheets describes transformation
- rules  A transformation rule: a pattern + a
- template  Pattern: a configuration in the
- source tree
- Template: a structure to be instantiated in the result tree  When a pattern is matched in the source tree, the

corresponding pattern is generated in the result tree



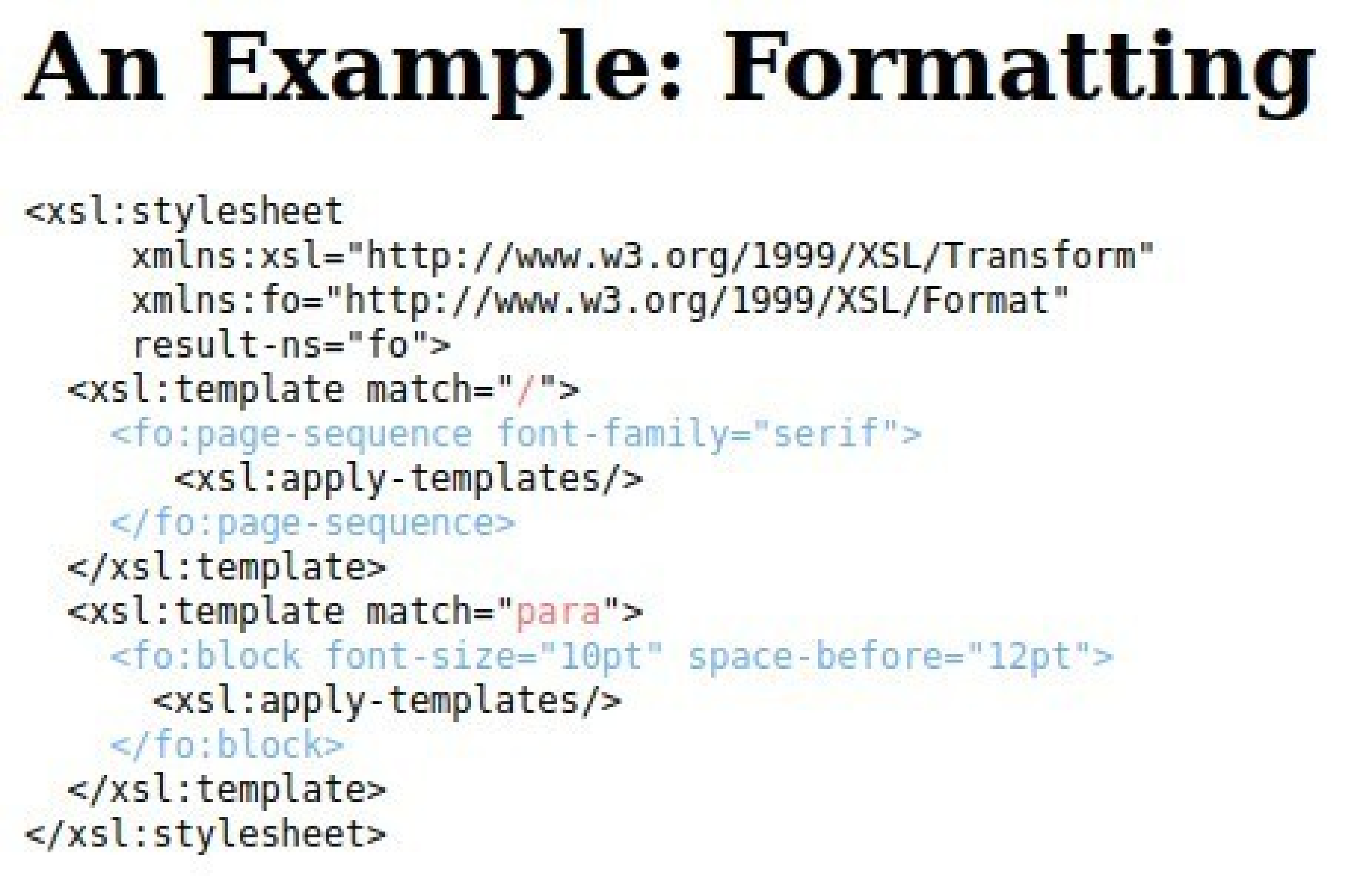


# An Example: Transformation

```
<xsl:template match="Title">
   <H1>
      <xsl:apply-templates/>
   </H1>
</xsl:template>
```

**Input** : `<Title>Introduction</Title>`

**Output** : `<H1>Introduction</H1>`



# An Example: Formatting

```
<xsl:stylesheet
     xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
     xmlns:fo="http://www.w3.org/1999/XSL/Format"
     result-ns="fo">
  <xsl:template match="/">
    <fo:page-sequence font-family="serif">
       <xsl:apply-templates/>
    </fo:page-sequence>
  </xsl:template>
  <xsl:template match="para">
    <fo:block font-size="10pt" space-before="12pt">
      <xsl:apply-templates/>
    </fo:block>
  </xsl:template>
</xsl:stylesheet>
```

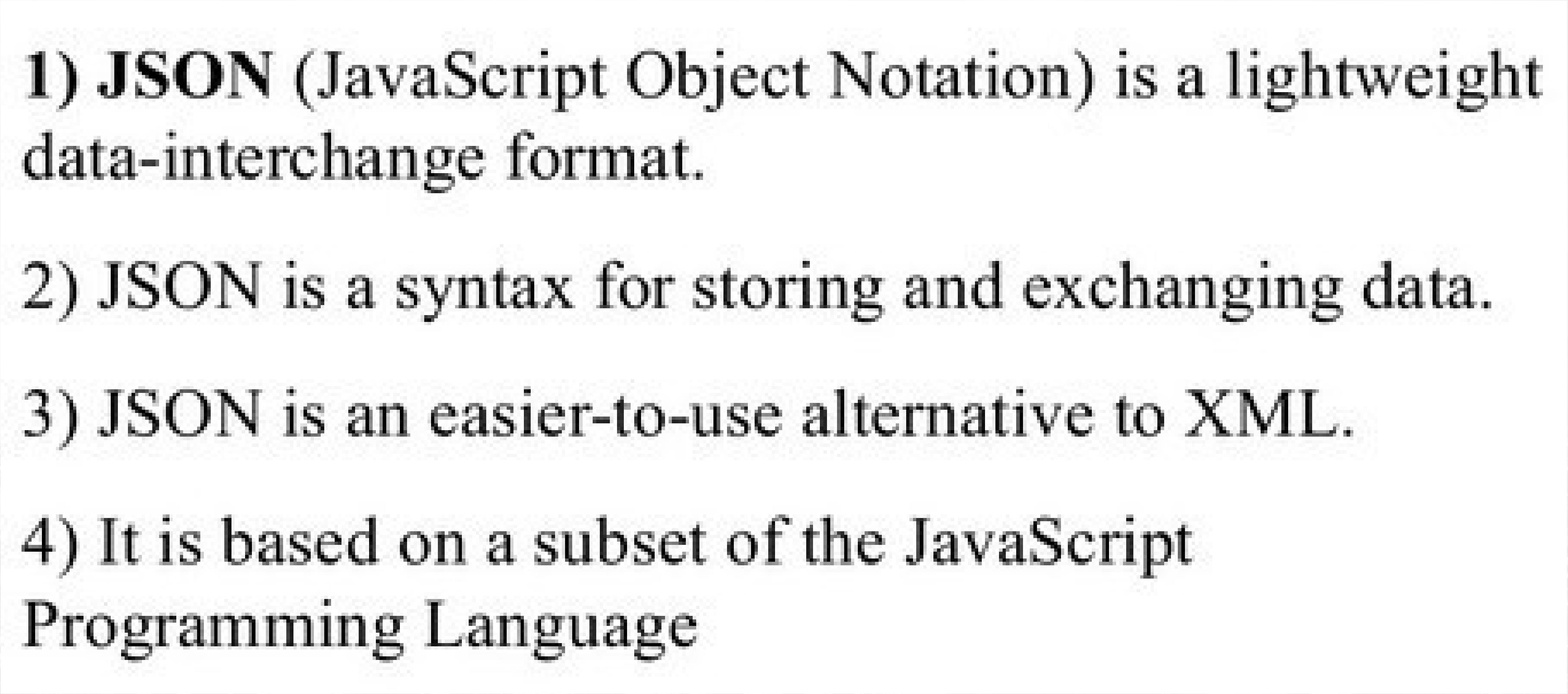
# XSL Usage

- Format XML documents by generating FOs
- Generate HTML or XHTML pages from XML
- data/documents  Transform XML documents into other
- XML documents  Generate some textual representation
- of an XML document

…and more

XSL may be used server-side or client-side,
 but is not intended to send FOs over the
wire

# JSON

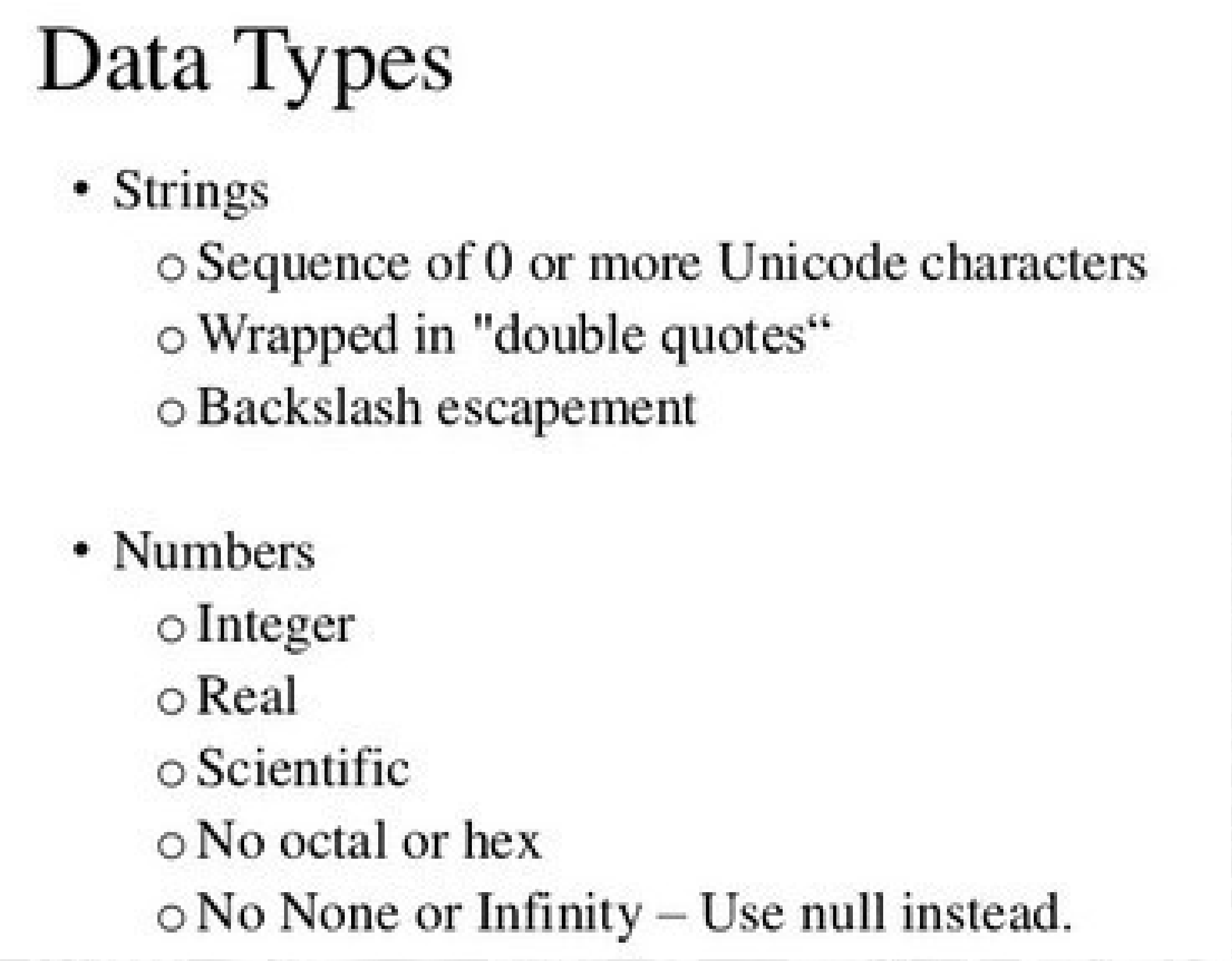


**1) JSON** (JavaScript Object Notation) is a lightweight data-interchange format.

2) JSON is a syntax for storing and exchanging data.

3) JSON is an easier-to-use alternative to XML.

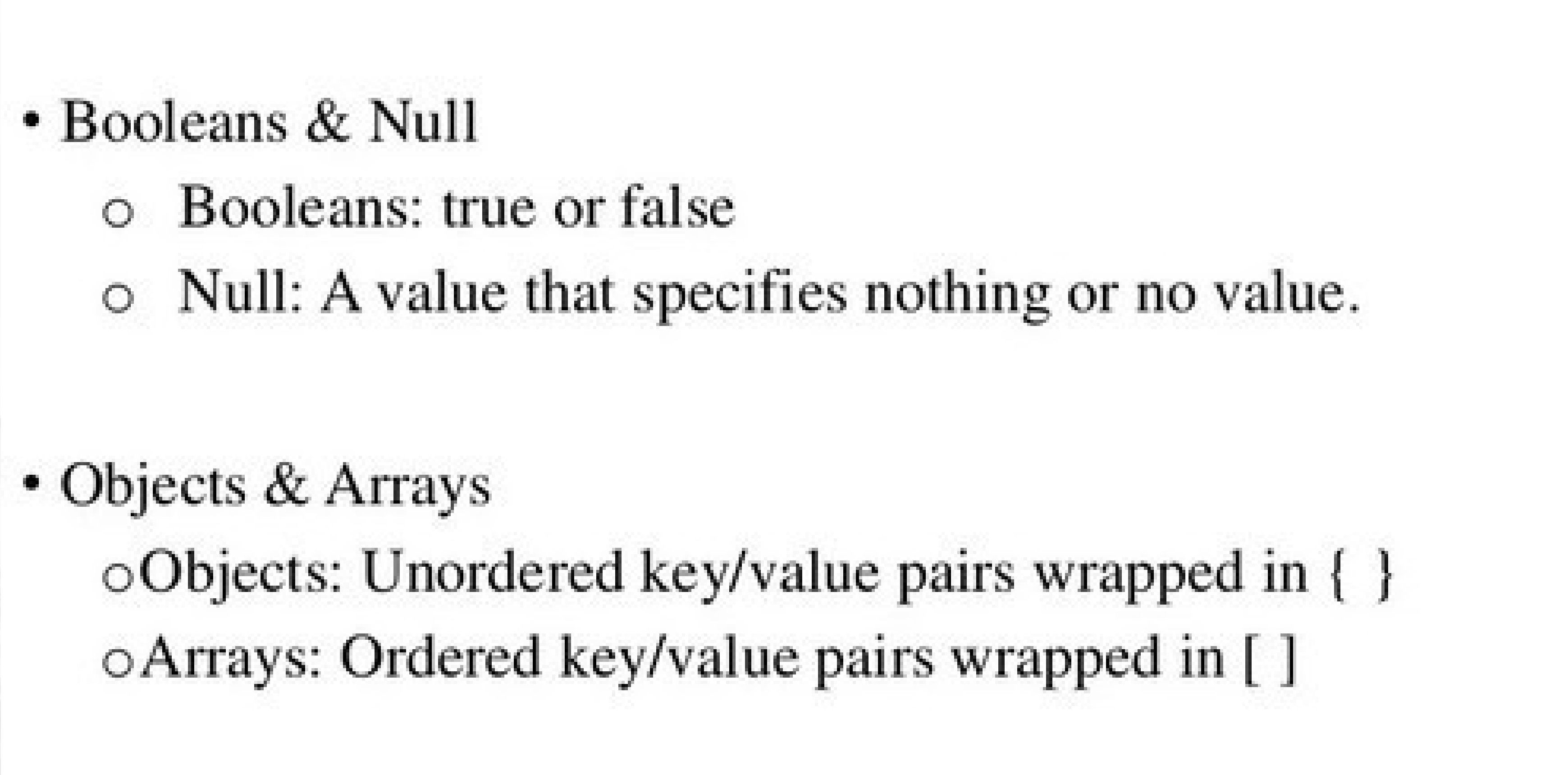
4) It is based on a subset of the JavaScript Programming Language



# Data Types

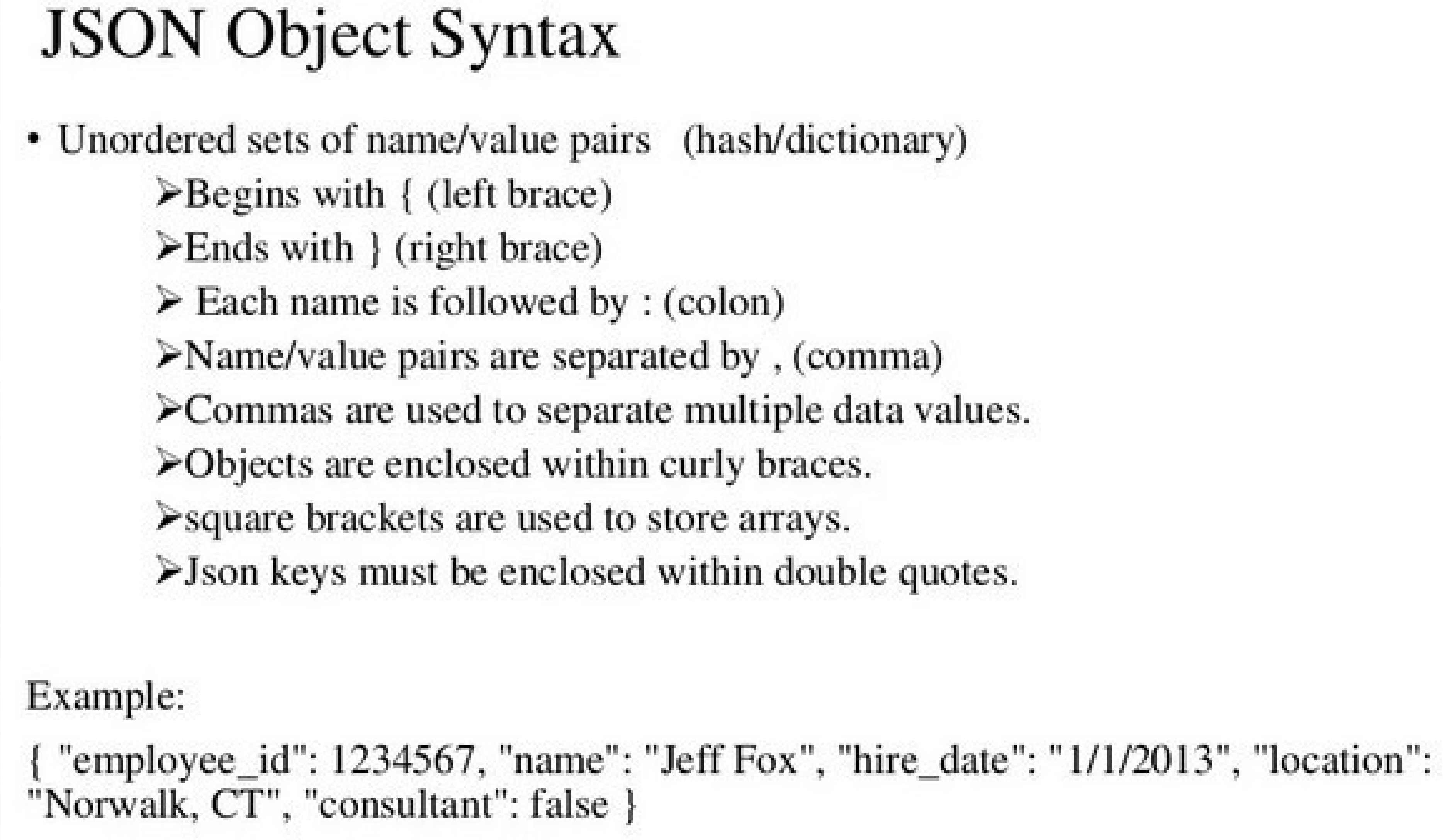
- Strings
  - Sequence of 0 or more Unicode characters
  - Wrapped in "double quotes“
  - Backslash escapement

- Numbers
  - Integer
  - Real
  - Scientific
  - No octal or hex
  - No None or Infinity – Use null instead.



- Booleans & Null
  - Booleans: true or false
  - Null: A value that specifies nothing or no value.

- Objects & Arrays
  - Objects: Unordered key/value pairs wrapped in { }
  - Arrays: Ordered key/value pairs wrapped in [ ]

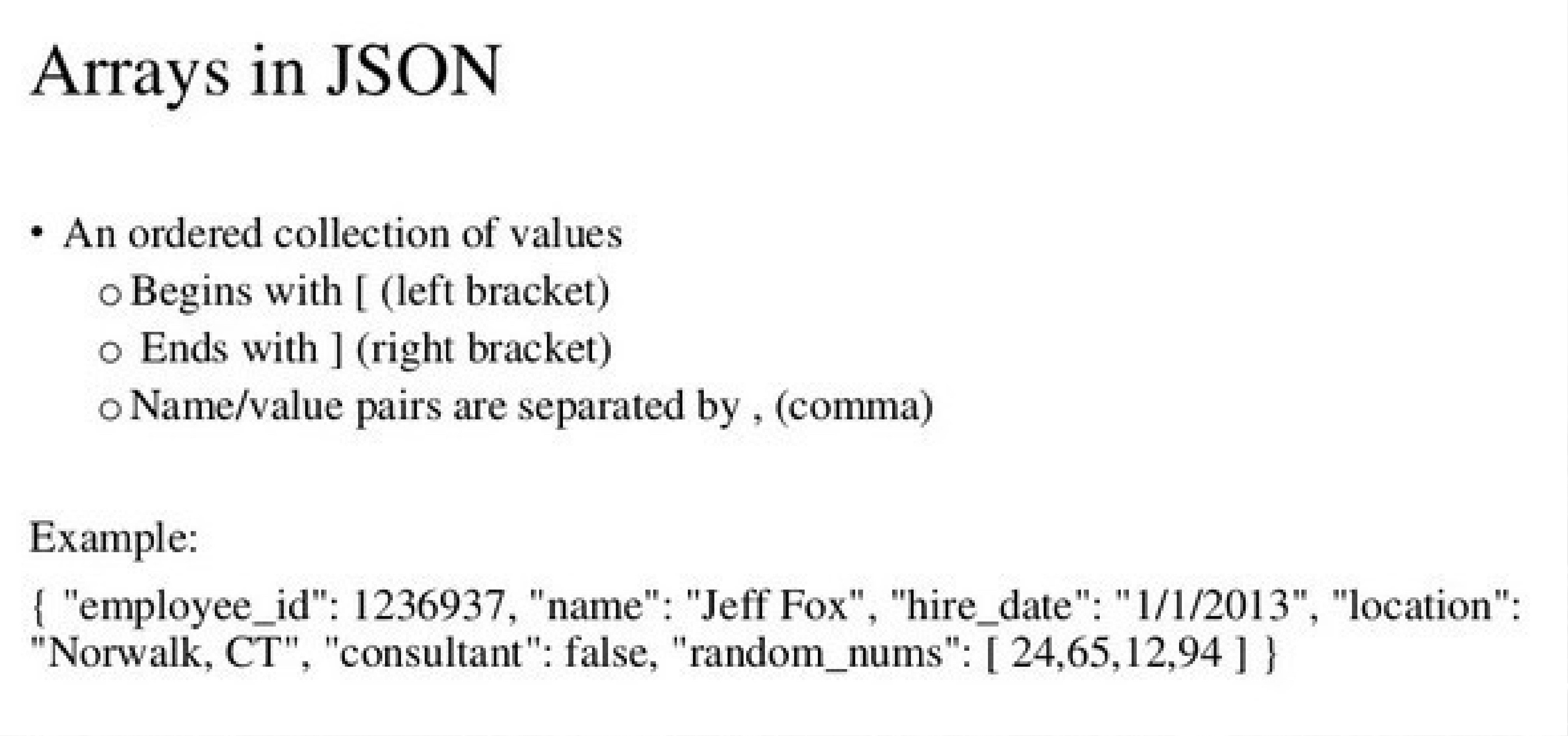


# JSON Object Syntax

- Unordered sets of name/value pairs (hash/dictionary)
  - ➢Begins with { (left brace)
  - ➢Ends with } (right brace)
  - ➢ Each name is followed by : (colon)
  - ➢Name/value pairs are separated by , (comma)
  - ➢Commas are used to separate multiple data values.
  - ➢Objects are enclosed within curly braces.
  - ➢square brackets are used to store arrays.
  - ➢Json keys must be enclosed within double quotes.

Example:

```
{ "employee_id": 1234567, "name": "Jeff Fox", "hire_date": "1/1/2013", "location":
"Norwalk, CT", "consultant": false }
```



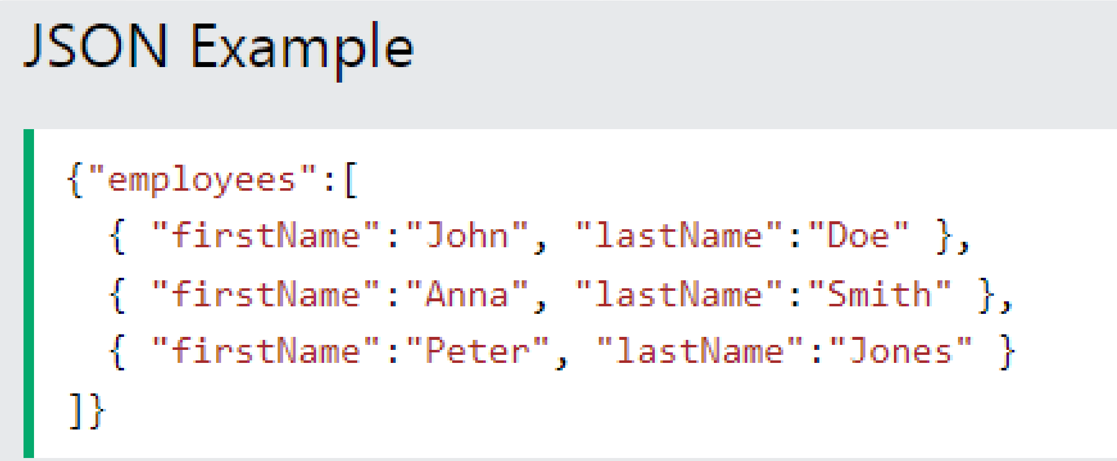
# Arrays in JSON

- An ordered collection of values
  - Begins with [ (left bracket)
  - Ends with ] (right bracket)
  - Name/value pairs are separated by , (comma)

Example:

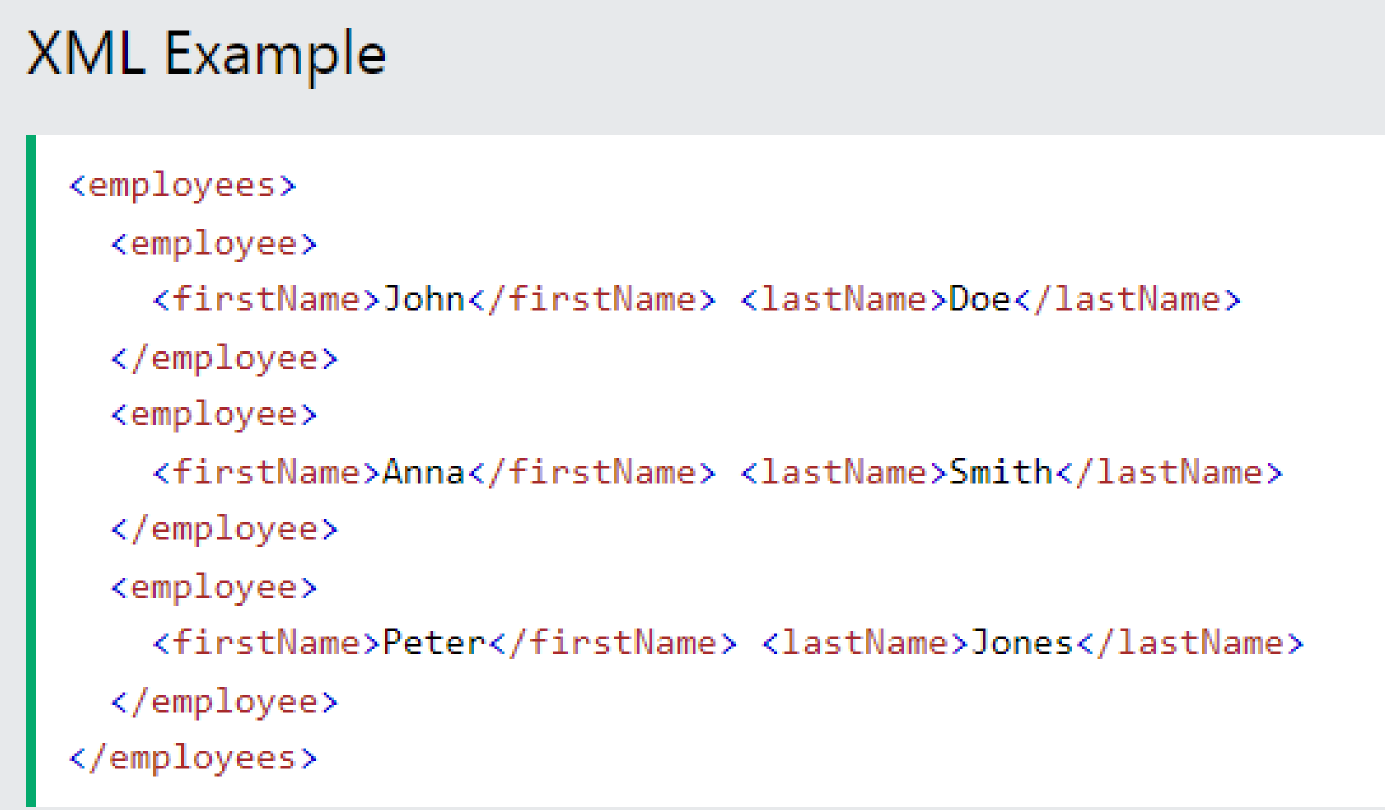
{ "employee_id": 1236937, "name": "Jeff Fox", "hire_date": "1/1/2013", "location": "Norwalk, CT", "consultant": false, "random_nums": [ 24,65,12,94 ] }

# JSON Vs XML



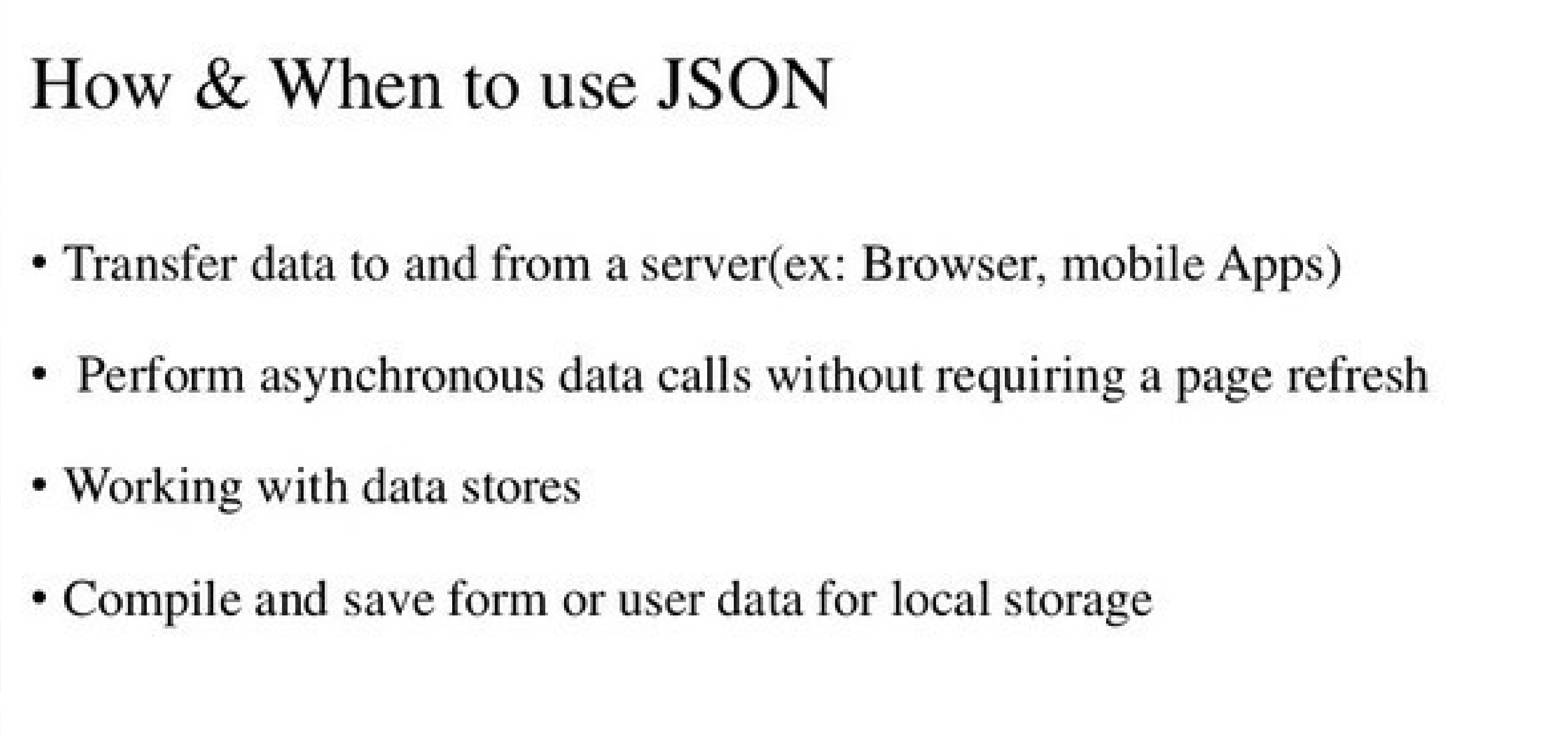
## JSON Example

```
{"employees":[
  { "firstName":"John", "lastName":"Doe" },
  { "firstName":"Anna", "lastName":"Smith" },
  { "firstName":"Peter", "lastName":"Jones" }
]}
```



## XML Example

```
<employees>
  <employee>
    <firstName>John</firstName> <lastName>Doe</lastName>
  </employee>
  <employee>
    <firstName>Anna</firstName> <lastName>Smith</lastName>
  </employee>
  <employee>
    <firstName>Peter</firstName> <lastName>Jones</lastName>
  </employee>
</employees>
```



# How & When to use JSON

- Transfer data to and from a server(ex: Browser, mobile Apps)
- Perform asynchronous data calls without requiring a page refresh
- Working with data stores
- Compile and save form or user data for local storage

# Thank You!