Web Security

Lecture 18

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Introduction

- Real-world web app., data are stored in *database*
  - *save* data to or *get* data from database
    - construct *SQL* statement
    - send *SQL* statement to *database*
      - *database*
        - execute *SQL* statement
        - return results back to web app.
- SQL statement *usually* contains ***user-provide data***
  - what if a SQL statement is not constructed properly?
    - injecting ***code*** into *SQL* statement
      - cause database to execute ***code***
      - SQL injection vulnerability

A Brief Tutorial of SQL

- Login to database, e.g., MySQL:
  - use MySQL database, which is an open-source relational database management system
  - login using the following command

```
$ mysql -uroot -pseedubuntu
Welcome to the MySQL monitor.
...
mysql>
```

login name password

mysql prompt: indicating login successfully

Note:
- space between –u and login name
- space between –p and password

- create database:
  - inside MySQL, create multiple databases
    - *'SHOW DATABSES'* command can be used to list existing databases
  - create new database called *dbtest*

```
mysql> SHOW DATABASES;
......
mysql> CREATE DATABASE dbtest;
```

create database command

SQL commands are not case sensitive
- using upper-case to separate from non-commands in lower-case

SQL Tutorial: Create a Table

- Relational database organizes data using tables
  - database has multiple tables
- create table called *employee* with seven attributes (i.e., columns) for the database *dbtest*

select database to use

```
mysql> USE dbtest
mysql> CREATE TABLE employee (
  ID       INT (6) NOT NULL AUTO_INCREMENT,
  Name     VARCHAR (30) NOT NULL,
  EID      VARCHAR (7) NOT NULL,
  Password VARCHAR (60),
  Salary   INT (10),
  SSN      VARCHAR (11),
  PRIMARY KEY (ID)
);
mysql> DESCRIBE employee;
+----------+-------------+------+-----+---------+----------------+
| Field    | Type        | Null | Key | Default | Extra          |
+----------+-------------+------+-----+---------+----------------+
| ID       | int(6)      | NO   | PRI | NULL    | auto_increment |
| Name     | varchar(30) | NO   |     | NULL    |                |
| EID      | varchar(30) | NO   |     | NULL    |                |
| Password | varchar(60) | YES  |     | NULL    |                |
| Salary   | int(10)     | YES  |     | NULL    |                |
| SSN      | varchar(11) | YES  |     | NULL    |                |
+----------+-------------+------+-----+---------+----------------+
```

define the structure of table 'employee'

- table columns are defined inside parentheses
  - each column contains
    - name, followed by type
    - number: maximum length
    - constraints (i.e., NOT NULL)

display the structure of table 'employee'

SQL Tutorial: Insert a Row

- use the '*INSERT INTO*' statement to insert new record into table:

```
mysql> INSERT INTO employee (Name, EID, Password, Salary, SSN)
       VALUES ('Ryan Smith', 'EID5000', 'paswd123', 80000,
               '555-55-5555');
```

  - insert a record into *employee* table
  - did not specify a value of the *ID column*, as it will be automatically set by the database

SQL Tutorial: Insert a Row

- the '*SELECT*' statement is the most common operation on databases
  - retrieves information from database

all records

```
mysql> SELECT * FROM employee;
+----+---------+---------+----------+--------+-------------+
| ID | Name    | EID     | Password | Salary | SSN         |
+----+---------+---------+----------+--------+-------------+
|  1 | Alice   | EID5000 | paswd123 |  80000 | 555-55-5555 |
|  2 | Bob     | EID5001 | paswd123 |  80000 | 555-66-5555 |
|  3 | Charlie | EID5002 | paswd123 |  80000 | 555-77-5555 |
|  4 | David   | EID5003 | paswd123 |  80000 | 555-88-5555 |
+----+---------+---------+----------+--------+-------------+
mysql> SELECT Name, EID, Salary FROM employee;
+---------+---------+--------+
| Name    | EID     | Salary |
+---------+---------+--------+
| Alice   | EID5000 |  80000 |
| Bob     | EID5001 |  80000 |
| Charlie | EID5002 |  80000 |
| David   | EID5003 |  80000 |
+---------+---------+--------+
```

asks the database for all its records, including all the columns

asks the database only for Name, EID and Salary columns

SQL Tutorial: WHERE Clause

- it is uncommon for a SQL query to retrieve all records in database
- '*WHERE*' clause is used to set conditions for several types of SQL statements including '*SELECT*', '*UPDATE*', '*DELETE*', etc.

```
mysql> SQL Statement
       WHERE predicate;
```

  - the above SQL statement only affects the rows for which the predicate in the '*WHERE*' clause is *TRUE*
    - row for which predicate evaluates to *FALSE* or *Unknown* are *not affected*
  - the predicate is a logical expression
    - multiple predicates can be combined using keywords *AND* and *OR*

SQL Tutorial: WHERE Clause

```
mysql> SELECT * FROM employee WHERE EID='EID5001';
+----+------+---------+----------+--------+-------------+
| ID | Name | EID     | Password | Salary | SSN         |
+----+------+---------+----------+--------+-------------+
|  2 | Bob  | EID5001 | paswd123 |  80000 | 555-66-5555 |
+----+------+---------+----------+--------+-------------+

mysql> SELECT * FROM employee WHERE EID='EID5001' OR Name='David';
+----+-------+---------+----------+--------+-------------+
| ID | Name  | EID     | Password | Salary | SSN         |
+----+-------+---------+----------+--------+-------------+
|  2 | Bob   | EID5001 | paswd123 |  80000 | 555-66-5555 |
|  4 | David | EID5003 | paswd123 |  80000 | 555-88-5555 |
+----+-------+---------+----------+--------+-------------+
```

- 1st query: return a record that has EID5001 in the EID field
- 2nd query: return the records that satisfy either EID = 'EID5001' or Name = 'David'

SQL Tutorial: WHERE Clause

- if the condition is always *True*, then all the rows are affected by SQL statement

```
mysql> SELECT * FROM employee WHERE 1=1;
+----+---------+---------+----------+--------+-------------+
| ID | Name    | EID     | Password | Salary | SSN         |
+----+---------+---------+----------+--------+-------------+
|  1 | Alice   | EID5000 | paswd123 |  80000 | 555-55-5555 |
|  2 | Bob     | EID5001 | paswd123 |  80000 | 555-66-5555 |
|  3 | Charlie | EID5002 | paswd123 |  80000 | 555-77-5555 |
|  4 | David   | EID5003 | paswd123 |  80000 | 555-88-5555 |
+----+---------+---------+----------+--------+-------------+
```

- this **1 = 1** predicate looks quite useless in real queries
  - useful in SQL Injection attacks

SQL Tutorial: UPDATE Statement

- use the '*UPDATE*' Statement to modify an existing record

multiple columns separated by comma

```
mysql> UPDATE employee SET Salary=82000 WHERE Name='Bob';
mysql> SELECT * FROM employee WHERE Name='Bob';
+----+------+---------+----------+--------+-------------+
| ID | Name | EID     | Password | Salary | SSN         |
+----+------+---------+----------+--------+-------------+
|  2 | Bob  | EID5001 | paswd123 |  82000 | 555-66-5555 |
+----+------+---------+----------+--------+-------------+
```

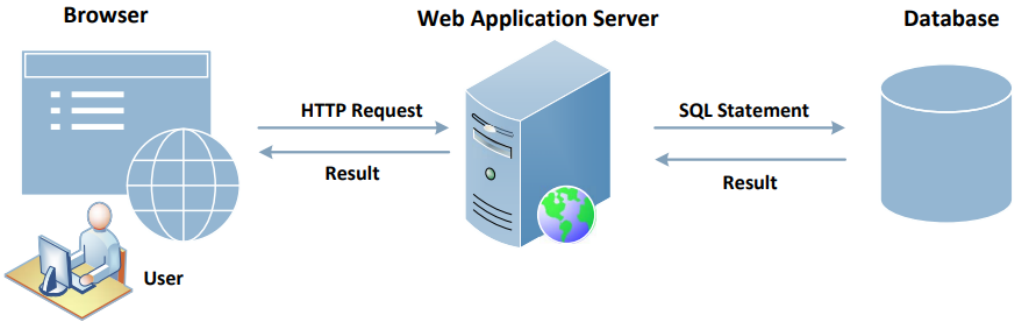
SQL Tutorial: Comments

- MySQL supports three comment styles
  - text from the # character to the end of line is treated as a comment
  - text from the -- _ (space) to the end of line is treated as a comment
    - this style requires the second dash to be followed by at least one whitespace or control character
  - similar to C language, text between /* and */ is treated as a comment
    - this style allows comment to be inserted into the middle of SQL statement; commend can span multiple lines

```
mysql> SELECT * FROM employee;    # Comment to the end of line
mysql> SELECT * FROM employee;    -- Comment to the end of line
mysql> SELECT * FROM /* In-line comment */ employee;
```

Interacting with Database in Web Application

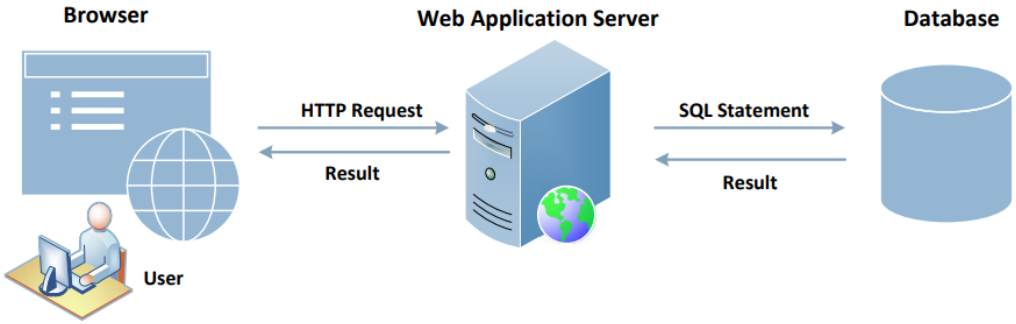
- Typical web app. consists of three major components:



  - web browser
    - get content; present content; interact with user; get user input
    - communicate with web app. server using HTTP or HTTPS
  - web app. server
    - generate and deliver content to browser; rely on independent database server for data management
    - interact with database using SQL
  - database

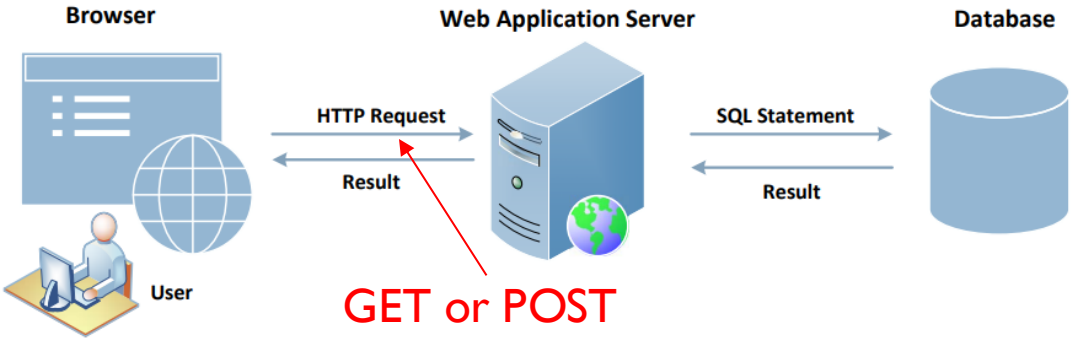
Interacting with Database in Web Application

- Typical web app. consists of three major components:



- ***SQL injection attacks*** can cause ***damage*** to database
- users do not directly interact with database but through web server
  - web app. server provide a channel for user's data to reach database
  - if this channel is not implemented properly, malicious users can attack database

Getting Data from User



- Form where users can type their data
  - once '*Submit*' button is clicked, an HTTP request will be sent out with data attached

EID EID5000
Password paswd123
Submit

- HTML source of the above form is given below:

```
<form action="getdata.php" method="get">
  EID:      <input type="text" name="EID"><br>
  Password: <input type="text" name="Password"><br>
            <input type="submit" value="Submit">
</form>
```

- request generated is:

name of input field

```
http://www.example.com/getdata.php?EID=EID5000&Password=paswd123
```

Getting Data from User

```
<form action="getdata.php" method="get">
  EID:      <input type="text" name="EID"><br>
  Password: <input type="text" name="Password"><br>
            <input type="submit" value="Submit">
</form>
```

- HTTP GET request
  - method field in HTML code specified GET type
  - in GET requests, parameters are attached after the question mark ? in the URL

```
http://www.example.com/getdata.php?EID=EID5000&Password=paswd123
```

  - each parameter has a name=value pair and are separated by "&"
  - in the case of HTTPS, the format would be similar but the data will be encrypted
- once this request reached the target PHP script (getdata.php)
  - the parameters inside HTTP request will be saved to an array $_GET or $_POST
  - an example shows a PHP script getting data from GET request

```
<?php
   $eid = $_GET['EID'];
   $pwd = $_GET['Password'];
   echo "EID: $eid --- Password: $pwd\n";
?>
```

$_GET: an associative array of variables passed to the current script via the URL parameters

Launching SQL Injection Attacks

- user input will become part of the SQL statement
  - is it possible for a user to change the meaning of the SQL statement?
- example: the intention of the web app developer by the following is for user to provide some data for the blank areas

```
SELECT Name, Salary, SSN
FROM employee
WHERE eid=' [                ] ' and password=' [                ] '
```

  - what if user inputs a random string in the password entry and types "EID5002' #" in the eid entry
  - the SQL statement will become the following

```
SELECT Name, Salary, SSN
FROM employee
WHERE eid= 'EID5002' #' and password='xyz'
```

everything from # sign to the end of line is considered as comment

Launching SQL Injection Attacks

- the SQL statement will be equivalent to the following:

```
SELECT Name, Salary, SSN
FROM employee
WHERE eid= 'EID5002'
```

  - return the name, salary and SSN of the employee whose EID is EID5002 even though the user doesn't know the employee's password.
- let's see if a user can get all the records from the database
  - assuming that we don't know all the EID's in the database
  - create a predicate for 'WHERE' clause so that it is true for all records

```
SELECT Name, Salary, SSN
FROM employee
WHERE eid= 'a' OR 1=1
```

always true