Web Programming with Python and JavaScript

Lecture 3: SQL

July 5, 2018

This Time

- Databases
- SQL

origin	destination	duration
New York	London	415
Shanghai	Paris	760
Istanbul	Tokyo	700
New York	Paris	435
Moscow	Paris	245

SQL

PostgreSQL

PostgreSQL Data Types

- INTEGER
- SERIAL
- DECIMAL
- VARCHAR
- TIMESTAMP
- BOOLEAN
- ENUM
- ...

PostgreSQL Data Types

- INTEGER

- SERIAL

- DECIMAL

- VARCHAR

- TIMESTAMP

- BOOLEAN

- ENUM

- ...

CRUD

Create
Retrieve
Update
Delete

Create
Retrieve
Update
Delete

Create a Table

```
CREATE TABLE <table> (
    <colname1> <coltype1> (<attributes>),
    <colname2> <coltype2> (<attributes>),
    <colname3> <coltype3> (<attributes>),
    ...
);
```

origin	destination	duration
New York	London	415
Shanghai	Paris	760
Istanbul	Tokyo	700
New York	Paris	435
Moscow	Paris	245

origin	destination	duration
New York	London	415
Shanghai	Paris	760
Istanbul	Tokyo	700
New York	Paris	435
Moscow	Paris	245

```
CREATE TABLE flights (
    id SERIAL PRIMARY KEY,
    origin VARCHAR NOT NULL,
    destination VARCHAR NOT NULL,
    duration INTEGER NOT NULL
);
```

```
CREATE TABLE flights (
    id SERIAL PRIMARY KEY,
    origin VARCHAR NOT NULL,
    destination VARCHAR NOT NULL,
    duration INTEGER NOT NULL
);
```

```sql
CREATE TABLE flights (
    id SERIAL PRIMARY KEY,
    origin VARCHAR NOT NULL,
    destination VARCHAR NOT NULL,
    duration INTEGER NOT NULL
);
```

```sql
CREATE TABLE flights (
    id SERIAL PRIMARY KEY,
    origin VARCHAR NOT NULL,
    destination VARCHAR NOT NULL,
    duration INTEGER NOT NULL
);
```

```sql
CREATE TABLE flights (
    id SERIAL PRIMARY KEY,
    origin VARCHAR NOT NULL,
    destination VARCHAR NOT NULL,
    duration INTEGER NOT NULL
);
```

```sql
CREATE TABLE flights (
    id SERIAL PRIMARY KEY,
    origin VARCHAR NOT NULL,
    destination VARCHAR NOT NULL,
    duration INTEGER NOT NULL
);
```

Attributes (aka Constraints)

- NOT NULL
- UNIQUE
- PRIMARY KEY
- DEFAULT
- CHECK
- ...

Insert New Data

```
INSERT INTO <table>
(<col1>, <col2>, ... )
VALUES
(<val1>, <val2>, ... );
```

```sql
INSERT INTO flights
(origin, destination, duration)
VALUES
('Lima', 'New York', 455);
```

```sql
INSERT INTO flights
(origin, destination, duration)
VALUES
('Lima', 'New York', 455);
```

```sql
INSERT INTO flights
(origin, destination, duration)
VALUES
('Lima', 'New York', 455);
```

```sql
INSERT INTO flights
(origin, destination, duration)
VALUES
('Lima', 'New York', 455);
```

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INSERT INTO flights
(origin, destination, duration)
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('Lima', 'New York', 455);
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```sql
INSERT INTO flights
(origin, destination, duration)
VALUES
('Lima', 'New York', 455);
```

```
INSERT INTO flights
(origin, destination, duration)
VALUES
('Lima', 'New York', 455);
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

Create
Retrieve
Update
Delete

Selecting Data

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights;
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

SELECT * FROM flights;

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights;
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

SELECT origin, destination FROM flights;

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

SELECT origin, destination FROM flights;

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights WHERE id = 3;
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights WHERE id = 3;
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights WHERE id = 3;
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights WHERE origin = 'New York';
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights WHERE origin = 'New York';
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights WHERE duration > 500;
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights WHERE duration > 500;
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights
WHERE destination = 'Paris' AND duration > 500;
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights
WHERE destination = 'Paris' AND duration > 500;
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```sql
SELECT * FROM flights
WHERE destination = 'Paris' OR duration > 500;
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights
WHERE destination = 'Paris' OR duration > 500;
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights
WHERE origin IN ('New York', 'Lima');
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights
WHERE origin IN ('New York', 'Lima');
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights
WHERE origin IN ('New York', 'Lima');
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights
WHERE origin LIKE '%a%';
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights
WHERE origin LIKE '%a%';
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights
WHERE origin LIKE '%a%';
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

```
SELECT * FROM flights
WHERE origin LIKE '%a%';
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

Some Useful SQL Functions

- SUM
- COUNT
- MIN
- MAX
- AVG
- ...

Create
Retrieve
Update
Delete

Updating Data

```
UPDATE <table>
SET <col> = <val>
WHERE <condition>;
```

```sql
UPDATE flights
SET duration = 440
WHERE origin = 'New York'
AND destination = 'London';
```

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

id	origin	destination	duration
1	New York	London	440
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

Create
Retrieve
Update
Delete

Deleting Data

```
DELETE FROM <table>
WHERE <condition>;
```

```sql
DELETE FROM flights
WHERE destination = 'Tokyo';
```

id	origin	destination	duration
1	New York	London	440
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

id	origin	destination	duration
1	New York	London	440
2	Shanghai	Paris	760
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

Helpful Selector Clauses

- LIMIT
- ORDER BY
- GROUP BY
- HAVING
- ...

Foreign Keys

flights

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

flights

id	origin	orig_code	destination	dest_code	duration
1	New York	JFK	London	LHR	415
2	Shanghai	PVG	Paris	CDG	760
3	Istanbul	IST	Tokyo	NRT	700
4	New York	JFK	Paris	CDG	435
5	Moscow	SVO	Paris	CDG	245
6	Lima	LIM	New York	JFK	455

locations

id	name	code
1	New York	JFK
2	Shanghai	PVG
3	Istanbul	IST
4	London	LHR
5	Moscow	SVO
6	Lima	LIM
7	Paris	CDG
8	Tokyo	NRT

flights

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

flights

id	orig_id	dest_id	duration
1	1	4	415
2	2	7	760
3	3	8	700
4	1	7	435
5	5	7	245
6	6	1	455

passengers

id	name	flight_id
1	Alice	1
2	Bob	1
3	Charlie	2
4	Diane	2
5	Eric	4
6	Francine	6
7	Greg	6

Joining Tables

Types of Joins

- JOIN (aka INNER JOIN)
- LEFT JOIN (aka LEFT OUTER JOIN)
- RIGHT JOIN (aka RIGHT OUTER JOIN)
- FULL OUTER JOIN

CREATE INDEX

Nested Queries

flights

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

passengers

id	name	flight_id
1	Alice	1
2	Bob	1
3	Charlie	2
4	Diane	2
5	Eric	4
6	Francine	6
7	Greg	6

```sql
SELECT flight_id FROM passengers
GROUP BY flight_id HAVING COUNT(*) > 1;
```

SELECT flight_id FROM passengers
GROUP BY flight_id HAVING COUNT(*) > 1;

id	name	flight_id
1	Alice	1
2	Bob	1
3	Charlie	2
4	Diane	2
5	Eric	4
6	Francine	6
7	Greg	6

SELECT flight_id FROM passengers
GROUP BY flight_id HAVING COUNT(*) > 1;

id	name	flight_id
1	Alice	1
2	Bob	1
3	Charlie	2
4	Diane	2
5	Eric	4
6	Francine	6
7	Greg	6

flight_id
1
2
6

```
SELECT flight_id FROM passengers
GROUP BY flight_id HAVING COUNT(*) > 1;
```

flight_id
1
2
6

```
SELECT * FROM flights WHERE id IN
(SELECT flight_id FROM passengers
GROUP BY flight_id HAVING COUNT(*) > 1);
```

flight_id
1
2
6

SELECT * FROM flights WHERE id IN
(SELECT flight_id FROM passengers
GROUP BY flight_id HAVING COUNT(*) > 1);

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

flight_id
1
2
6

SELECT * FROM flights WHERE id IN
(SELECT flight_id FROM passengers
GROUP BY flight_id HAVING COUNT(*) > 1);

id	origin	destination	duration
1	New York	London	415
2	Shanghai	Paris	760
3	Istanbul	Tokyo	700
4	New York	Paris	435
5	Moscow	Paris	245
6	Lima	New York	455

flight_id
1
2
6

Break

Injection Attacks

Username

Enter Username

Password

Enter Password

Login

```
SELECT * FROM users
WHERE (username = uname)
AND (password = pword)
```

Username

milo

Password

puppy

Login

```
SELECT * FROM users
WHERE (username = uname)
AND (password = pword)
```

```sql
SELECT * FROM users
WHERE (username = 'milo')
AND (password = 'puppy')
```

Username

hacker

Password

1' OR '1' = '1

Login

```sql
SELECT * FROM users
WHERE (username = uname)
AND (password = pword)
```

```sql
SELECT * FROM users
WHERE (username = 'hacker')
AND (password = '1' OR '1' = '1')
```

Race Conditions

Race Conditions

BANK ACCOUNT

Doug Lloyd
Acct #27

Balance

$100.00

Race Conditions

```
SELECT balance FROM bank WHERE
acct = 27;
```

BANK ACCOUNT

Doug Lloyd
Acct #27

Balance

$100.00

Race Conditions

```
SELECT balance FROM bank WHERE
acct = 27;
```

100.00

BANK ACCOUNT

Doug Lloyd
Acct #27

Balance

$100.00

Race Conditions

```
SELECT balance FROM bank WHERE
acct = 27;
```

100.00

BANK ACCOUNT

Doug Lloyd
Acct #27

Balance

$100.00

```
UPDATE bank
SET balance = balance – 100
WHERE acct = 27
```

Race Conditions

```
SELECT balance FROM bank WHERE
acct = 27;
```

$\longrightarrow$

100.00

```
UPDATE bank
SET balance = balance – 100
WHERE acct = 27
```

$\longrightarrow$

BANK ACCOUNT

**Doug Lloyd
Acct #27**

Balance

$0.00

Race Conditions

BANK ACCOUNT

Doug Lloyd
Acct #27

Balance

$100.00

Race Conditions

```
SELECT balance FROM bank WHERE
acct = 27;
```

BANK ACCOUNT

Doug Lloyd
Acct #27

Balance
$100.00

Race Conditions

```
SELECT balance FROM bank WHERE
acct = 27;
```

100.00

BANK ACCOUNT

Doug Lloyd
Acct #27

Balance

$100.00

Race Conditions

SELECT balance FROM bank WHERE
acct = 27;

100.00

BANK ACCOUNT

**Doug Lloyd
Acct #27**

Balance

$100.00

SELECT balance FROM bank WHERE
acct = 27;

Race Conditions

SELECT balance FROM bank WHERE
acct = 27;

100.00

BANK ACCOUNT

**Doug Lloyd
Acct #27**

Balance

$100.00

SELECT balance FROM bank WHERE
acct = 27;

100.00

Race Conditions

SELECT balance FROM bank WHERE
acct = 27;

100.00

BANK ACCOUNT

**Doug Lloyd
Acct #27**

Balance

$100.00

SELECT balance FROM bank WHERE
acct = 27;

100.00

UPDATE bank
SET balance = balance – 100
WHERE acct = 27

Race Conditions

SELECT balance FROM bank WHERE
acct = 27;

→ 100.00

BANK ACCOUNT

**Doug Lloyd
Acct #27**

Balance

$0.00

SELECT balance FROM bank WHERE
acct = 27;

← 100.00

UPDATE bank
SET balance = balance – 100
WHERE acct = 27

Transactions

- BEGIN
- COMMIT

SQLAIchemy