MICHIGAN

ROSS SCHOOL OF BUSINESS

A Gentle Introduction to SQL

ICOS Big Data Summer Camp

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(slides inspired by Mike Cafarella)

Learning Overview

- What is a database
- Why is SQL cool?
- Intro to schema and tables
- Running queries
- Appreciate big data's research potential
- On-ramp for SQL – read MOAR books!

Databases! – Who's used one today?

Trick Question – EVERYONE! (probably)

- Used a Starbucks rewards card
- Tracked your meal in a dieting app
- Paid someone with Venmo
- Bookmarked something with Pocket
- Bought an e-book on your Kindle
- Favorited a Tweet
- Clicked a story link on Facebook
- Looked up an actor in IMDB
- Gave House of Cards four stars on Netflix
- Used your ID to get into a building
- Walked with your FitBit
- PURCHASED ANYTHING!

What is a database?

- A database is an organized collection of data
- Relational Databases (SQL)
    - SQLite, MySQL, SQL Server, PostgreSQL
- Relational Databases (NoSQL)
    - CouchDB, Cassandra, MongoDB, Redis
- Blockchain Databases
    - Bitcoin, Ethereum, etc.

Fine. What is a *relational* database?

- A relational database is a set of “relations” with two parts
  - ~ Instances - a data table, with rows (records), and columns (fields, attributes)
  - ~ Schema – relation name, columns names, and data format
- Excel comparison
  - ~ Instances are like tabs
  - ~ Schema is tab name, column headers and cell format cells (e.g., number, date, text)

Relational Databases - Cool!! but Tricky?

GREAT!!

- Millions of Rows!!
- Efficient
- Data Safe
- Slicing and Dicing
- Think VLOOKUP & Pivot Tables

Tricky?

- Special Software
- Structured Query Language - SQL

The software is often free and SQL is basically English!

Still not convinced? Ask Cassandra!

“Hey! Stack Exchange! I have this amazing Research idea! And It will help you understand how Rankings motivate cooperative and uncooperative behavior in your communities.”

“We love amazing ideas! Send us the theoretical SQL query for the dataset you want and we can talk!”

StackExchange

“Thanks, Stack Exchange! And thanks Big Data Camp!”

Relational Databases (1)

- The software is called a Relational Database Management System (RDBMS) – e.g., SQLite
- Your dataset is “a database”, managed by an RDBMS
- An RDBMS does lots of things, but mainly:
    - Keeps data safe
    - Gives you a powerful query language

AID	Name	Country	Sport
1	Simone Biles	USA	Gymnastics
2	Usain Bolt	Jamaica	Track
3	Michael Phelps	USA	Swimming

Instance of Athlete Relation

AID	Name	Country	Sport
1	Simone Biles	USA	Gymnastics
2	Usain Bolt	Jamaica	Track
3	Michael Phelps	USA	Swimming

What is the schema?

(aid: integer, name: string, country: string, sport:string)

Let’s make this table - Athlete

AID	Name	Country	Sport
1	Simone Biles	USA	Gymnastics
2	Usain Bolt	Jamaica	Track
3	Michael Phelps	USA	Swimming

Creating Relations in SQL

- Create the Athlete relation (table)

```
CREATE TABLE Athlete
(aid INTEGER,
 name CHAR(30),
 country CHAR(20),
 sport CHAR(20))
```

AID	Name	Country	Sport

Adding & Deleting Rows in SQL

```
INSERT INTO  Athlete (aid, name, country, sport)
VALUES  (1,  ‘Simone Biles’ ,  ‘USA’ ,  ‘Gymnastics’ )
```

```
INSERT INTO  Athlete (aid, name, country, sport)
VALUES  (2,  ‘Usain Bolt’ ,  ‘Jamaica’ ,  ‘Track’ )
```

```
INSERT INTO  Athlete (aid, name, country, sport)
VALUES  (3,  ‘Michael Phelps’ ,  ‘USA’ ,  ‘Swimming’ )
```

- And we are going to add another row!

```
INSERT INTO  Athlete (aid, name, country, sport)
VALUES  (4,  ‘Harvard Lorentzen’ ,  ‘Norway’ ,
 ‘Speedskating’ )
```

Table. Athlete. Boom!

AID	Name	Country	Sport
1	Simone Biles	USA	Gymnastics
2	Usain Bolt	Jamaica	Track
3	Michael Phelps	USA	Swimming
4	Harvard Lorentzen	Norway	Speedskating

Getting Data in SQL (1)

- SELECT all of the rows and columns:

```
SELECT *
FROM Athlete
```

AID	Name	Country	Sport
1	Simone Biles	USA	Gymnastics
2	Usain Bolt	Jamaica	Track
3	Michael Phelps	USA	Swimming
4	Harvard Lorentzen	Norway	Speedskating

- Only names and sports:

```
SELECT name, sport
FROM Athlete
```

```
SELECT A.name, A.sport
FROM Athlete A
```

Name	Sport
Simone Biles	Gymnastics
Usain Bolt	Track
Michael Phelps	Swimming
Harvard Lorentzen	Speedskating

Getting Data in SQL (2)

AID	Name	Country	Sport
1	Simone Biles	USA	Gymnastics
2	Usain Bolt	Jamaica	Track
3	Michael Phelps	USA	Swimming
4	Harvard Lorentzen	Norway	Speedskating

- SELECT names and sports WHERE country is USA:

```
SELECT A.name, A.sport
FROM Athlete A
WHERE A.country = ‘USA’
```

Name	Sport
Simone Biles	Gymnastics
Michael Phelps	Swimming

Basic SQL Query

Attributes from input relations

```
SELECT [DISTINCT] attr-list
FROM relation-list
WHERE qualification
GROUP BY
ORDER BY
```

List of relations

Attr1 op Attr2

OPS: <, >, =, <=, >=, <>

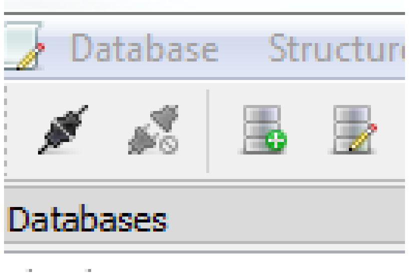
Combine using AND, OR, NOT

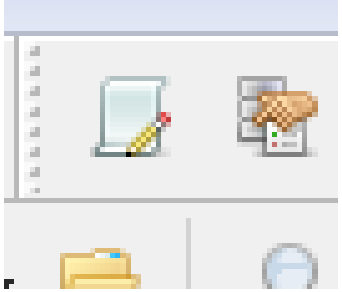
Partition Data into Groups

Sort data if you would like

Setup SQLite Studio

- Download SQL_DBC from the Github Site
- Under Database menu choose "Add a Database" and navigate to wherever you have saved SQL_BDC
- In the Database Menu highlight SQL_BDC and hit Connect Looks like two plugs connecting
- Click icon that looks like a notepad with a pencil





Scenario - Eastern University Endowment

- You are a new equity analyst and your manager know about your SQL skills….
- …So he has put you in charge of all data pulls from the database!!

Hands-On #0

- Get your bearings first:
  - ~ See what is in the Financial table
  - ~ SELECT * FROM Financial where ROWID=30477
  - ~ SELECT * FROM Financial where ROWID=1940
  - ~ SELECT * FROM Financial where ticker='AMZN'

Hands-On #1 - Internet Company Revenue

- *Revenue made by Ticker-AMZN in all years*
- *Revenue made by CompanyName - 'ALPHABET INC' in all years*
- *Revenue made by Zillow in all years*
  - *Try company name like "%Zillow%'*

Example of Basic Query(1)

- Schema:
  - Sailors (sid, sname, rating, age)
  - Boats (bid, bname, color)
  - Reserves (sid, bid, day)

Example of Basic Query(2)

Boats

bid	bname	color
101	jeff	red
103	boaty	black

Sailors

sid	sname	rating	age
22	dustin	7	45
58	rusty	10	35
31	lubber	8	55

Reserves

sid	bid	day
22	101	Oct-10
58	103	Nov-12
58	103	Dec-13

Example of Basic Query(3)

- Schema:
  - ~ Sailors (sid, sname, rating, age)
  - ~ Boats (bid, bname, color)
  - ~ Reserves (sid, bid, day)
- Find the names of sailors who have reserved boat #103
- Are the names of the sailors and the numbers of the boats reserved in the same place?
- Must JOIN the tables

Example of Basic Query(4)

Reserves x Sailors

	sid	bid	day	sid	sname	rating	age
	22	101	Oct-10	22	dustin	7	45
	22	101	Oct-10	58	rusty	10	35
	22	101	Oct-10	31	lubber	8	55
	58	103	Nov-12	22	dustin	7	45
➡	58	103	Nov-12	58	rusty	10	35
	58	103	Nov-12	31	lubber	8	55
	58	103	Dec-13	22	dustin	7	45
➡	58	103	Dec-13	58	rusty	10	35
	58	103	Dec-13	31	lubber	8	55

Example of Basic Query (5)

- Find the names of sailors who have reserved boat #103

```
SELECT S.sname
FROM Sailors S, Reserves R
WHERE S.sid = R.sid AND R.bid = 103
```

This is a JOIN – old school

sname
rusty
rusty

Example of Basic Query(6)

- Find the names of sailors who have reserved boat #103

```
SELECT S.sname
FROM Sailors S INNER JOIN Reserves R
ON S.sid = R.sid
WHERE R.bid = 103
```

This is a JOIN – new school. Use the new school

sname
rusty
rusty

Using DISTINCT

3. Project columns in attr-list
   (eliminate duplicates only if DISTINCT)

```
SELECT DISTINCT S.sname
FROM Sailors S INNER JOIN Reserves R
ON S.sid = R.sid
WHERE R.bid = 103
```

What’s the effect of adding DISTINCT?

sname
rusty

Another Example

- Find the colors of boats reserved by a sailor named rusty

```
SELECT B.color
FROM Sailors S INNER JOIN Reserves R
INNER JOIN Boats B
ON S.sid = R.sid AND R.bid = B.bid
WHERE S.sname = 'rusty'
```

Hands-On #2 Sectors

- Provide a list of company names, tickers and industry sector names for all companies in SIC2=54
- Provide a list of company names, tickers industry sector name, fiscal year and revenue for all companies in SIC2=54
- Provide a list of company names, tickers industry sector name, fiscal year and revenue for all companies in the “Pharmaceutical Preparations” sector (SIC2 or SIC4?)

ORDER BY clause

- Most of the time, results are unordered
- You can sort them with the ORDER BY clause

Attribute(s) in ORDER BY clause must be in SELECT list.

Find the names and ages of all sailors, in increasing order of age

```
SELECT S.sname, S.age
FROM Sailors S
ORDER BY S.age[ASC
```

Find the names and ages of all sailors, in decreasing order of age

```
SELECT S.sname, S.age
FROM Sailors S
ORDER BY S.age DESC
```

ORDER BY clause

```
SELECT S.sname, S.age, S.rating
FROM Sailors S
WHERE S.age > 40
ORDER BY S.age ASC, S.rating DESC
```

What does this query compute?

Find the names, ages, & ratings of sailors over the age of 40.

Sort the result in <u>increasing</u> order of age.

If there is a tie, sort those results in decreasing order of rating.

Hands-On #3 – Pharma Revenue

- Provide a list of company names, tickers industry sector name, fiscal year and revenue for all companies in the “Pharmaceutical Preparations” sector for Fiscal Year 2015 ORDERED BY REVENUE DESCENDING

Hands-On #4 Food Shops Revenue

- Provide a list of company names, tickers industry sector name, fiscal year and revenue for all companies in SIC2=54. Where 2014 Revenue is greater than 20 BILLION DOLLARS!! (Revenue field is already in millions of dollars.) ORDER BY Revenue ASCENDING

Aggregate Operators

```
SELECT  COUNT (*) FROM  Sailors S
```

```
SELECT COUNT (DISTINCT S.name)
FROM Sailors S
```

COUNT (*)
COUNT ([DISTINCT] A)
SUM ([DISTINCT] A)
AVG ([DISTINCT] A)
MAX (A) *Can use Distinct*
MIN (A) *Can use Distinct*

```
SELECT  AVG (S.age)
FROM  Sailors S
WHERE  S.rating=10
```

```
SELECT  AVG ( DISTINCT S.age)
FROM  Sailors S
WHERE  S.rating=10
```

Hands-On #5 Counts and Averages

- Count the number of companies in the Food Shop sector in 2014
- Find the average revenue for companies in the Food Shop sector in 2015
- Count the number of companies in the Broker dealer sector in 2015 (SIC4=6211)
- Find Average Revenue for companies in the Broker dealer sector in 2015 (SIC4=6211)

GROUP BY

- Conceptual evaluation
  - ~ Partition data into groups according to some criterion
  - ~ Evaluate the aggregate for each group

Example: *For each rating level, find the age of the youngest sailor*

```
SELECT  MIN (S.age), S.rating
FROM  Sailors S
GROUP BY  S.rating
```

Excel Equivalent: *Think about the results you would want from a pivot table….*

Hands-On #6 - Group By

- Provide SIC4 code, sector name and count of all companies in
  - Bottled and canned soft drinks
  - Wines, brandy and Brandy spirits
  - Bottled and canned soft drinks
  - Distilled and blended liquors
  - HINT if you need to address multiple criteria in a where clause you can try WHERE Code in (A,B,C,D)

Hands-On #6 - Group By

```
SELECT s.codevalue, s.description,
count(c.ticker) FROM SIC4 S INNER JOIN
Company c ON s.codevalue=c.SIC4
WHERE S.codevalue IN (2082, 2084, 2086,
2085)
GROUP BY S.codevalue
```

Hands-On #7

- Harder:
  - ~ Provide two digit SIC Code, sector name and Average 2015 Revenue for each sector and order by avg revenue descending

Hands-On #7

```
SELECT s.codevalue, s.description,
count(c.ticker) AS Count, avg(f.revenue) AS
AverageRevenue
FROM COMPANY C INNER JOIN Financial F
INNER JOIN SIC2 S ON s.codevalue=c.SIC2
AND c.gvkey=f.gvkey
WHERE f.fiscalyear=2015
GROUP BY S.codevalue
ORDER BY AverageRevenue DESC
```

NULL Values in SQL

- NULL represents ‘unknown’ or ‘inapplicable’
- WHERE clause eliminates rows that don’t evaluate to true

What does this query return?

```
SELECT sname
FROM sailors
WHERE age > 45
      OR age <= 45
```

sailors

sid	sname	rating	age
22	dustin	7	45
58	rusty	10	NULL
31	lubber	8	55

Yes, it returns just dustin and

NULL Values in Aggregates

- NULL values generally ignored when computing aggregates

```
SELECT AVG(age)
FROM sailors
```

Returns 50!

sailors

sid	sname	rating	age
22	dustin	7	45
58	rusty	10	NULL
31	lubber	8	55

Questions?

BONUS
The Power of Joins

Basic SQL Query

SELECT [DISTINCT] attr-list

FROM relation-list

WHERE qualification

GROUP BY

ORDER BY

Attributes from input relations

List of relations

Attr1 op Attr2

OPS: <, >, =, <=, >=, <>

Combine using AND, OR, NOT

Partition Data into Groups

Sort data if you would like

The Power of Joins (1)

```
SELECT name, COUNT(A.playerID) AS playerCount
FROM Allstars A
INNER JOIN Teams T
ON A.teamID = T.teamID
GROUP BY name
ORDER BY playerCount DESC
```

The Power of Joins (2)

- *There needs to be a common identifier between tables for the join to be useful*

- *Could you join a table with itself……*

Board of Directors

- *What is a board of directors?*
- *What is a board interlock?*
- *What is a social network?*
- *What do I need to create a social network map of board interlocks?*