SQL

Joseph Hallett

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Last time

We did some database theory, and drew some pretty doodles

This time

Lets write code!

SQLite 3

The database we're going to be using in this course is SQLite3

```
sqlite3
```

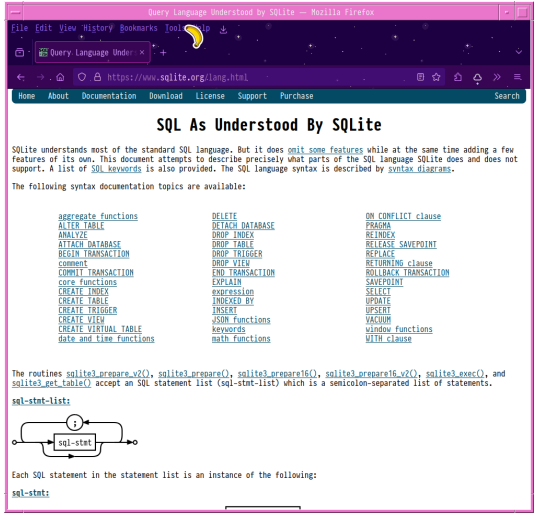
```
SQLite version 3.44.2 2023-11-24 11:41:44
Enter ".help" for usage hints.
sqlite>
```

(Do check out the `.help` command… there are some useful things to make output more readable!)

```
.headers on
.mode column
```

Why I like SQLite…

- It's fast
- Very little set up
  - Just point it at your database go
  - (Do ask the TAs about the hell of setting up MariaDB ;-))
- It's relatively unsurprising
- The docs are *really* good!
- It's installed *almost* everywhere



SQL

To query *most* relational database we use a language called *SQL*
Query language for asking questions about databases from 1974

- Standardized in 1986 in the US and 1987 everywhere else
- Still the dominant language for queries today

Not a general purpose programming language

- Not Turing complete
- Weird English-like syntax

Standardized?

You would be so lucky!

- *In theory*, yes
- *In practice*, absolutely not

Every database engine has *small* differences…

- Some have quite big ones too!

Lots have differences in performance

- SQLite is good with strings, most others prefer numbers

Managing these differences used to be an entire degree/job in its own right!

- Now we just manage databases badly!

I'll try and stick to relatively conventional syntax…

- But if you find something doesn't work, check *your database's* documentation

Convention says SQL keywords are written in CAPITALS

- But it doesn't actually matter… you do you.

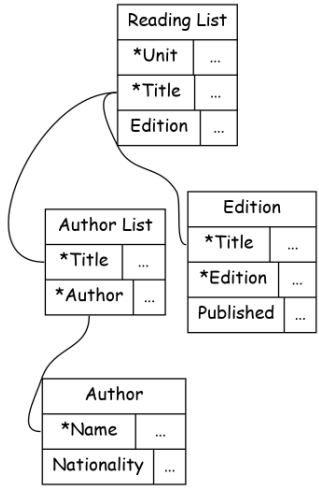
More than one indentation style too

- I like the Haskell-esque one
  - Makes it easy to delete/add lines and not have to fix up commas as you go
  - As with C, you do you (but if you write it all on one line… *eww*).

Reading lists

Last time we were modelled a reading list database…

- Let's code it in SQL



CREATE TABLE

Each of the entities we described is going to become a separate table

- (We'll `insert` rows later to create the actual data)

Lets start with the `author` table

```
CREATE TABLE author
( name TEXT
, nationality TEXT
);
```

DROP TABLE

What about if we want to delete it?

```
DROP TABLE author;
```

But it'll throw an error if you haven't already created the table.

```
DROP TABLE IF EXISTS author;

CREATE TABLE IF NOT EXISTS author
( name TEXT
, nationality TEXT
);
```

And all the rest…

```
CREATE TABLE IF NOT EXISTS readinglist
( unit TEXT
, title TEXT
, edition INTEGER
);

CREATE TABLE IF NOT EXISTS authorlist
( title TEXT
, author TEXT
);

CREATE TABLE IF NOT EXISTS edition
( title TEXT
, edition INTEGER
, published DATE
);

CREATE TABLE IF NOT EXISTS author
( name TEXT
, nationality TEXT
);
```

Data in SQL tables has a *type* which says what sort of data it is

`INT / INTEGER` whole numbers

`TEXT` strings

`BLOB` binary blobs of data (could be anything)

`REAL` floating point numbers

`DECIMAL(5,2)` a decimal number of 5 digits (2 of which are after the decimal point)

`CHARACTER(10) / VARCHAR(10)` A string of 10 characters or upto 10 characters.

`DATE / DATETIME` a timestamp

`BOOLEAN` true or false

Others exist. Some are more efficient than others on different databases.

So now what?

Lets start adding the data!

```
INSERT INTO author(name,nationality)
VALUES ("Michael␣W.␣Lucas", "American")
    , ("Brian␣W.␣Kernighan", "Canadian")
    , ("P.J.␣Plaugher", "American")
;
```

And can we read it back out?

```
SELECT *
FROM author
;
```

name	nationality
Michael W. Lucas	American
Brian W. Kernighan	Canadian
P.J. Plaugher	American

What about if we don't know an author's nationality?

SQL has a special value called NULL to indicate you *don't know something*.

```
INSERT INTO author(name)
VALUES ("Elonka␣Dunin");
```

```
SELECT * FROM author;
```

name	nationality
Michael W. Lucas	American
Brian W. Kernighan	Canadian
P.J. Plaugher	American
Elonka Dunin	

NULL causes problems

Whilst you *can* leave blanks in your database with NULL

- Not generally a good idea
- NULL wreaks havoc when you come to JOIN tables to each other
- And when you do statistics…

Best to add a *constraint* to say that a field can *never* be NULL.

```
CREATE TABLE IF NOT EXISTS author
( name TEXT NOT NULL,
, nationality TEXT NOT NULL,
);
```

What other constraints do we have

I've said `NOT NULL` exists, what others are there?

- `NOT NULL` this can never be blank
- `UNIQUE` no other row can have the same value here
- `CHECK ()` run a check that a value meets a condition

`PRIMARY KEY` implies `NOT NULL` and `UNIQUE` (and that it's a primary key!)

Keys…

We can declare a single field PRIMARY KEY, but what if we want a *composite* key?

- What if I want a FOREIGN KEY
  - (Check that this column lines up with something in another table)

```
CREATE TABLE IF NOT EXISTS authorlist
( title TEXT
, author TEXT
, PRIMARY KEY (title, author)
, FOREIGN KEY(author) REFERENCES author(name)
);
```

You don't have to declare primary key, or foreign key relationships…

- But it *might* make your database faster (indexes)
- You can do advanced tricks for how data should change as other tables change
- Helps to keep you sane!

Lets move on from books

I'm bored of books, and don't want to populate an entire database for the sake of a lecture…
Lets ~~steal~~ borrow a music library database and have an explore!

```
.tables
```

```
Album       Employee    InvoiceLine PlaylistTrack
Artist      Genre       MediaType   Track
Customer    Invoice     Playlist
```

```
SELECT *
FROM Artist
;
```

ArtistId	Name
1	AC/DC
2	Accept
3	Aerosmith
4	Alanis Morissette
5	Alice In Chains
6	Antônio Carlos Jobim
7	Apocalyptica
8	Audioslave
9	BackBeat

Lets try that again

```
SELECT Name
FROM Artist
LIMIT 5
;
```

Name
AC/DC
Accept
Aerosmith
Alanis Morissette
Alice In Chains

```
SELECT COUNT(Name) AS Number
FROM Artist
;
```

Number
275

I wonder who else's music is in here?

```
SELECT Name
FROM Artist
WHERE Name IS "Chappell␣Roan"
;
```

```
SELECT Name
FROM Artist
WHERE Name LIKE "Avril␣%"
;
```

Name
Avril Lavigne

```
SELECT Name
FROM Artist
WHERE Name LIKE "%␣zep%l%in%"
;
```

Name
Led Zeppelin
Dread Zeppelin

What about Albums?

```
SELECT *
FROM Album
LIMIT 10
;
```

AlbumId	Title	ArtistId
1	For Those About To Rock We Salute You	1
2	Balls to the Wall	2
3	Restless and Wild	2
4	Let There Be Rock	1
5	Big Ones	3
6	Jagged Little Pill	4
7	Facelift	5
8	Warner 25 Anos	6
9	Plays Metallica By Four Cellos	7
10	Audioslave	8

What about Led Zeppelin albums?

```
SELECT Album.Title, Artist.Name
FROM Album
JOIN Artist
ON Album.ArtistId = Artist.ArtistId
WHERE Artist.Name LIKE "Led Zeppelin"
;
```

Title	Name
BBC Sessions [Disc 1] [Live]	Led Zeppelin
Physical Graffiti [Disc 1]	Led Zeppelin
BBC Sessions [Disc 2] [Live]	Led Zeppelin
Coda	Led Zeppelin
Houses Of The Holy	Led Zeppelin
In Through The Out Door	Led Zeppelin
IV	Led Zeppelin
Led Zeppelin I	Led Zeppelin
Led Zeppelin II	Led Zeppelin
Led Zeppelin III	Led Zeppelin
Physical Graffiti [Disc 2]	Led Zeppelin
Presence	Led Zeppelin
The Song Remains The Same (Disc 1)	Led Zeppelin
The Song Remains The Same (Disc 2)	Led Zeppelin

Okay, so how many Led Zeppelin albums?

```
SELECT COUNT(Album.Title) AS Albums, Artist.Name
FROM Album
JOIN Artist
ON Album.ArtistId = Artist.ArtistId
WHERE Artist.Name LIKE "Led%"
GROUP BY Artist.Name
;
```

Albums	Name
14	Led Zeppelin

Whose got the most albums?

```
SELECT COUNT(Album.Title) AS Albums, Artist.Name
FROM Album
JOIN Artist
ON Album.ArtistId = Artist.ArtistId
GROUP BY Artist.Name
ORDER BY Albums DESC
LIMIT 10
;
```

Albums	Name
21	Iron Maiden
14	Led Zeppelin
11	Deep Purple
10	U2
10	Metallica
6	Ozzy Osbourne
5	Pearl Jam
4	Various Artists
4	Van Halen
4	Lost

Lets just list the artists with more than 5 albums

```
SELECT COUNT(Album.Title) AS Albums, Artist.Name
FROM Album
JOIN Artist
ON Album.ArtistId = Artist.ArtistId
WHERE Albums >= 5
GROUP BY Artist.Name
ORDER BY Albums DESC
LIMIT 10
;
```

Parse error near line 2: misuse of aggregate: COUNT()

Aggregates are tricky

When you use an aggregate function like COUNT() you can't filter on it with WHERE.

- Instead you need to use HAVING…

```
SELECT COUNT(Album.Title) AS Albums, Artist.Name
FROM Album
JOIN Artist
ON Album.ArtistId = Artist.ArtistId
GROUP BY Artist.Name
HAVING Albums >= 5
ORDER BY Albums DESC
;
```

Albums	Name
21	Iron Maiden
14	Led Zeppelin
11	Deep Purple
10	U2
10	Metallica
6	Ozzy Osbourne
5	Pearl Jam

Aggregates to be aware of:

- `COUNT()` counts number of rows
- `SUM()` adds values in rows
- `MAX()` gives biggest value
- `MIN()` gives minimum value
- `AVG()` gives the average of the rows

Whose got the least?

```
SELECT COUNT(Album.Title) AS Albums
    , Artist.Name
FROM Album
JOIN Artist
ON Album.ArtistId = Artist.ArtistId
GROUP BY Artist.Name
ORDER BY Albums ASC
LIMIT 5
;
```

Albums	Name
1	Aaron Copland & London Symphony Orchestra
1	Aaron Goldberg
1	Academy of St. Martin in the Fields & Sir Neville Marriner
1	Academy of St. Martin in the Fields Chamber Ensemble & Sir Neville Marriner
1	Academy of St. Martin in the Fields, John Birch, Sir Neville Marriner & Sylvia McNair

BUT WHAT ABOUT AVRIL LAVIGNE?

```
SELECT COUNT(Album.Title) AS Albums, Artist.Name
FROM Album
JOIN Artist
ON Album.ArtistId = Artist.ArtistId
WHERE Artist.Name LIKE "Avril%"
;
```

Albums	Name
0	

When we do a JOIN in SQL its technically an INNER JOIN.

- That means we need something on both sides
- If there are no albums to join onto artists…
  - Then they are not included in the results.

If we want to include them we need an OUTER JOIN

OUTER JOIN

Three variants:

a LEFT OUTER JOIN b if there's something in a but nothing in b to join it to… then leave a NULL for the missing values.

a RIGHT OUTER JOIN b if there's something in b but nothing in a to join it to… then leave a NULL for the missing values.

a FULL OUTER JOIN b include all the entries in a and b adding NULL s as needed

```
SELECT "Albums␣with␣no␣artist" AS Description
    , COUNT(Album.Title) AS Count
FROM Album
LEFT OUTER JOIN Artist
ON Album.ArtistId = Artist.ArtistId
WHERE Artist.Name IS NULL
;
```

Description	Count
Albums with no artist	0

```
SELECT "Artists␣with␣no␣album" AS Description
    , COUNT(Artist.Name) AS Count
FROM Album
RIGHT OUTER JOIN Artist
ON Album.ArtistId = Artist.ArtistId
WHERE Album.Title IS NULL
;
```

Description	Count
Artists with no album	71

Seems a little excessive…

```
SELECT "Artists␣with␣no␣album" AS Description
    , COUNT(Artist.Name) AS Count
FROM Album
RIGHT OUTER JOIN Artist
ON Album.ArtistId = Artist.ArtistId
WHERE Album.Title IS NULL
UNION
SELECT "Albums␣with␣no␣artist" AS Description
    , COUNT(Album.Title) AS Count
FROM Album
LEFT OUTER JOIN Artist
ON Album.ArtistId = Artist.ArtistId
WHERE Artist.Name IS NULL
;
```

Description	Count
Albums with no artist	0
Artists with no album	71

(Use UNION ALL if you want to insist that the tables you're joining have the same fields).

Why IS?

NULL means *I don't know* which means that the logic gets a bit funky.

- How would you know if an unknown equaled a value?
- How would you know if a value was unknown?
- What is an unknown equal to?

Lets not get bogged down in philosophy!

- If you want to test whether a value `IS NULL` use `IS` not `=`
- Otherwise your joins will *sometimes* be *weird*

Sub Queries

Lets try and find the average number of albums per artist in the database!

- To do this we'll need a *sub-query*

A sub-query is when we use the results of one SQL query as part of the input for a second.
We can get the number of albums each artist has had with:

```
SELECT COUNT(Album.Title) AS Albums, Artist.Name
FROM Album
RIGHT OUTER JOIN Artist
ON Album.ArtistId = Artist.ArtistId
GROUP BY Artist.Name
LIMIT 5;
```

Albums	Name
0	A Cor Do Som
2	AC/DC
1	Aaron Copland & London Symphony Orchestra
1	Aaron Goldberg
1	Academy of St. Martin in the Fields & Sir Neville Marriner

The naming of tables is a difficult matter…

We could turn our query into a separate table…

- CREATE TEMPORARY TABLE ensures our table isn't saved to the database
- Will persist through the current session though
- Will not update if Artist or Album changes though

```
CREATE TEMPORARY TABLE AlbumsPerArtist AS
SELECT COUNT(Album.Title) AS Albums, Artist.Name
FROM Album
RIGHT OUTER JOIN Artist
ON Album.ArtistId = Artist.ArtistId
GROUP BY Artist.Name
;

SELECT SUM(Albums) as Albums
     , COUNT(Name) AS Artists
     , AVG(Albums) as "Albums␣per␣Artist"
FROM AlbumsPerArtist;
```

Albums	Artists	Albums per Artist
347	275	1.26181818181818

Subqueries avoid naming things

But if we know we're never going to use it again we can create a subquery by wrapping our first query in ( ).

- Useful if you're rubbish at thinking of names
- Subquery rerun every time query run

```
SELECT SUM(Albums) as Albums
     , COUNT(Name) AS Artists
     , AVG(Albums) as "Albums␣per␣Artist"
FROM (
  SELECT COUNT(Album.Title) AS Albums, Artist.Name
  FROM Album
  RIGHT OUTER JOIN Artist
  ON Album.ArtistId = Artist.ArtistId
  GROUP BY Artist.Name
);
```

Albums	Artists	Albums per Artist
347	275	1.26181818181818

Thats the basics of SQL

We've covered:

- `CREATE TABLE` and `DROP TABLE`
- `INSERT`-ing data
- Data types
- `SELECT`-ing data `WHERE` there is are conditions
- Various `JOIN`-s
- `NULL`
- Aggregate queries
- Subqueries

That's 99% of all you'll ever need

- Lets play with different queries in the lab

Now…

- What other things can we ask this database?