122COM: Databases

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Overview

1 Databases
- SQL
- SQLite

2 Python
- Dynamic queries
  - SQL injection
- Efficient inserting

3 Recap

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SQL

Database *(noun)* - a collection of information that is organized so that it can easily be accessed, managed, and updated.

- Pronounced S-Q-L or Sequel.
    - Structured Query Language.
- 4th generation language.
- Used to query relational databases.
- Doesn't matter what underlying database is.
    - MS SQL Server, Oracle, PostgreSQL, MySQL, SQLite.

    - In reality, minor variations.

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Built around tables.

- Can be imagined like a spreadsheet.

Row/
record $\rightarrow$

id	forename	surname	job
0	Malcolm	Reynolds	Captain
4	Zoe	Washburne	Co-captain
11	Hoban	Washburne	Pilot
23	Kaywinnet	Frye	Mechanic

$\uparrow$
Column/attribute

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C
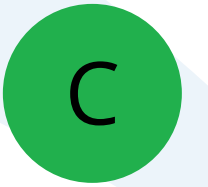
Many types of query.

■ SELECT - Get information from the database.

■ INSERT - Add information to the database.

■ DELETE - Remove information.

Also used for database administration.

■ CREATE - Create a whole new table/schema/function.

■ ALTER - Modify a table/schema/function.

■ DROP - Delete a whole table/schema/function.

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SELECT   C

Used to retrieve information from the database.

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SELECT

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```
SELECT * FROM staff;
```

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```
SELECT * FROM staff;
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#	id	forename	surname	job
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```
SELECT * FROM staff WHERE surname = 'Washburne';
```

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SELECT C

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```
SELECT * FROM staff WHERE surname = 'Washburne';
```

#	id	forename	surname	job
1	4	Zoe	Washburne	Co-captain
2	11	Hoban	Washburne	Pilot

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What if we want to now how many records there are?

- count() function.
- More efficient.
  - Minimum amount of data.

count()

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```
SELECT count(*) FROM staff;
```

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11	Hoban	Washburne	Pilot
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```
SELECT count(*) FROM staff;
```

#	count(*)
1	4

INSERT

Used to add information to the database.

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INSERT I

Used to add information to the database.

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INSERT

Used to add information to the database.

id	forename	surname	job
0	Malcolm	Reynolds	Captain
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11	Hoban	Washburne	Pilot
23	Kaywinnet	Frye	Mechanic

```
INSERT INTO staff VALUES (42, 'Simon', 'Tam', 'Doctor');
```
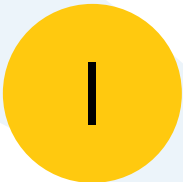
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INSERT ⓘ

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23	Kaywinnet	Frye	Mechanic

```
INSERT INTO staff VALUES (42, 'Simon', 'Tam', 'Doctor');
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id	forename	surname	job
0	Malcolm	Reynolds	Captain
4	Zoe	Washburne	Co-captain
11	Hoban	Washburne	Pilot
23	Kaywinnet	Frye	Mechanic
42	Simon	Tam	Doctor

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INSERT

I

Used to add information to the database.

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INSERT

Used to add information to the database.

```
INSERT INTO staff (forename, id, surname)
      VALUES ('River', 43, 'Tam');
```

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INSERT

Used to add information to the database.

```
INSERT INTO staff (forename, id, surname)
        VALUES ('River', 43, 'Tam');
```

id	forename	surname	job
0	Malcolm	Reynolds	Captain
4	Zoe	Washburne	Co-captain
11	Hoban	Washburne	Pilot
23	Kaywinnet	Frye	Mechanic
42	Simon	Tam	Doctor
43	River	Tam	

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Databases   C

Why use databases at all?

- Databases…
    - have structure.
    - scale.
    - multi-user.
    - fault tolerant.
- Can include SQL queries in other languages.

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SQLite

Using SQLite3 in labs.

- Not really a database.
  - Behaves like one.

  - SQL.

- Good for small/non-urgent databases.
  - $\leq$ gigabytes of data.

- Efficient
  - Don't need to waste resources on a 'real' database.

- Convenient.
  - Don't need to install, configure, managed a 'real' database.

  - Portable, 1 file.

- No network.
  - Single user only.

Python

C

How to use SQL queries in Python?

```python
import sqlite3 as sql

con = sql.connect('firefly.sqlite')
cur = con.cursor()


cur.execute('''SELECT * FROM staff;''')
for row in cur:
    print(row)


con.close()
```
lec_select.py

```
(0, 'Malcolm', 'Reynolds', 'Captain')
(4, 'Zoe', 'Washburne', 'Co-captain')
(11, 'Hoban', 'Washburne', 'Pilot')
(23, 'Kaywinnet', 'Frye', 'Mechanic')
```

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Python C

Multiple queries.

```python
import sqlite3 as sql

con = sql.connect('firefly.sqlite')
cur = con.cursor()

cur.execute('SELECT count(*) FROM staff;')
print(cur.fetchone()[0])

cur.execute('SELECT * FROM staff;')
for row in cur:
    pass

con.close()
```

lec_multi.py

So far looked at static queries.

- Same query is run every time.
- Real power is in dynamic queries.
  - Code creates new queries to ask new questions.

Dynamic queries

```python
import sqlite3 as sql

con = sql.connect('firefly.sqlite')
cur = con.cursor()


question = input('Who is the...')


cur.execute('''SELECT forename, surname FROM staff
               WHERE job = ?;''', (question,))


for row in cur:
    print('%s %s' % row)
```

lec_dynamic.py

```
Who is the...Captain
Malcolm Reynolds
```

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Bad dynamic queries

```
cur.execute('''SELECT forename, surname FROM staff
              WHERE job = ?;''', (question,))
```

```
cur.execute('''SELECT forename, surname FROM staff
              WHERE job = "%s";''' % question )
```

- User could input anything.

  - `Captain"; DROP TABLE staff; --`

- Sanitise inputs.

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Bad dynamic queries

```
cur.execute('''SELECT forename, surname FROM staff
               WHERE job = ?;''', (question,))
```

```
cur.execute('''SELECT forename, surname FROM staff
               WHERE job = "%s";''' % question )
```

- User could input anything.
  - Captain"; DROP TABLE staff; --
- Sanitise inputs.
- Always use placeholders.

Bad dynamic queries

```
cur.execute('''SELECT forename, surname FROM staff
               WHERE job = ?;''', (question,))
```

```
cur.execute('''SELECT forename, surname FROM staff
               WHERE job = "%s";''' % question )
```

- User could input anything.

  - Captain"; DROP TABLE staff; --

- Sanitise inputs.
- Always use placeholders.
  - No exceptions.

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Bad dynamic queries

```
cur.execute('''SELECT forename, surname FROM staff
               WHERE job = ?;''', (question,))
```

```
cur.execute('''SELECT forename, surname FROM staff
               WHERE job = "%s";''' % question )
```

- **User could input anything.**
    - `Captain"; DROP TABLE staff; --`
- **Sanitise inputs.**
- **Always use placeholders.**
    - No exceptions.
    - NO EXCEPTIONS!

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```
cur.execute('''SELECT forename, surname FROM staff
               WHERE job = ?;''', (question,))
```

```
cur.execute('''SELECT forename, surname FROM staff
               WHERE job = '%s'''' % question
```

- User should input any job.
  - Contains DROP TABLE staff;
- Sanitise inputs
- Always use placeholders.
  - No exceptions.
  - NO EXCEPTIONS!

NO EXCEPTIONS

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SQL injection
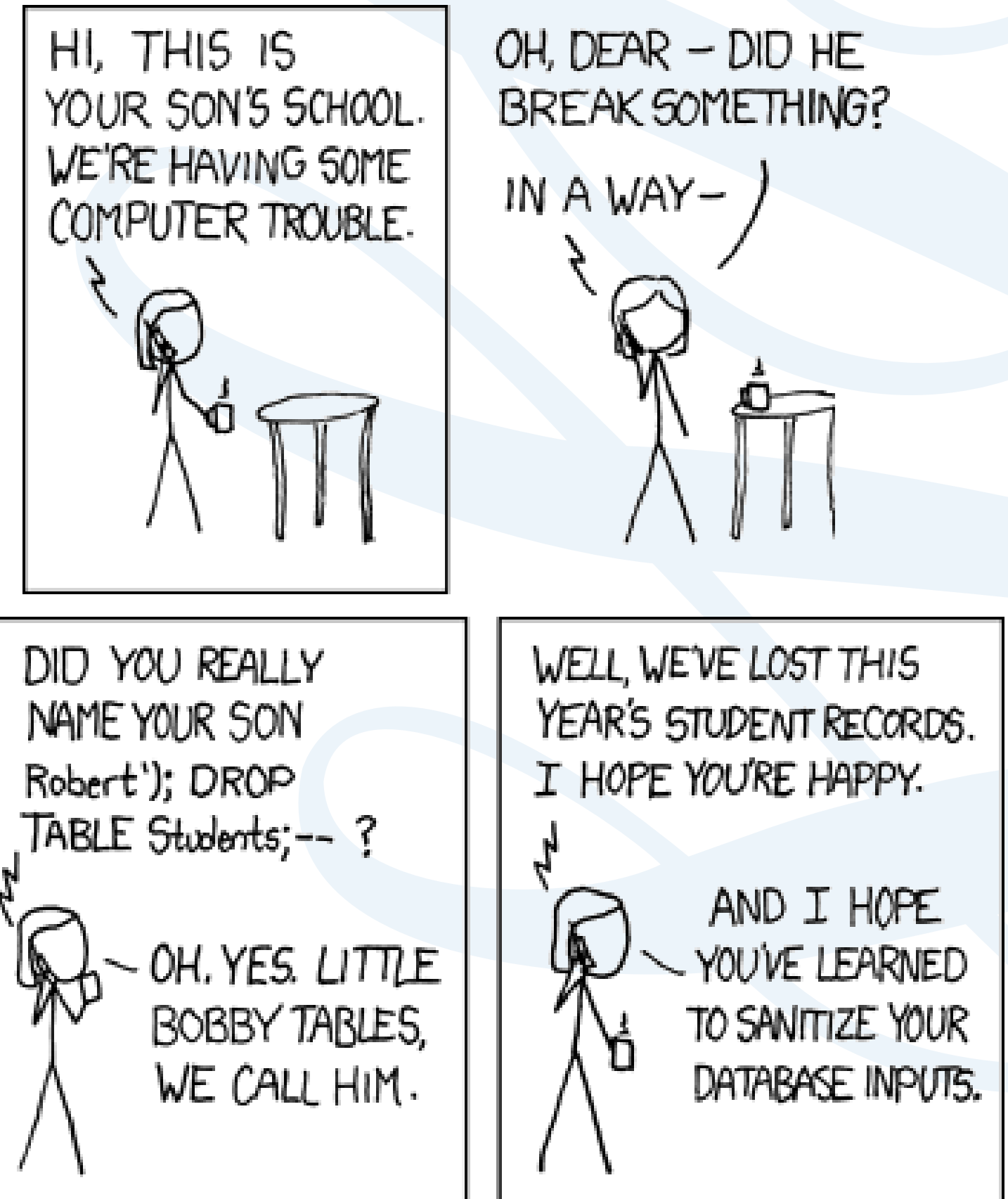
Around since at least 1998.

Notable SQL injection attacks.

- 2015 TalkTalk - 160,000 customers' details.

- 2014 Hold security - found 420,000 vulnerable websites.

- 2012 Yahoo - 450,000 logins.

- 2011 MySql - mysql.com compromised.

- 2008 Heartland Payment - 134,000,000 credit cards.

Many, many more.

HI, THIS IS YOUR SON'S SCHOOL. WE'RE HAVING SOME COMPUTER TROUBLE.

OH, DEAR – DID HE BREAK SOMETHING?

IN A WAY–

DID YOU REALLY NAME YOUR SON Robert'); DROP TABLE Students;-- ?

OH. YES. LITTLE BOBBY TABLES, WE CALL HIM.

WELL, WE'VE LOST THIS YEAR'S STUDENT RECORDS. I HOPE YOU'RE HAPPY.

AND I HOPE YOU'VE LEARNED TO SANITIZE YOUR DATABASE INPUTS.

https://xkcd.com/327/

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Efficient inserting

A

```
con = sql.connect('firefly.sqlite')
cur = con.cursor()

cur.execute('''INSERT INTO staff (forename, surname)
               VALUES (?,?)''', ('River', 'Tam'))
con.commit()
con.close()
```

`lec_single_insert.py`

`commit()` command.

- Have modified database.

- Tell database to save changes.

- `revert()` command to undo everything done since `commit()`.

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Multiple inserts

A

What is you want to insert a lot of records?

■ Could run multiple small INSERT statements.

■ Slow.

■ Could run one big INSERT statement.

■ Fast.

```python
con = sql.connect('firefly.sqlite')
cur = con.cursor()


people = [('Simon','Tam','Doctor'), ('River','Tam',None)]


cur.executemany('''INSERT INTO staff (forename, surname, job)
                   VALUES (?,?,?)''', people)


cur.commit()
con.close()
```

`lec_multi_insert.py`

Quiz
`https://tophat.com/`
Join code: 094769

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Recap

- SQL used to query databases.
- Databases are...
  - fault tolerant.
  - multi user.
  - scalable.
- Always use place holders in dynamic queries.
  - Say no to SQL injection!
- Inserting data
  - Avoid small inserts.
  - Use big inserts.

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The End