CSCI 476: Computer Security

SQL Injection Attack (Part 1)

Reese Pearsall

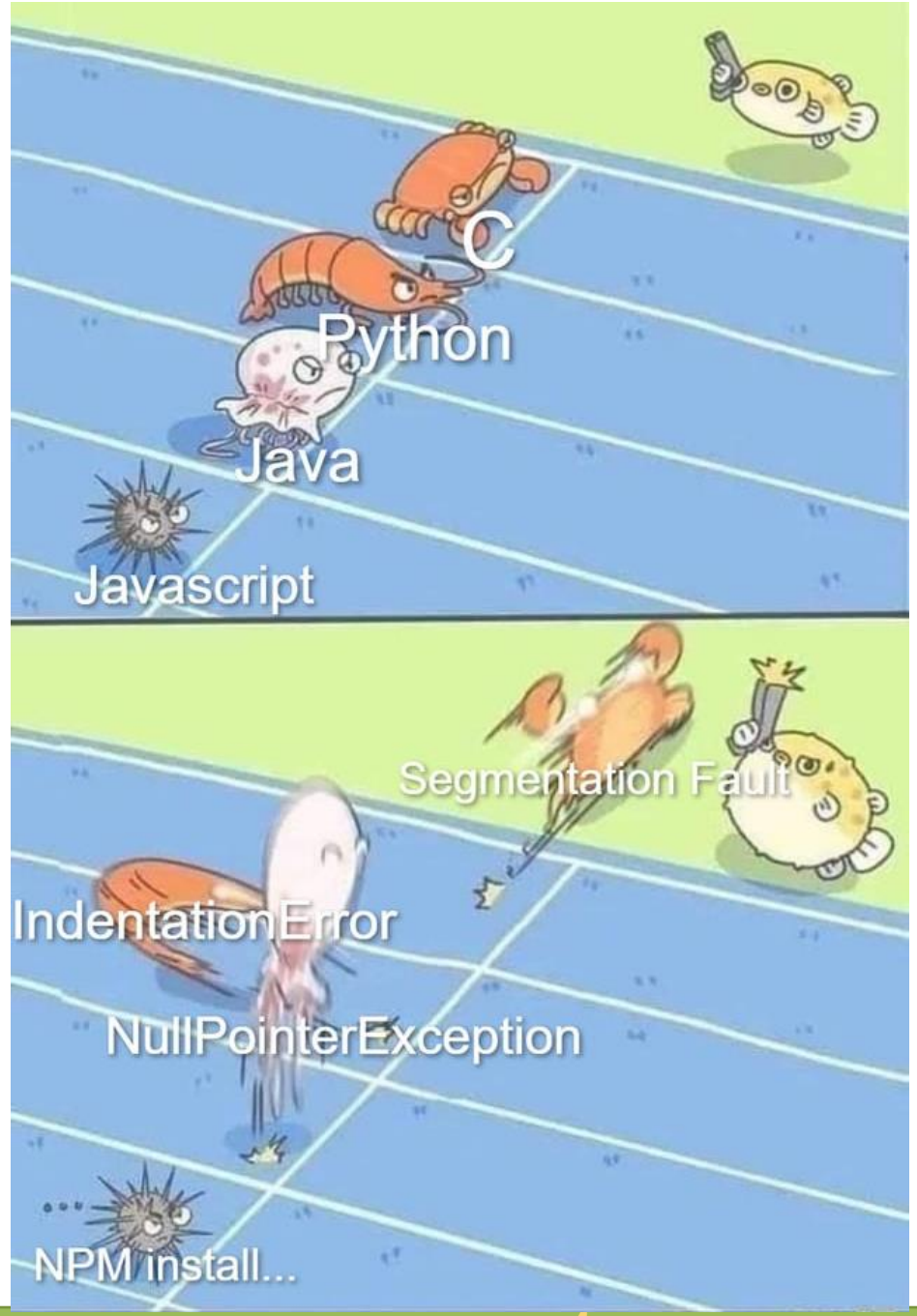
Spring 2023

Announcements

Lab 3 (Buffer Overflow) Due Sunday **March 5th** @ **11:59 PM**

Friday will be a lab 3 help session (no lecture)

Next week might be a little bit wacky



Research Project

Security Research Project

Due **Sunday** April 23rd

Overview

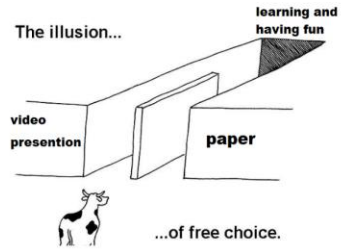
We cant cover all the different areas of security in this class. This project is designed for you to research an interesting topic in security of your choice. You have the choice of writing a paper, or creating a video presentation of your topic. You can submit your research project at any point during the semester.

Rules

Generally, most security topics are fair game, but there are a few ground rules.

- You must get the topic approved by Reese first (email/Discord dm/office hours)
- You cannot select a topic that we cover in this class. This is a list of the topics that I plan to cover in this class
- Don't select a topic that might require you to download malware onto your machine. That is a bad idea.

Instructions



Partners are NOT allowed and you CANT use a late pass on this assignment. There are two options for the research project. You must select one.

I. Paper

You will write at least a 4 page paper (double spaced) about your topic. In your paper, you should include at least 3 references from some online or physical source. You should *at least* address the following topics in your paper:

- **Introduction-** Clearly state your topic and its relevancy/importance in cybersecurity. If this is a recent cybersecurity topic, has it appeared in the news recently?
- **Background-** Any necessary background on concepts, related projects, or literature that are necessary to understand your project.
- **System/Methodology-** Deep dive into specifics of your topic: how it works, when it would be used, defense mechanisms, severity, etc. This section will vary depending on what your topic is
- **Conclusion and future work-** What is the takeaway for your paper? What was learned? What does the future look like? Is research still being done around your topic?
- **References-** You should at least have 3 references. Use whatever citation format you would like

II. Video Presentation

You will create a video presentation that is accompanied by a powerpoint/slide deck. Your presentation should be at least 6 minutes long. You should *at least* address the following topics in your presentation:

Brief Review of The Internet

Communication of the web:

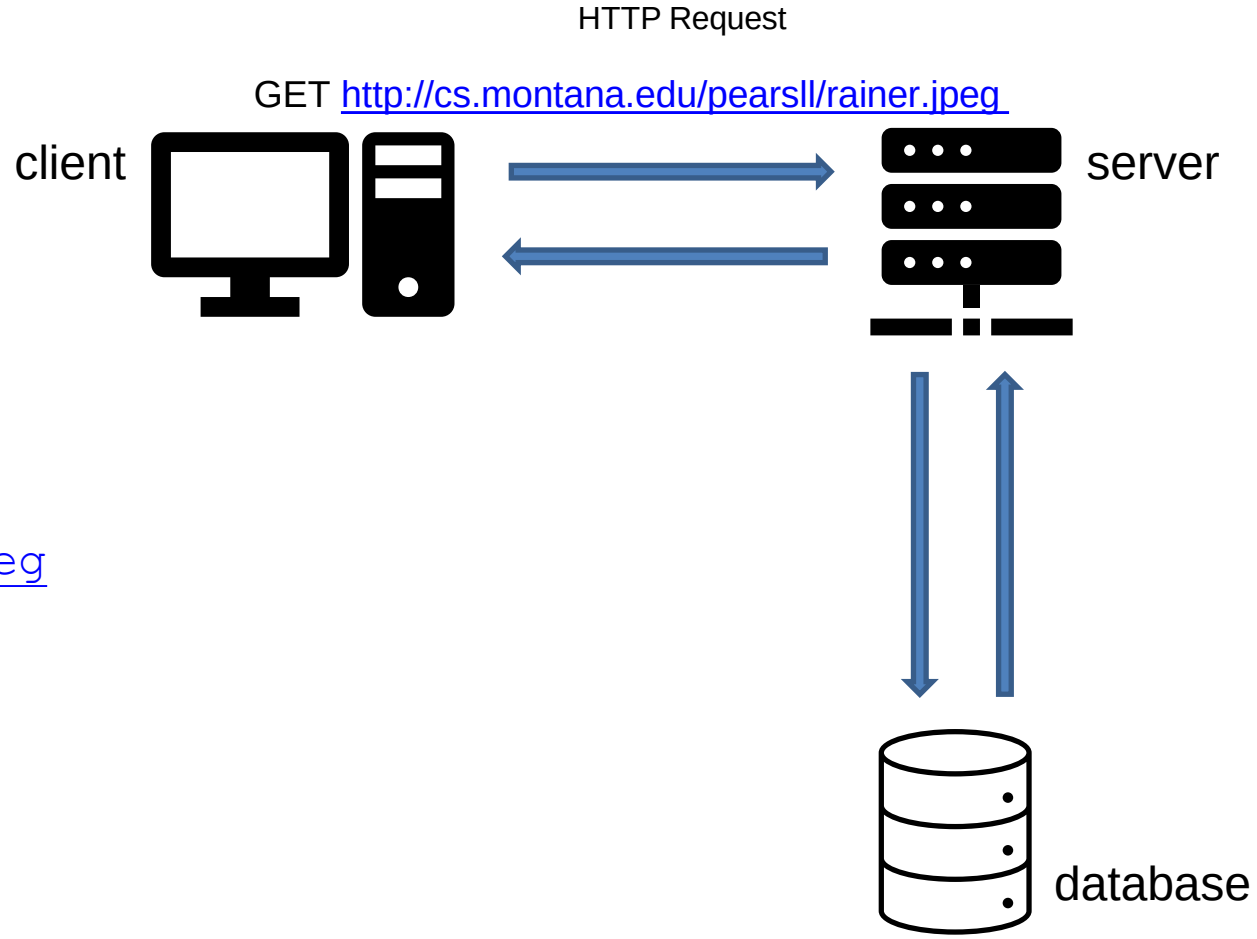
- URL

```
protocol://hostname[:port]/[path/]file
```

ex.
http://cs.montana.edu/pearsall/rainer.jpeg

HTTP Request:

- **Format**: Method, Headers, Body
- **Methods**: GET, POST, HAD, UPDATE
- Headers: Host, referrer, User-agent, Cookie…



Brief Review of The Internet

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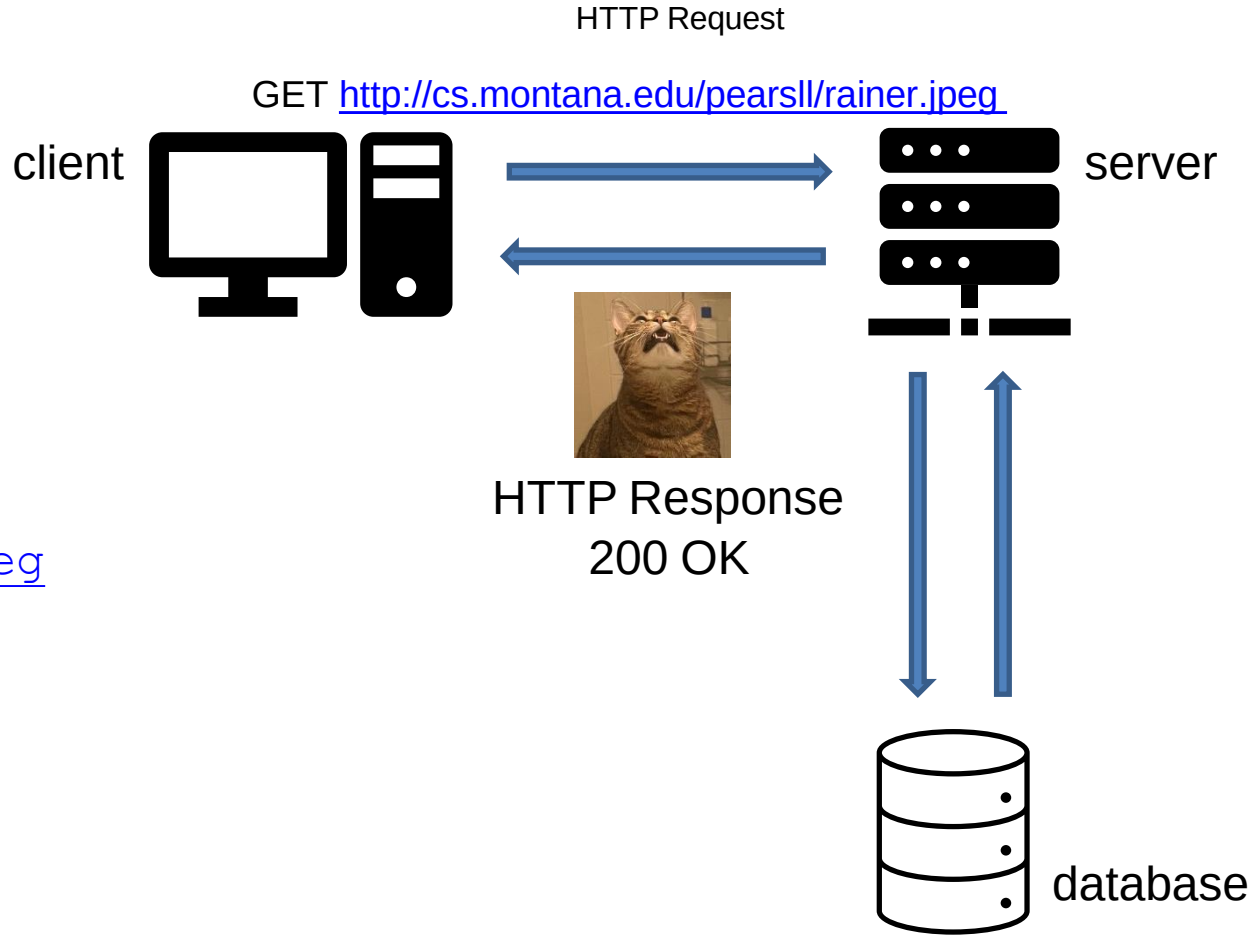


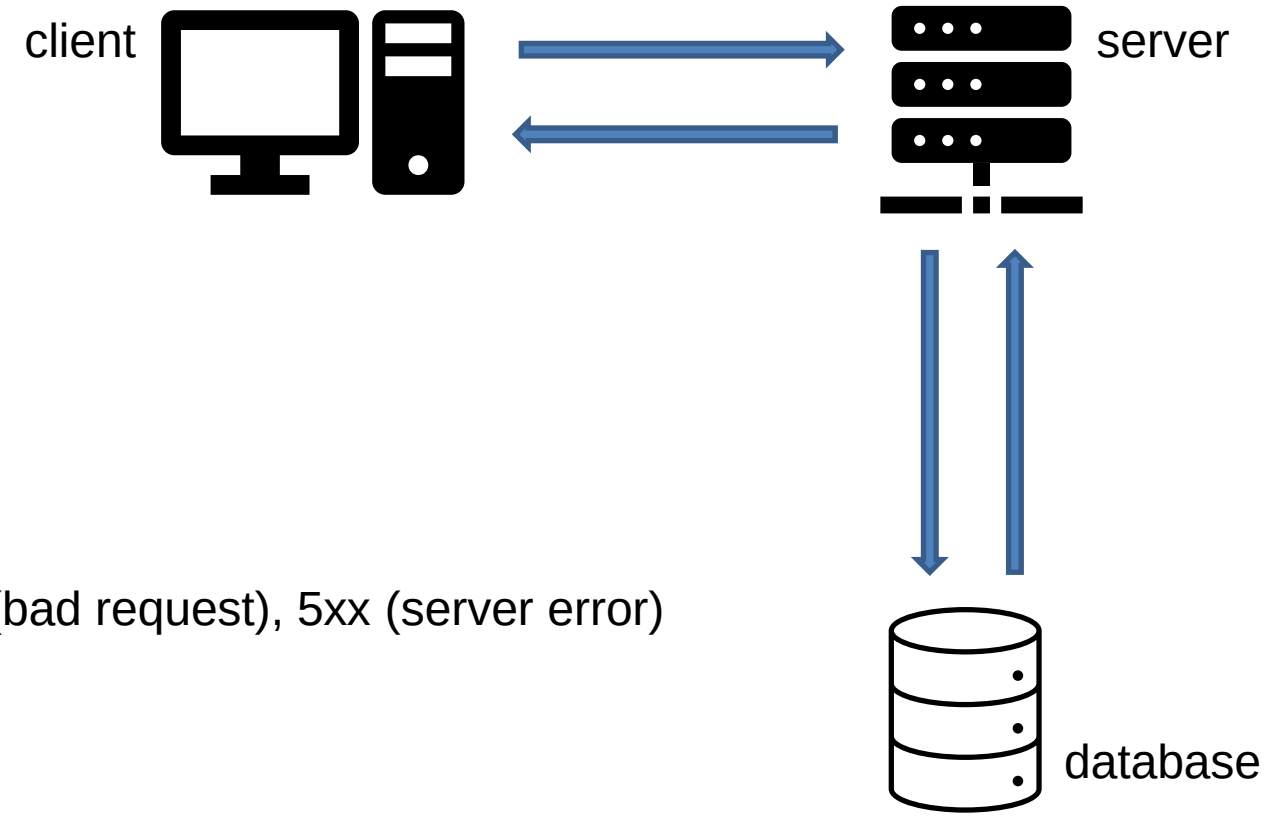
HTTP Request:

- **Format**: Method, Headers, Body
- **Methods**: GET, POST, HAD, UPDATE
- Headers: Host, referrer, User-agent, Cookie…

HTTP Response:

- **Format**: Status, Response Headers, Body
- **Status Codes**: 2xx (successful), 3xx (redirect), 4xx (bad request), 5xx (server error)

Brief Review of The Internet



Communication of the web:

- URL

HTTP Request:

- **Format**: Method, Headers, Body
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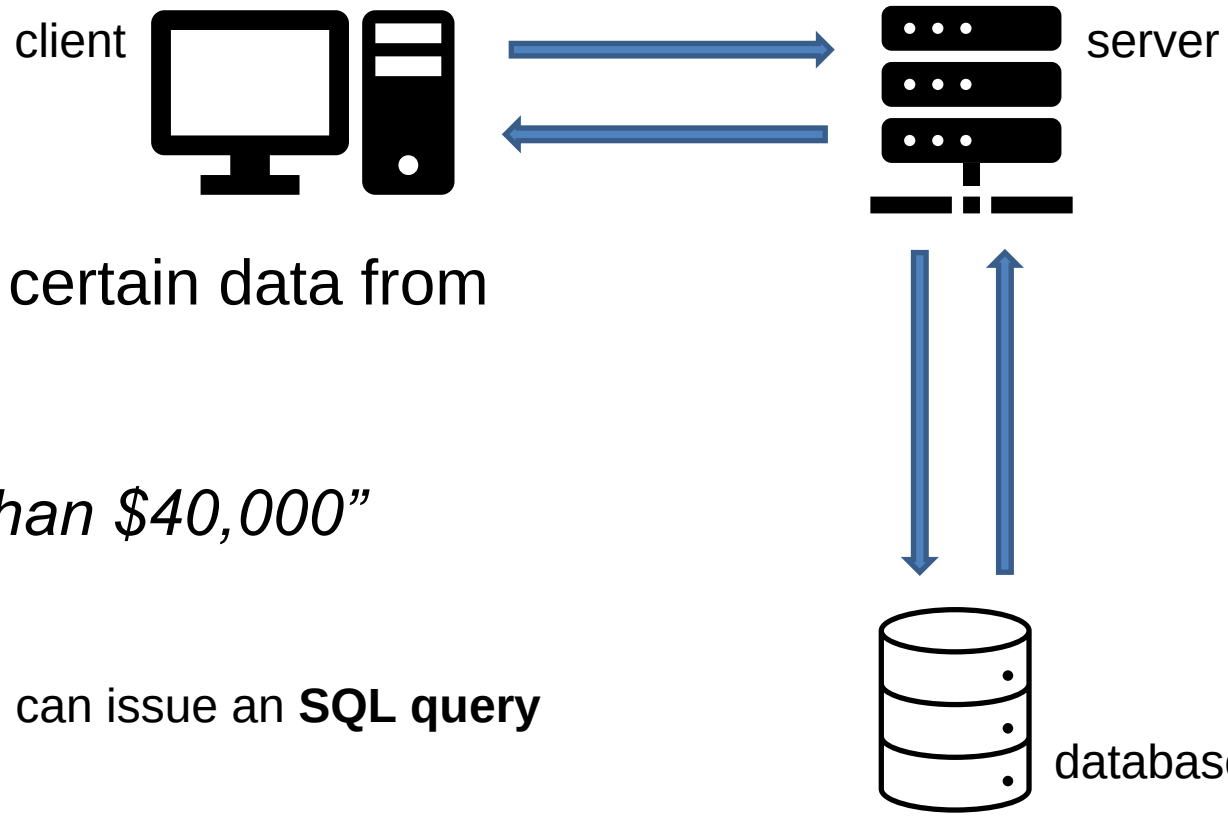
HTTP Response:

- **Format**: Status, Response Headers, Body
- **Status Codes**: 2xx (successful), 3xx (redirect), 4xx (bad request), 5xx (server error)

Server-side functionality

- Serve static resources (HTML, CSS, Images)
- Serve dynamic Resources (PHP, Ruby, Java, Javascript…)
- Query Databases
  - Relational (MySql)
  - Non-Relational (MongoDB)

Brief Review of The Internet



Often times, we will want to query only certain data from the database

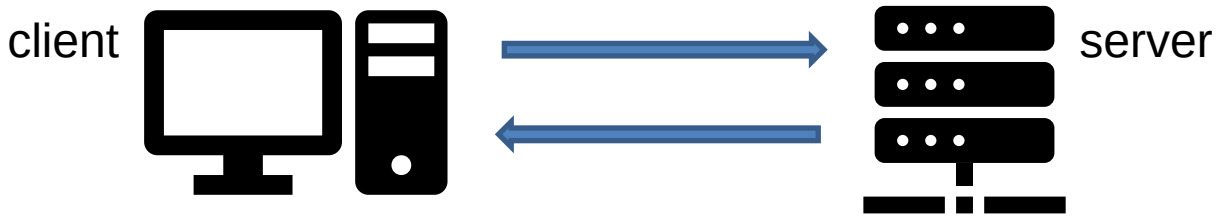
- *"Give me all the red, SUV cars"*
- *"Give me all the cars that cost less than $40,000"*

If we are working with an SQL-like database, then we can issue an **SQL query**

Query parameters can be passed via URL or in an HTTP request

```
protocol://hostname[:port]/[path/]file[?color=red&type=suv]
```

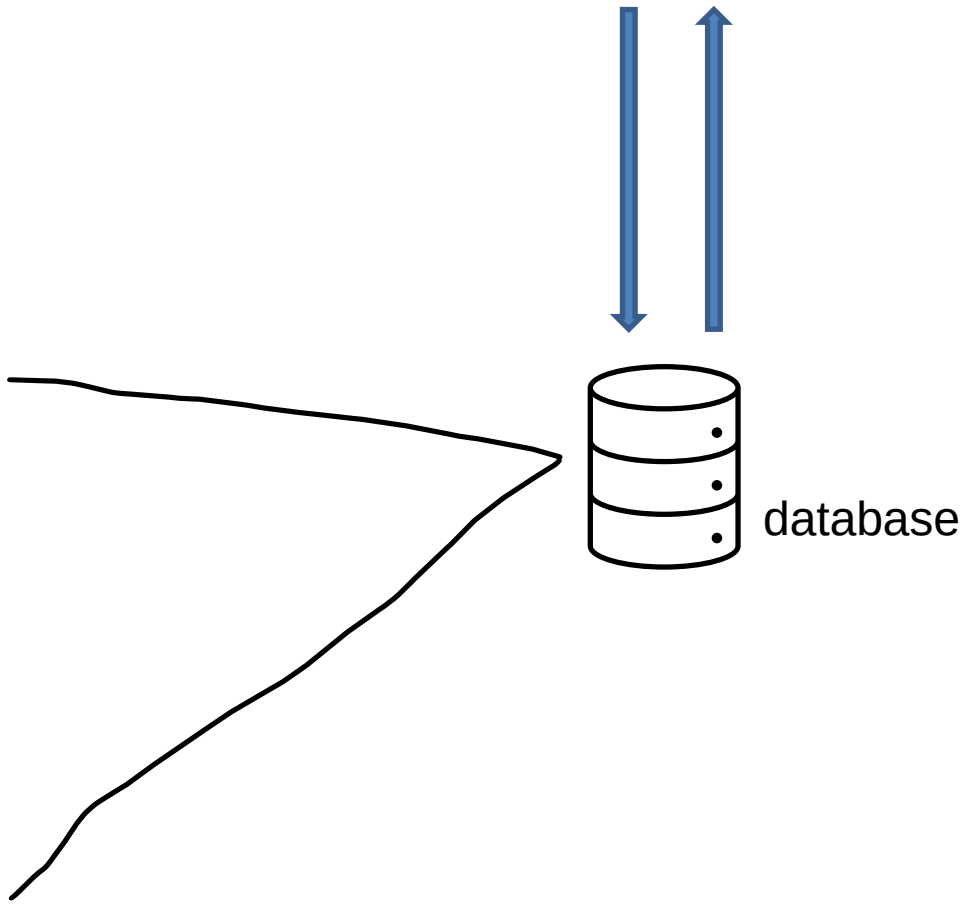
Brief Review of The Internet



In SQL, our database consists of **tables**
Each row is an entry in the database
Each column represents an attribute of the entries

FRIENDS

ID	FirstName	LastName	Age	Job
1	Reese	Pearsall	15	Instructor
2	John	Paxton	51	Director
3	Sean	Yaw	34	Professor
4	Susan	McCartney	28	Student
5	Tom	Brady	46	Quarterback
6	Parker	Pearsall	27	Chemist



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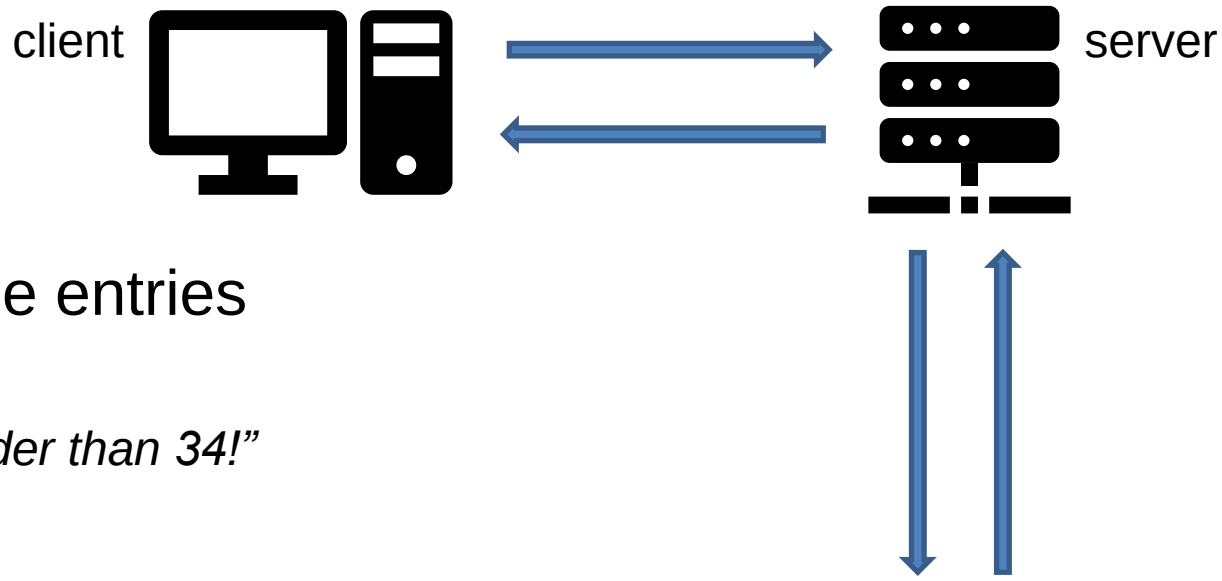

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"I want to see the names of all my friends who are older than 34!"

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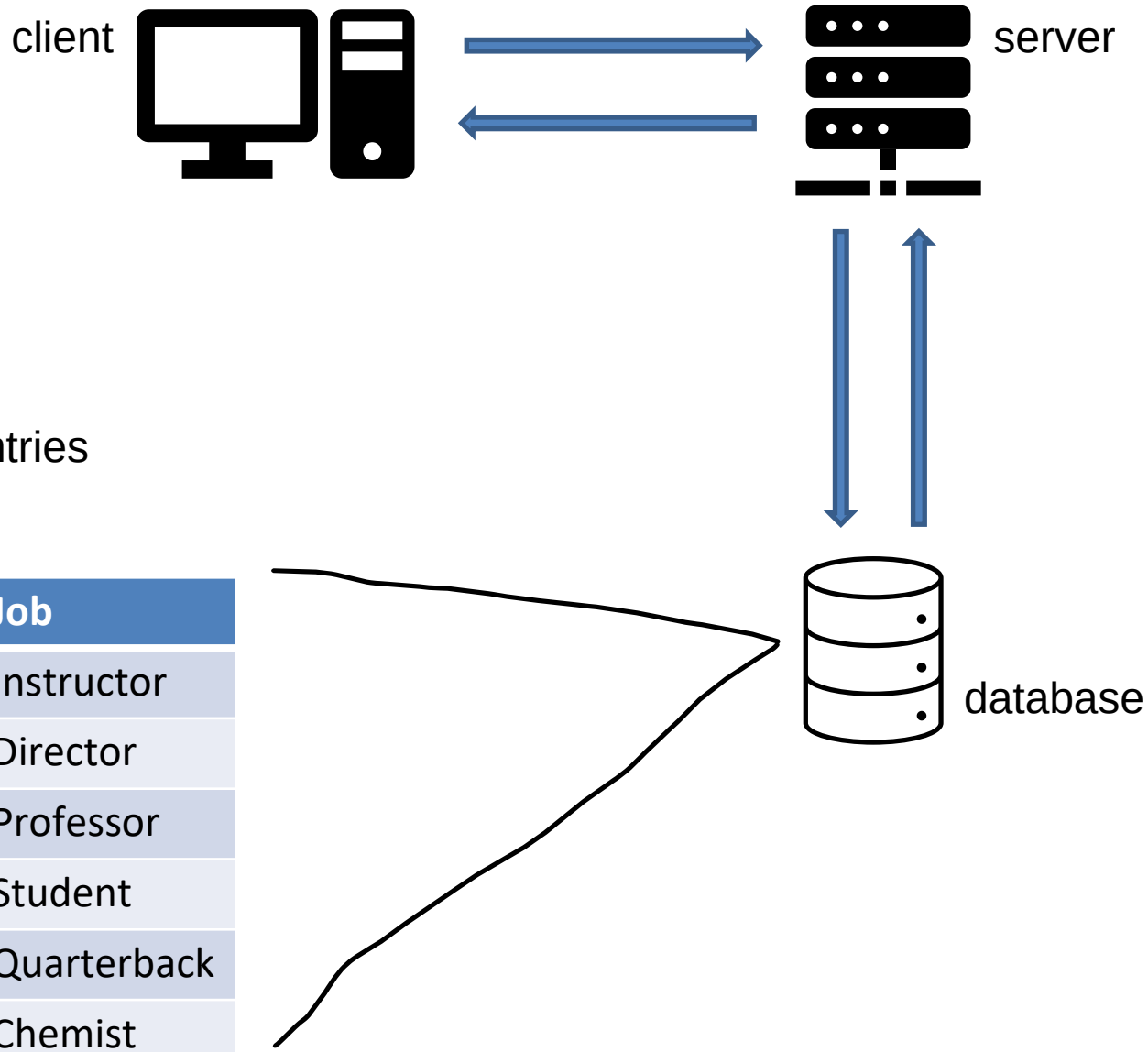

SQL Query Format

```
SELECT__FROM___WHERE __
```

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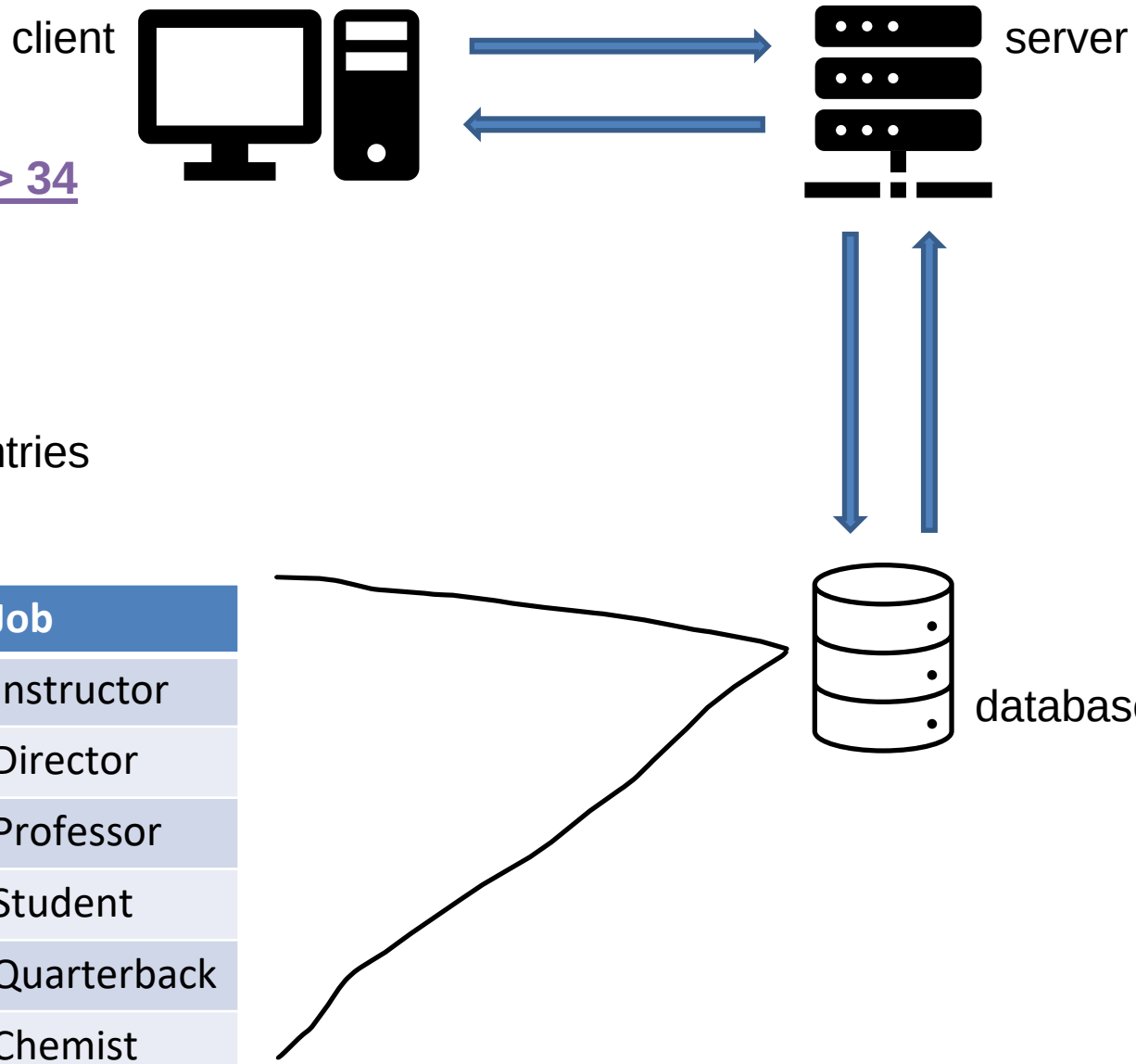

SQL Query Format

```
SELECT FirstName FROM FRIENDS WHERE AGE > 34
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In SQL, our database consists of **tables**
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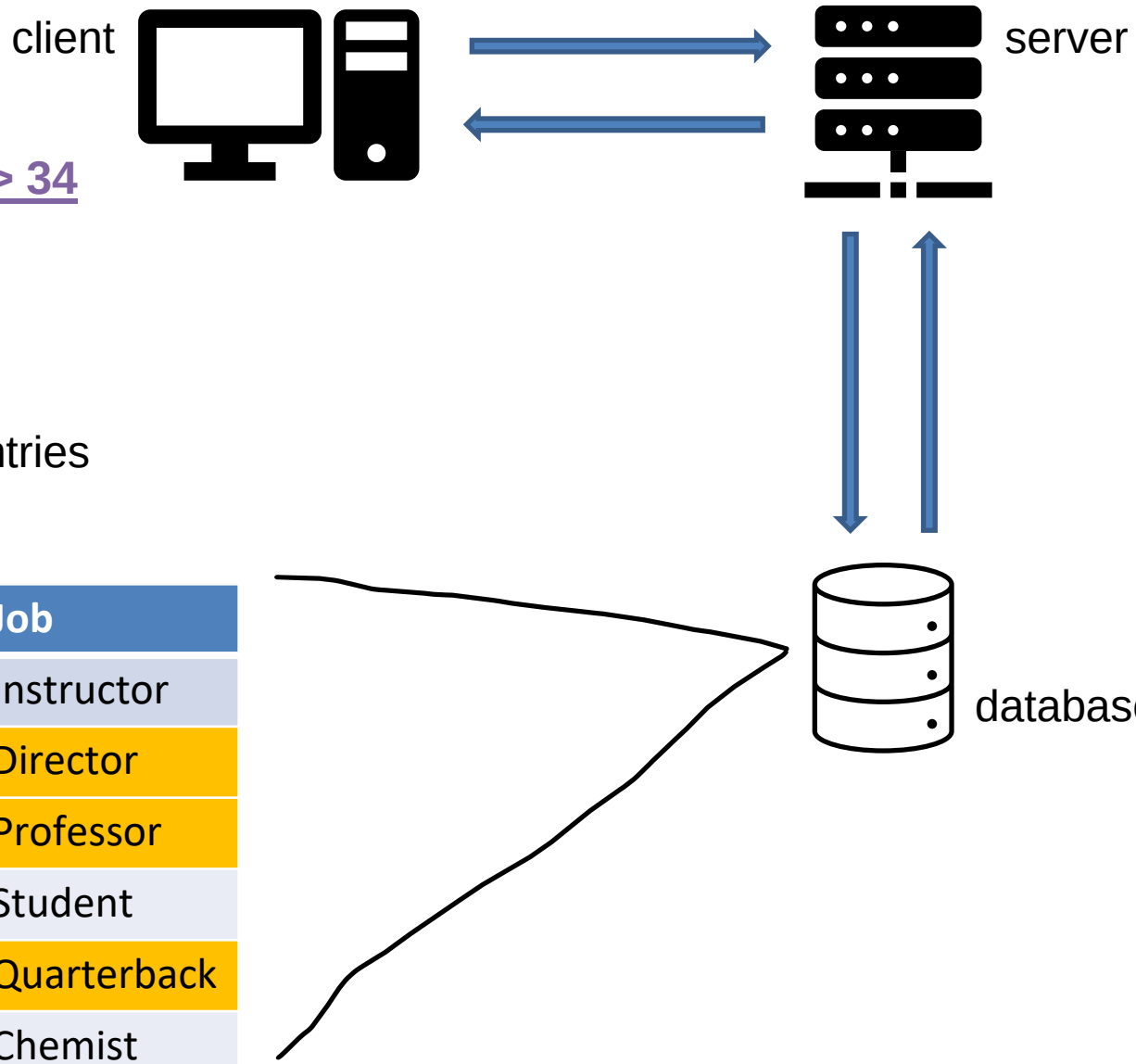

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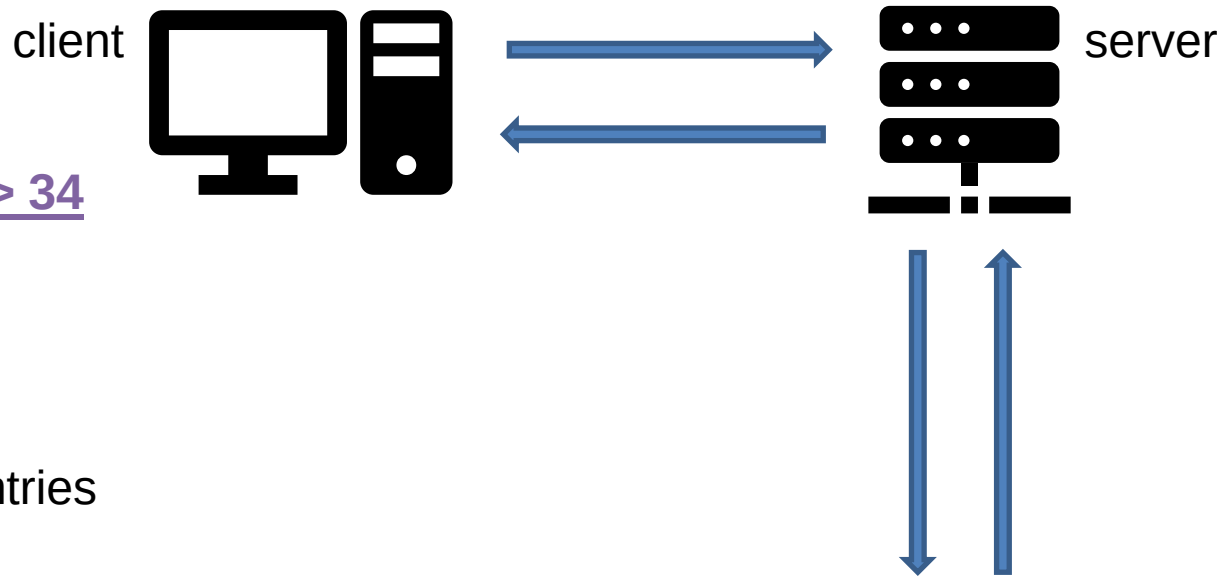

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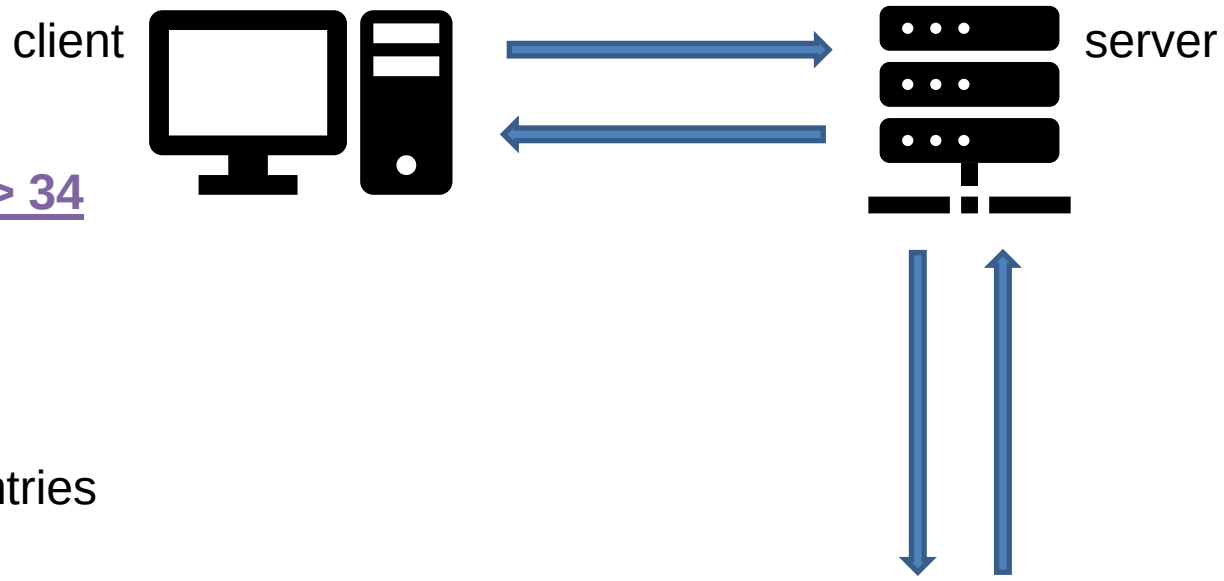

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```
Response: John, Sean, Tom
```

Setup

We will use docker again to create a web server running an SQL server!

- cd into the `04_sqli folder`

- `docker-compose up -d`

```
[10/06/22]seed@VM:~/.../04_sqli$ docker-compose up -d
Building mysql
Step 1/7 : FROM mysql:8.0.22
8.0.22: Pulling from library/mysql
```

- `Log into the mysql server`

```
[10/06/22]seed@VM:~/.../04_sqli$ docker ps
CONTAINER ID        IMAGE                  COMMAND                  CREATED             STATUS              PORTS                  NAMES
883e1f09accc        seed-image-mysql-sqli  "docker-entrypoint.s…"   7 seconds ago       Up 6 seconds        3306/tcp, 33060/tcp    mysql-10.9.0.6
bf48a4d2de9f        seed-image-www-sqli    "/bin/sh -c 'service…"   7 seconds ago       Up 6 seconds                               www-10.9.0.5
[10/06/22]seed@VM:~/.../04_sqli$ docksh 88
root@883e1f09accc:/#
```

Setup

- Log into the mysql server

```
[10/06/22]seed@VM:~/.../04_sqli$ docker ps
CONTAINER ID        IMAGE                     COMMAND                  CREATED             STATUS              PORTS                    NAMES
883e1f09accc        seed-image-mysql-sqli     "docker-entrypoint.s…"   7 seconds ago       Up 6 seconds        3306/tcp, 33060/tcp      mysql-10.9.0.6
bf48a4d2de9f        seed-image-www-sqli       "/bin/sh -c 'service…"   7 seconds ago       Up 6 seconds                                 www-10.9.0.5
[10/06/22]seed@VM:~/.../04_sqli$ docksh 88
root@883e1f09accc:/#
```

- Log in with credentials and show databases

```
root@883e1f09accc:/# mysql --user=root --password=dees
mysql: [Warning] Using a password on the command line interface can be insecure.
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 8
Server version: 8.0.22 MySQL Community Server - GPL

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affiliates. Other names may be trademarks of their respective
owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql> show databases;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| mysql              |
| performance_schema |
| sqllab_users       |
| sys                |
+--------------------+
5 rows in set (0.00 sec)

mysql>
```

- We will be using the `sqllab_users` database

```
mysql> use sqllab_users
Reading table information for completion of table and column names
You can turn off this feature to get a quicker startup with -A

Database changed
mysql> show tables;
+------------------------+
| Tables_in_sqllab_users |
+------------------------+
| credential             |
+------------------------+
1 row in set (0.00 sec)
```

```
mysql> show tables
    -> ;
+------------------------+
| Tables_in_sqllab_users |
+------------------------+
| credential             |
+------------------------+
1 row in set (0.00 sec)

mysql> describe credential
    -> ;
+-------------+--------------+------+-----+---------+----------------+
| Field       | Type         | Null | Key | Default | Extra          |
+-------------+--------------+------+-----+---------+----------------+
| ID          | int unsigned | NO   | PRI | NULL    | auto_increment |
| Name        | varchar(30)  | NO   |     | NULL    |                |
| EID         | varchar(20)  | YES  |     | NULL    |                |
| Salary      | int          | YES  |     | NULL    |                |
| birth       | varchar(20)  | YES  |     | NULL    |                |
| SSN         | varchar(20)  | YES  |     | NULL    |                |
| PhoneNumber | varchar(20)  | YES  |     | NULL    |                |
| Address     | varchar(300) | YES  |     | NULL    |                |
| Email       | varchar(300) | YES  |     | NULL    |                |
| NickName    | varchar(300) | YES  |     | NULL    |                |
| Password    | varchar(300) | YES  |     | NULL    |                |
+-------------+--------------+------+-----+---------+----------------+
11 rows in set (0.01 sec)

mysql>
```

The database that we are using in this lab only has one table (`credential`)

Basic SQL Queries

```
mysql> select * from credential
    -> ;
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
| ID | Name  | EID   | Salary | birth | SSN      | PhoneNumber | Address | Email | NickName | Password                                 |
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
|  1 | Alice | 10000 |  20000 | 9/20  | 10211002 |             |         |       |          | fdbe918bdae83000aa54747fc95fe0470fff4976 |
|  2 | Boby  | 20000 |  30000 | 4/20  | 10213352 |             |         |       |          | b78ed97677c161c1c82c142906674ad15242b2d4 |
|  3 | Ryan  | 30000 |  50000 | 4/10  | 98993524 |             |         |       |          | a3c50276cb120637cca669eb38fb9928b017e9ef |
|  4 | Samy  | 40000 |  90000 | 1/11  | 32193525 |             |         |       |          | 995b8b8c183f349b3cab0ae7fccd39133508d2af |
|  5 | Ted   | 50000 | 110000 | 11/3  | 32111111 |             |         |       |          | 99343bff28a7bb51cb6f22cb20a618701a2c2f58 |
|  6 | Admin | 99999 | 400000 | 3/5   | 43254314 |             |         |       |          | a5bdf35a1df4ea895905f6f6618e83951a6effc0 |
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
6 rows in set (0.01 sec)

mysql> select Salary from credential
    -> ;
+--------+
| Salary |
+--------+
|  20000 |
|  30000 |
|  50000 |
|  90000 |
| 110000 |
| 400000 |
+--------+
6 rows in set (0.00 sec)

mysql>
```

```
SELECT _____ FROM _____ WHERE _____ ;
```

Select everything

```
SELECT * FROM credential;
```

ID	Name	EID	Salary	birth	SSN	PhoneNumber	Address	Email	NickName	Password
1	Alice	10000	20000	9/20	10211002					fdbe918bdae83000aa54747fc95fe0470fff4976
2	Boby	20000	30000	4/20	10213352					b78ed97677c161c1c82c142906674ad15242b2d4
3	Ryan	30000	50000	4/10	98993524					a3c50276cb120637cca669eb38fb9928b017e9ef
4	Samy	40000	90000	1/11	32193525					995b8b8c183f349b3cab0ae7fccd39133508d2af
5	Ted	50000	110000	11/3	32111111					99343bff28a7bb51cb6f22cb20a618701a2c2f58
6	Admin	99999	400000	3/5	43254314					a5bdf35a1df4ea895905f6f6618e83951a6effc0

```
SELECT Salary, SSN FROM crediential WHERE Name="Boby";
```

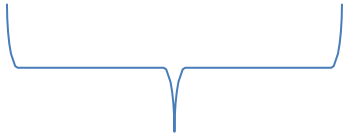
Salary	SSN
30000	10213352

SELECT * FROM credential; **#this is a comment**

```
SELECT * FROM credential; -- this is a comment
```

```
SELECT * /*this is a comment*/ FROM credential;
```

```
SELECT SSN FROM credential WHERE 1=1;
```



Always True, so select all the rows!

```
+----------+
| SSN      |
+----------+
| 10211002 |
| 10213352 |
| 98993524 |
| 32193525 |
| 32111111 |
| 43254314 |
+----------+
```

We have **`and`** and **`or`** operators

```
mysql> select * from credential where Name="Alice" and Salary="20000";
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
| ID | Name  | EID   | Salary | birth | SSN      | PhoneNumber | Address | Email | NickName | Password                                 |
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
|  1 | Alice | 10000 |  20000 | 9/20  | 10211002 |             |         |       |          | fdbe918bdae83000aa54747fc95fe0470fff4976 |
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
```

(both conditions need to be true)

```
mysql> select * from credential where Name="Alice" or Name="Ryan";
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
| ID | Name  | EID   | Salary | birth | SSN      | PhoneNumber | Address | Email | NickName | Password                                 |
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
|  1 | Alice | 10000 |  20000 | 9/20  | 10211002 |             |         |       |          | fdbe918bdae83000aa54747fc95fe0470fff4976 |
|  3 | Ryan  | 30000 |  50000 | 4/10  | 98993524 |             |         |       |          | a3c50276cb120637cca669eb38fb9928b017e9ef |
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
2 rows in set (0.00 sec)
```

(only one, or both, conditions need to be true)

We can update information in SQL tables with the **UPDATE** keyword

```
UPDATE credential SET Name="Sammie" WHERE Name="Samy";
```

```
select * from credential;
```

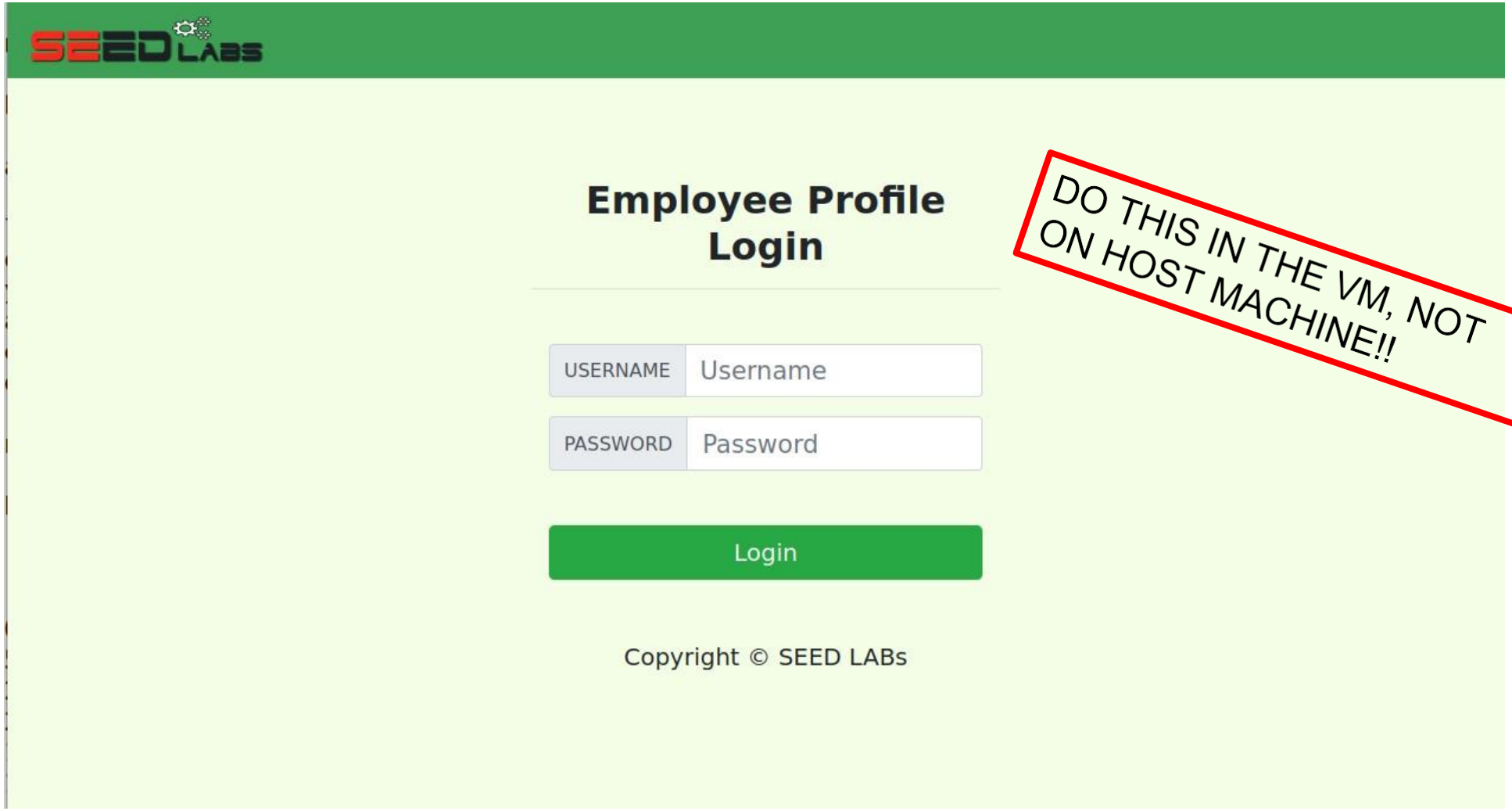
ID	Name	EID	Salary	birth	SSN	PhoneNumber	Address	Email	NickName	Password
1	Alice	10000	20000	9/20	10211002					fdbe918bdae83000aa54747fc95fe0470fff4976
2	Boby	20000	30000	4/20	10213352					b78ed97677c161c1c82c142906674ad15242b2d4
3	Ryan	30000	50000	4/10	98993524					a3c50276cb120637cca669eb38fb9928b017e9ef
4	Sammie	40000	90000	1/11	32193525					995b8b8c183f349b3cab0ae7fccd39133508d2af
5	Ted	50000	110000	11/3	32111111					99343bff28a7bb51cb6f22cb20a618701a2c2f58
6	Admin	99999	400000	3/5	43254314					a5bdf35a1df4ea895905f6f6618e83951a6effc0

```
Select * FROM credential WHERE Name="Samy"
```

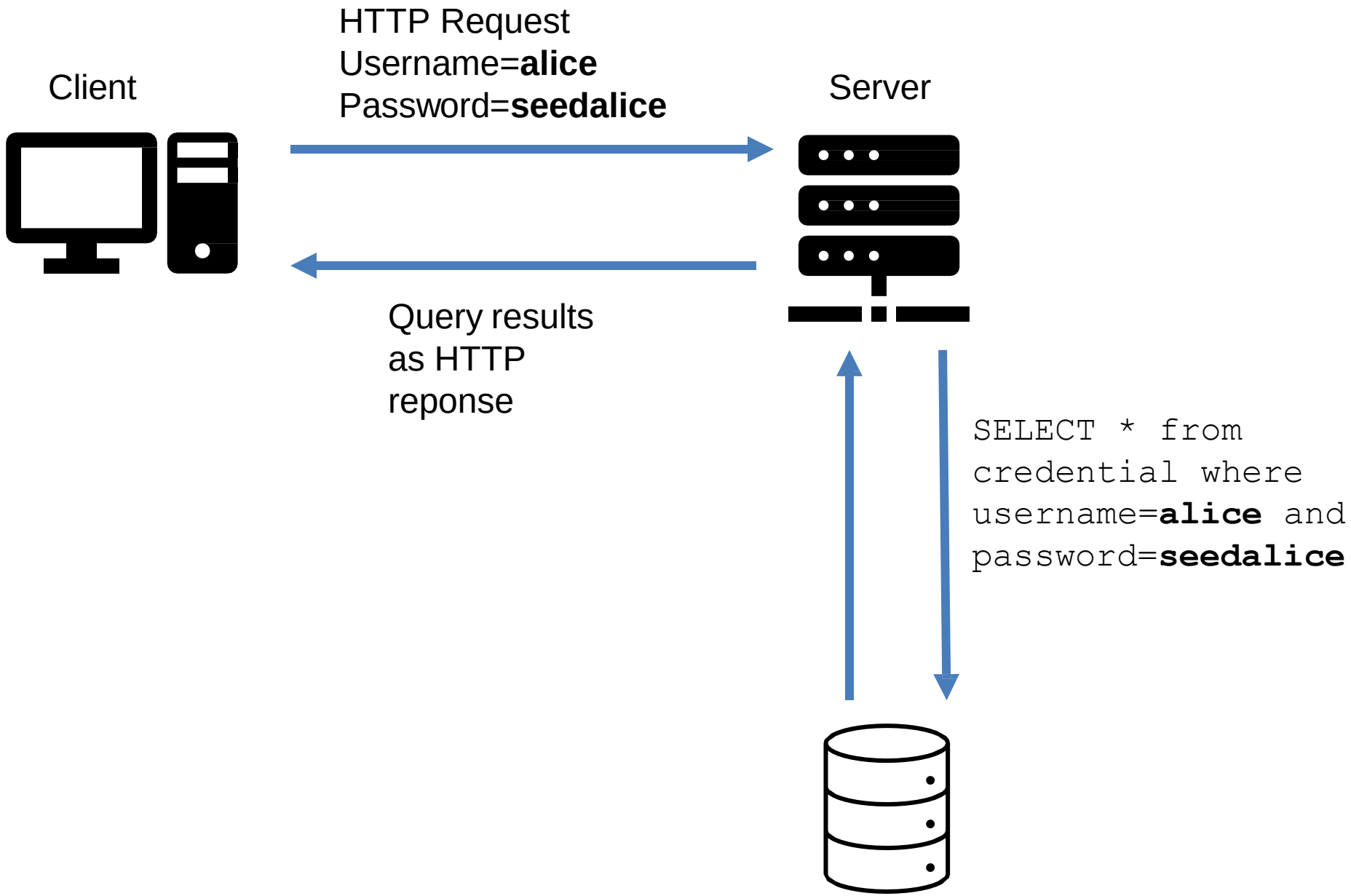
(no results)

SQL Injections

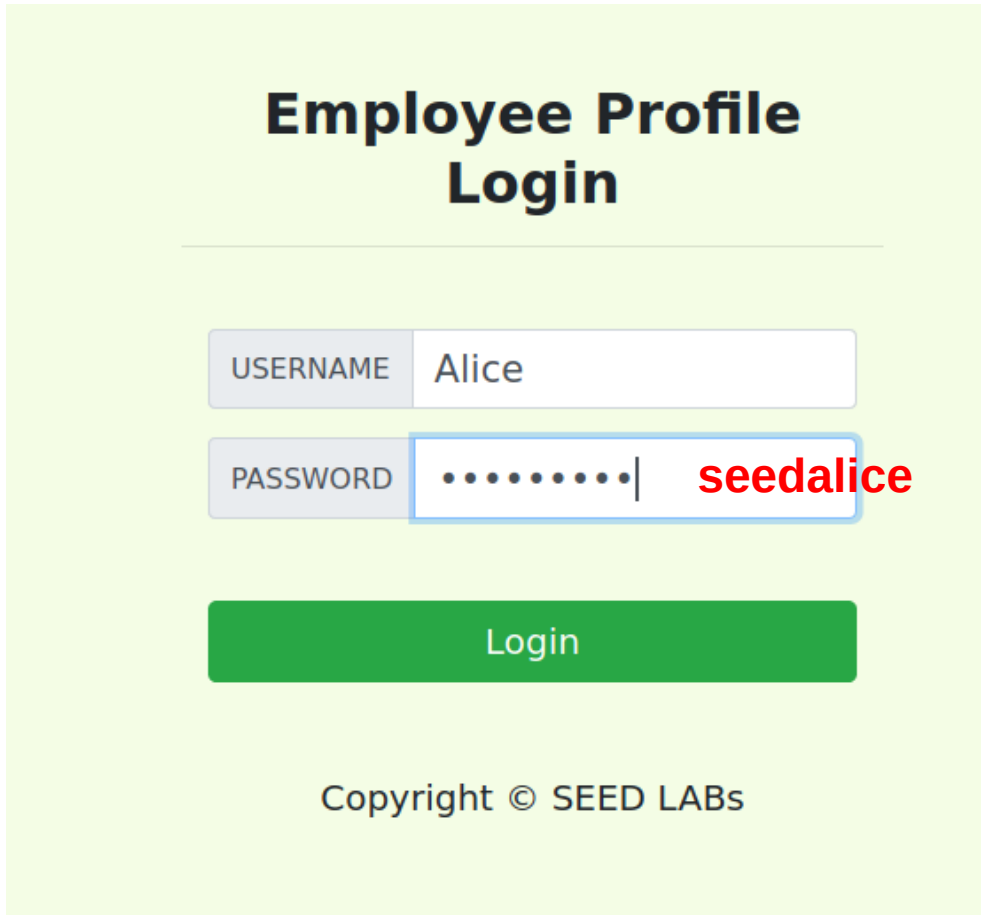
http://www.seedlabsqlinjection.com/

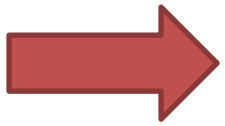


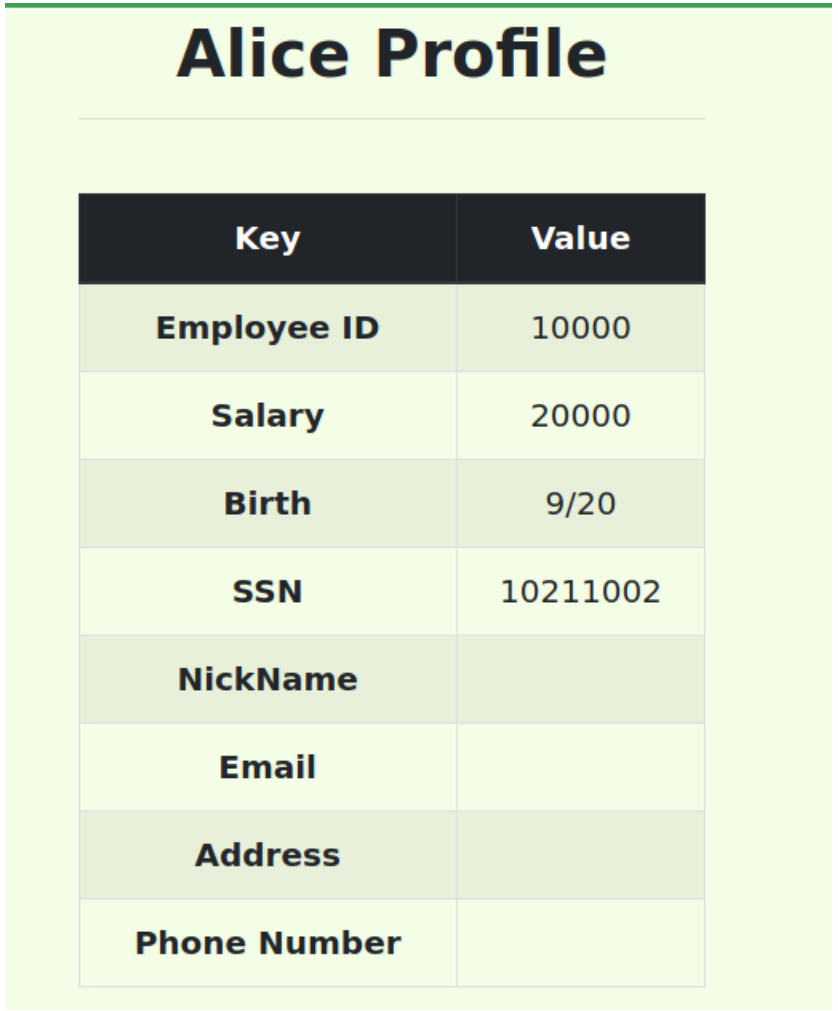
Flow of stuff



The server issues an SQL query to pull all of Alice's information, and then sends an HTTP response back







Storing Passwords

```
mysql> select * from credential;
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
| ID | Name  | EID   | Salary | birth | SSN      | PhoneNumber | Address | Email | NickName | Password                                 |
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
|  1 | Alice | 10000 |  20000 | 9/20  | 10211002 |             |         |       |          | fdbe918bdae83000aa54747fc95fe0470fff4976 |
|  2 | Boby  | 20000 |  30000 | 4/20  | 10213352 |             |         |       |          | b78ed97677c161c1c82c142906674ad15242b2d4 |
|  3 | Ryan  | 30000 |  50000 | 4/10  | 98993524 |             |         |       |          | a3c50276cb120637cca669eb38fb9928b017e9ef |
|  4 | Samy  | 40000 |  90000 | 1/11  | 32193525 |             |         |       |          | 995b8b8c183f349b3cab0ae7fccd39133508d2af |
|  5 | Ted   | 50000 | 110000 | 11/3  | 32111111 |             |         |       |          | 99343bff28a7bb51cb6f22cb20a618701a2c2f58 |
|  6 | Admin | 99999 | 400000 | 3/5   | 43254314 |             |         |       |          | a5bdf35a1df4ea895905f6f6618e83951a6effc0 |
+----+-------+-------+--------+-------+----------+-------------+---------+-------+----------+------------------------------------------+
6 rows in set (0.00 sec)
```

In our table, the plaintext password is not stored in the database (good!!). Instead, the **hash** of the password is stored

SHA1 and other hash functions online generator

seedalice | hash

sha-1

Result for sha1: fdbe918bdae83000aa54747fc95fe0470fff4976

A hash function is used to generate a fixed-length, deterministic, unique output* for a given input

Code for webpage can be found in `04_sqli/image_www/code/unsafe_home.php`

```
$sql ="SELECT id, name, eid, salary, birth, ssn,
            phoneNumber, address, email, nickname, password
      FROM credential
      WHERE name= '$input_uname' and password='$hashed_pwd'";
```

Code for webpage can be found in `04_sqli/image_www/code/unsafe_home.php`

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```

Username input from webpage

Password input from webpage

One long PHP string that is eventually executed *as an SQL query*

$sql = “SELECT * FROM credential WHERE name= ‘**Alice**' and password=‘**seedalice**'";

PHP Code

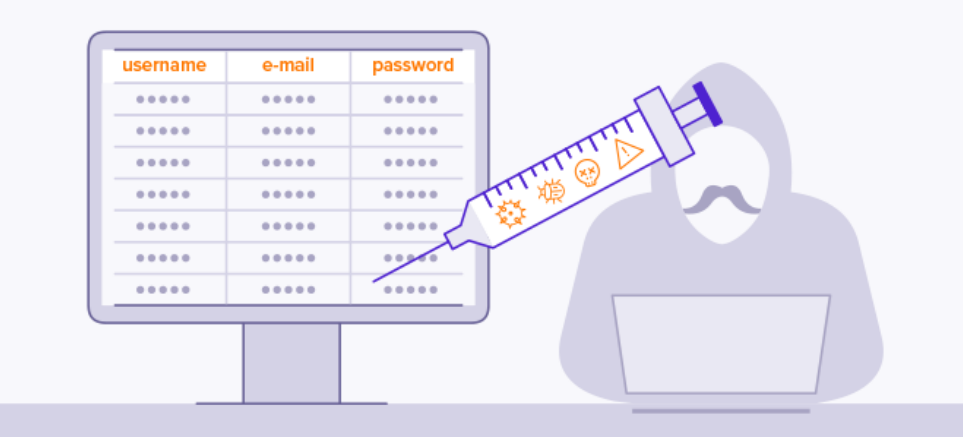
```
SELECT * FROM credential WHERE
name= ‘Alice' and password=‘seedalice’;
```

SQL Command that is executed

The values that we supply on the webpage eventually get turned into code!

An **SQL Injection** is a code injection attack where an attacker is able to manipulate and interfere with SQL queries to access information that is not supposed to be accessed

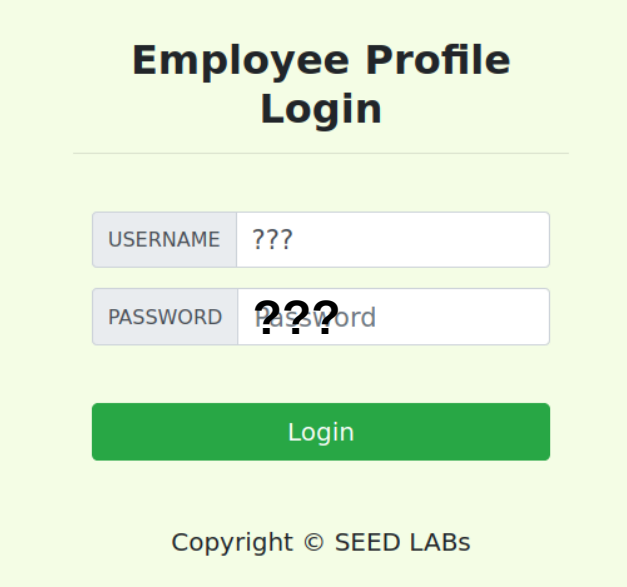
Ie. We can trick a server into running our SQL queries



SQL Injections

```
SELECT * FROM credential WHERE
name= '          ' and password='          ';
```

Suppose we don't know Alice's password. How could we still get her information?



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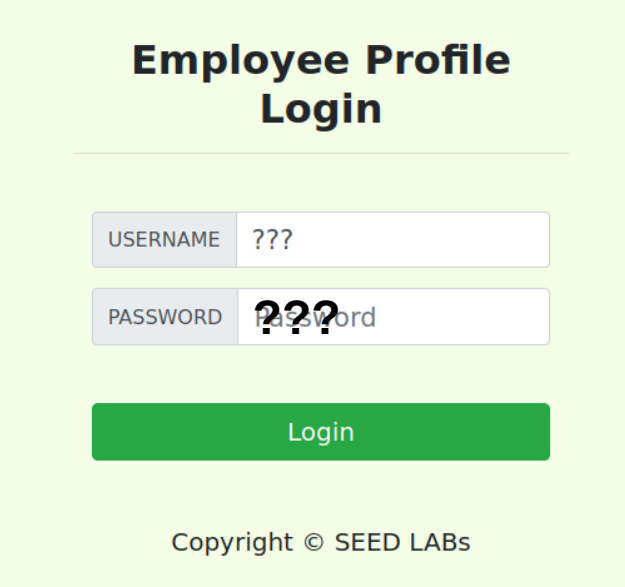


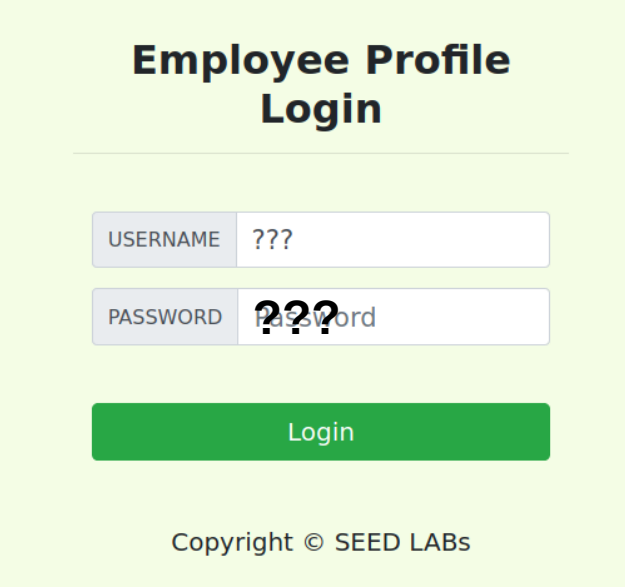
USERNAME = `Alice'#`

Password = ???

SQL Injections

```
SELECT * FROM credential WHERE
name= 'Alice'#' and password='';
```

Suppose we don't know Alice's password. How could we still get her information?



USERNAME = `Alice'#`

Closes the string

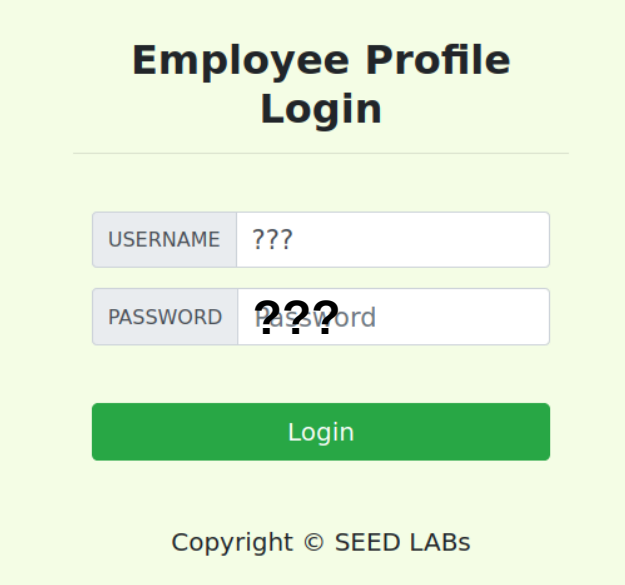
Comment out rest of query

Password = `asdasdasdasdas`

SQL Injections

```
SELECT * FROM credential WHERE
name= 'Alice'#' and password='';
```

Suppose we don't know Alice's password. How could we still get her information?



USERNAME = `Alice'#`

Closes the string

Comment out rest of query

Password = `asdasdasdasdas`

It doesn't matter what the password is, because we comment out the entire 2nd part of the **`and`** clause