Basics of Databases/SQL

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CAS Code Review
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Key points

What is a database?
What is a a *relational* database?
Quick overview:
- DB/tables/rows/datatypes
- Writing queries

Practical example:
- Build a db and create a table
- Insert data
- Try some queries
- Interpreting the output

Postgres in brief

What is a database?

- A structured collection of data

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[Virgo, M87, galaxy, 12h 30m 49.42338s, +12° 23′ 28.0439″, Virgo cluster]

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Unstructured data!

~~*[Virgo, M87, galaxy, 12h 30m 49.42338s, +12° 23′ 28.0439″, Virgo cluster]*~~

What is a database?

- A structured collection of data
- **Hierarchical, network, relational, object-oriented……**

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- A structured collection of data
- Hierarchical, network, **relational**, object-oriented……

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Name	ID	Type	RA	DEC	Group
Virgo	M87	Elliptical	187.7059	+12.3911	Virgo cluster

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Columns/Fields

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Rows/records

What is a relational database?

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- Predefined data types

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“….kind of seems like just a spreadsheet. What’s the big deal?”

Why bother with a relational database?

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- Efficiency

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- Mysterious table-based powers

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….I will come back to this

Why bother with a relational database?

- Efficiency
- Mysterious table-based powers
- **Incredibly powerful, elegant query capabilities**

SQL: Structured Query Language

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- Relational databases are always associated with a *Relational Database Management System (RDBMS).*

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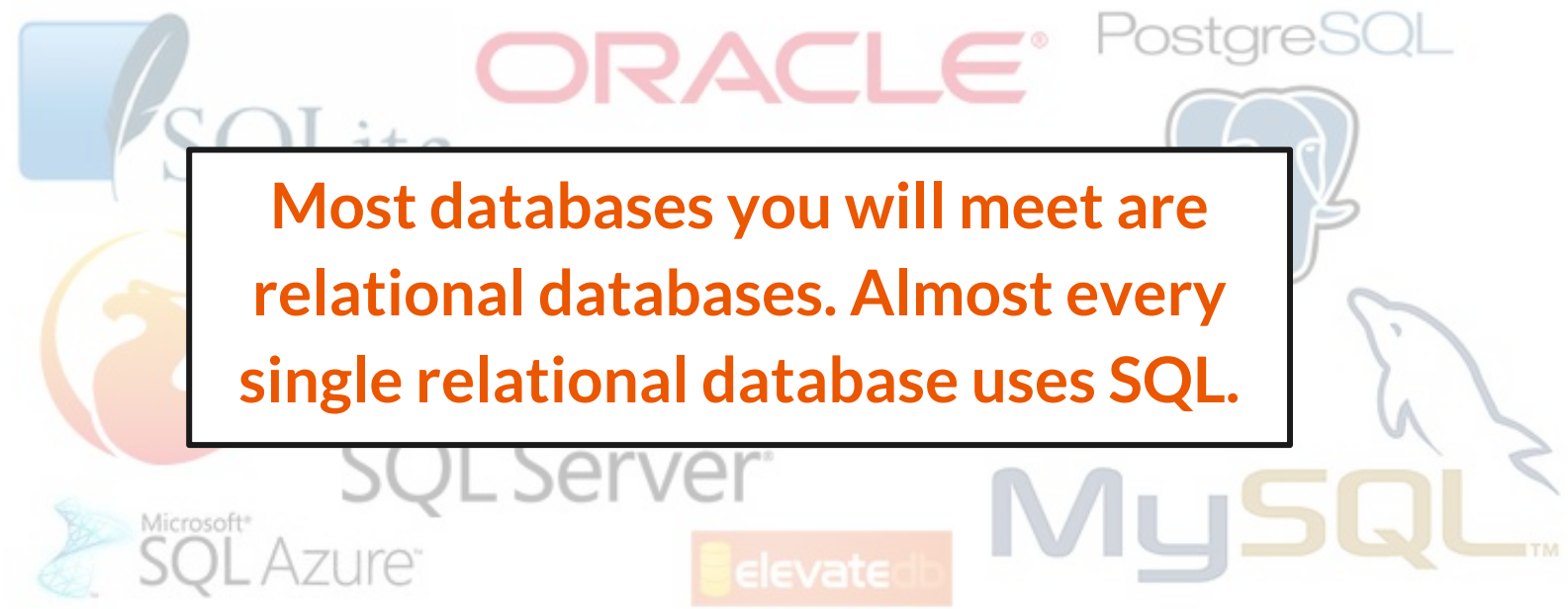
SQL: Structured Query Language

- Relational databases are always associated with a *Relational Database Management System (RDBMS).*
- A set of programs/OS that creates/maintains the DB, and makes queries possible
- **Overwhelmingly, the language of the DBMS is SQL**

SQL: Structured Query Language

Image: http://www.virtutech.com.au

SQL: Structured Query Language



Most databases you will meet are relational databases. Almost every single relational database uses SQL.

Image: http://www.virtutech.com.au

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- Let’s start with SQLite

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- Let’s start with SQLite
- It is straightforward, and readily transferable

Great! I want to learn SQLite!

- In python 2:
  - import sqlite3 as sql
- At the command line on, eg, gstar:
  - Module load sqlite

Creating a database

- In python 2:

```
import sqlite3 as sql

conn = sql.connect('test_database.db')

cur = conn.cursor()
```

Connect to a database if it exists; create it if it does not.

- At the command line
  $ sqlite3 **test_database**

Using a cursor

```
import sqlite3 as sql

conn = sql.connect('test_database.db')

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Using a cursor

- A cursor is a “temporary work area created in the system memory when a SQL statement is executed” (codeproject.com)

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...ie: in python, the cursor is where you are going to **execute** all your **queries - all your interactions with the database**

Query 1: CREATE TABLE in your new database

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```
import sqlite3 as sql

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cur = conn.cursor()

cur.execute("CREATE TABLE my_galaxies (id text, name text, type text, ra float, dec float, group_name text)")

cur.close()
conn.close()
```

Ok, we want to execute an SQL query!

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THIS STRING IS THE QUERY
WE WANT TO EXECUTE

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```

Type any query directly at the sqlite command prompt to achieve the same thing

```
sqlite> .database
seq  name             file
---  ---------------  ----------------------------------------------------------
0    main             /mnt/home/shegarty/test_database
sqlite> .tables
sqlite> CREATE TABLE my_galaxies (id text, name text, type text, ra float, dec float, group_name text);
sqlite> .tables
my_galaxies
```

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We have to declare both the name and the data type of each field.

Different SQL implementations use slightly different types; check the documentation

Query 2: INSERTing data to your new table

```
import sqlite3 as sql

conn = sql.connect('test_database.db')

cur = conn.cursor()

cur.execute("CREATE TABLE IF NOT EXISTS my_galaxies (gal_id text, name text, type text, ra float, dec float, group_name text)")

cur.execute("INSERT INTO my_galaxies VALUES(?, ?, ?, ?, ?, ?)",("M87", "Virgo", "Elliptical", 187.7059, 12.3911, "Virgo Cluster"
cur.commit()

cur.close()
conn.close()
```

We are going to execute an INSERT statement

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```

Always have to indicate the table that we want to use!

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This is a very basic syntax for inserting data

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These ?'s in the statement show we are going to place a variable in each of our six columns...

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cur.close()
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```

And finally, commit our changes...

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Note: we can alter this data later using the UPDATE statement

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cur.commit()

cur.execute("SELECT * FROM my_galaxies")

my_selection = cur.fetchall()

print my_selection
```

We are going to execute a SELECT statement

Query 3: SELECTing data from your new table

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Again, have to indicate which table we want to operate on

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SELECT * loads EVERYTHING from that table into our cursor workspace

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cur.execute("SELECT * FROM my_galaxies")

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```

Then, we fetch it from that memory, and can work with it.

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import sqlite3 as sql

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cur.execute("CREATE TABLE IF NOT EXISTS my_galaxies (gal_id text, name text, type text, ra float, dec float, group_name text)")

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cur.commit()

cur.execute("SELECT * FROM my_galaxies")

my_selection = cur.fetchall()

print my_selection

cur.execute("SELECT name, ra, dec FROM my_galaxies")

my_selection_by_columns = cur.fetchall()

print my_selection_by_columns

cur.close()
conn.close()
```

We can also select the columns we are interested in

Writing complex queries: examples from SkyServer

See http://skyserver.sdss.org/dr8/en/help/docs/realquery.asp

Writing complex queries: examples from SkyServer

```
-- This sample query find all objects with spectra
-- classified as stars. The query also checks that zWarning has no bits set,
-- meaning that there are no known problems with the spectra.

-- Other possible values with of class are 'QSO', 'GALAXY' and 'UNKNOWN'.

SELECT TOP 100 specObjID
FROM SpecObj
WHERE class = 'STAR' AND zWarning = 0
```

See http://skyserver.sdss.org/dr8/en/help/docs/realquery.asp

Writing complex queries: examples from SkyServer

```
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SELECT TOP 100 specObjID
FROM SpecObj
WHERE class = 'STAR' AND zWarning = 0
```

```
SELECT TOP 1000 objID
FROM Galaxy
WHERE
        (r - extinction_r) < 22
```

See http://skyserver.sdss.org/dr8/en/help/docs/realquery.asp

Writing complex queries: examples from SkyServer

```
-- This sample query finds unique objects in an RA/Dec box.
-- For a more efficient way to find objects by position, see the next query,
-- Searching around a sky position.

SELECT TOP 100
      objID, ra ,dec                    -- Get the unique object ID and coordinates
FROM
      PhotoPrimary                      -- From the table containing photometric data for unique objects
WHERE
      ra > 185 and ra < 185.1
      AND dec > 15 and dec < 15.1       -- that matches our criteria
```

See http://skyserver.sdss.org/dr8/en/help/docs/realquery.asp

Writing complex queries: examples from SkyServer

```
-- Provide a list of moving objects consistent with an asteroid.
-- This sample query uses the 'as' syntax, which allows you to
-- give your own names to columns in the results.

SELECT TOP 10
      objID, ra, dec,
      sqrt( power(rowv,2) + power(colv, 2) ) as velocity
FROM PhotoObj
WHERE
      (power(rowv,2) + power(colv, 2)) > 50
      AND rowv != -9999 and colv != -9999
```

See http://skyserver.sdss.org/dr8/en/help/docs/realquery.asp

Why bother with a relational database?

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- Efficiency
- Incredibly powerful, elegant query capabilities
- **You can use these queries across *and between* multiple tables**

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- Efficiency
- Incredibly powerful, elegant query capabilities
- You can use these queries across and between multiple tables
- **JOIN or UNION commands let you do this**

```
-- When you need to search for data in two or more tables, you must "join" the tables
-- together for the purposes of your query by using a JOIN...ON statement.
-- JOIN...ON allows you to search for data and/or constraints in both tables.

-- The syntax of the statement is:
-- JOIN [the second table] ON [a variable the tables have in common].
-- The variable the tables have in common is called the "key" (think of it
-- as the key that unlocks your ability to search two tables).
-- The key variable(s) in each table are shown on the About the Database page.
-- Find the two tables you want to join and look for a key variable they have in common.

-- The sample query looks for spectra of quasars and shows the date and time at which
-- each spectrum was taken.

SELECT TOP 100
       sp.objID,
       sp.ra,
       sp.dec,
       sp.mjd,
       px.taiBegin,
       px.taiEnd,
       sp.fiberID,
       sp.z
FROM specPhoto AS sp
JOIN plateX AS px
       ON sp.plateID = px.plateID
WHERE
       (sp.class='QSO')
       AND sp.z > 3
```

See http://skyserver.sdss.org/dr8/en/help/docs/realquery.asp

Summary

- Databases let you store your data in a structured way
- Relational databases, which structure your data into tables, are particularly useful
- SQL lets us interact with relational databases
- You can get started with SQL relatively quickly - and learn to write very powerful queries!