Introduction to SQL

Feb 2016

Objectives

- Understand the *what* and *why* of Relational Database Management Systems
- *Generally*, how to create and populate a RDBMS
- *Specifically*, how to extract data from a RDBMS using SQL

By the end of this day, you will be able to connect to a Postgres database, answer questions using data and/or download data for further investigation.

What is a Relational Database Management System? (RDBMS)

- *Persistent* data storage system
  - survives after the process in which it was created has ended.
  - is written to non-volatile storage.
  - is infrequently accessed and unlikely to be changed.
- RDMBS was the *de facto* standard for storing data
  - Examples: Oracle, MySQL, SQLServer, Postgres
  - With “Big Data”, this is beginning to change.

Why RDBMS?

An RDMBS provides the ability to:

- model relations in data
- query data and their relations efficiently
- maintain data consistency and integrity

RDBMS Data Model

- **Schema** defines the structure of the data
- The database is composed of a number of user-defined **tables**
- Each **table** will have **columns (aka fields)** and **rows (aka records)**
- A **column** is of a certain **data type** such as integer, string, or date
- A **row** is an entry in a table with data for each column of that table

With a new data source, your first task is typically to understand the schema (not trivial)

Database Table Example

```
CREATE TABLE users {
    id INTEGER PRIMARY KEY,
    name VARCHAR(255),
    age INTEGER,
    city VARCHAR(255),
    state VARCHAR(2)
}
```

The data types available vary from system to system. The above is an example for PostgreSQL where VARCHAR is a string data type.

Primary Key

A primary key is a special column of a table that uniquely identifies that entry.

- EXAMPLE from the *users* table

A primary key is not always an integer - it could be a combination of columns, hash, timestamp..etc.,

Foreign Keys

Foreign Keys are columns that reference some other entry in the database.

Foreign key entry could be in the same table or in some other table.

Example:

```
CREATE TABLE visits {
    id INTEGER PRIMARY KEY,
    created_at TIMESTAMP,
    user_id INTEGER REFERENCES users(id)
}
```

Schema Normalization

Minimizes Redundancy. For example:

- Details about a user(address, age) are only stored once (in a *users* table)
- Any other table (eg. *purchases*) where this data might be relevant, only references the user_id
- Choose Normalized or Denormalized Schemas based on the use case:
  - Heavy reporting (Data Warehouse)
  - Transactional Systems (Ordering System)

SQL

Structured Query Language (SQL)

- As a data scientist, your main interaction with RDBMS will be to *extract* information that already exists in a database
- SQL is the language used to query relational databases
- All RDBMS use SQL and the syntax and keywords are the same for the most part, across systems
- SQL is used to interact with RDBMS, allowing you to create tables, alter tables, insert records, update records, delete records, and query records within and across tables.
- Even non-relational databases like Hadoop usually have a SQL-like interface available

SQL syntax

All SQL queries have three main ingredients:

```
SELECT  *What* data do you want?
  FROM  *Where* do you want to get the data from?
 WHERE  *Under what* conditions?
```

SQL is *Declarative* rather than *Imperative*. That is, you tell the machine what you want and it (database optimizer) decides how to do it

Advanced: You can use Explain-plan to look at the *how*

SQL Queries

Select the columns *name*, *age* from the table *users*.

```
SELECT name, age
FROM users
```

- SQL always returns a table, so the output of the query above is a sub-table of *users* with 2 columns.

Select *name* and *age* for every user in *users* who live in CA.

```
SELECT name, age
FROM users
WHERE state = 'CA'
```

SQL Examples

More SQL

- Joins
- Subqueries
- Order of Operations

JOINS

- **JOIN** clause used to query across multiple tables using *foreign keys*
- Every **JOIN** has two segments:
  - Specifying the *tables* to JOIN
  - Specifying the *columns* to match

JOIN types

There are different JOIN types to deal with different situations:

- **INNER JOIN** discards any entries that do not have a match between the tables based on the keys specified.
- **LEFT OUTER JOIN** keeps all entries in the left table regardless of whether a match is found in the right table
- **RIGHT OUTER JOIN** keeps all the entries in the right table instead of the left regardless of the match.
- **FULL OUTER JOIN** will keep the rows of both tables no matter what

Inner Joins

```
SELECT * FROM TableA
INNER JOIN TableB
ON TableA.name = TableB.name

id  name        id   name
--  ----        --   ----
1   Pirate      2    Pirate
3   Ninja       4    Ninja
```

Inner join produces only the set of records that match in both Table A and Table B.

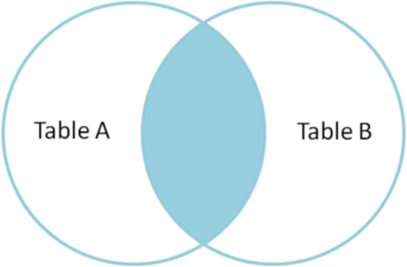


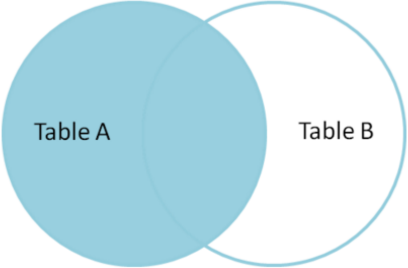
Figure 1:Inner Join

copied from http://blog.codinghorror.com/a-visual-explanation-of-sql-joins/

Left Join

```
SELECT * FROM TableA
LEFT OUTER JOIN TableB
ON TableA.name = TableB.name

id  name       id    name
--  ----       --    ----
1   Pirate     2     Pirate
2   Monkey     null  null
3   Ninja      4     Ninja
4   Spaghetti  null  null
```



Left outer join produces a complete set of records from Table A, with the matching records (where available) in Table B. If there is no match, the right side will contain null.

Figure 2:Left Join

copied from http://blog.codinghorror.com/a-visual-explanation-of-sql-joins/

Outer Join

```
SELECT * FROM TableA
FULL OUTER JOIN TableB
ON TableA.name = TableB.name
```

id	name	id	name
1	Pirate	2	Pirate
2	Monkey	null	null
3	Ninja	4	Ninja
4	Spaghetti	null	null
null	null	1	Rutabaga
null	null	3	Darth Vader

Full outer join produces the set of all records in Table A and Table B, with matching records from both sides where available. If there is no match, the missing side will contain null.

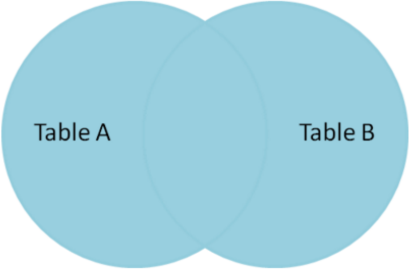


Figure 3:Outer Join

Subqueries

- In general, you can replace any table name with a SELECT statement.
  - SELECT ..... FROM (SELECT ....)
- If a query returns a *single value*, you can treat it as such.
  - WHERE var1 = (SELECT ...)
- If a query returns a **single column**, you can treat it sort of like a list/vector
  - WHERE var1 IN (SELECT ...)

Order of Evaluation of a SQL SELECT Statement

1. **FROM + JOIN**: first the product of all tables is formed
2. **WHERE**: the where clause filters rows that do not meet the search condition
3. **GROUP BY + (COUNT, SUM, etc)**: the rows are grouped using the columns in the group by clause and the aggregation functions are applied on the grouping
4. **HAVING**: like the **WHERE** clause, but can be applied after aggregation
5. **SELECT**: the targeted list of columns are evaluated and returned
6. **DISTINCT**: duplicate rows are eliminated
7. **ORDER BY**: the resulting rows are sorted

Summary:

You should have learnt how to:

- Connect to Postgres via the command line
- Explain the difference between different types of joins
- List the order of operations in SQL
- Write queries on a single table using SELECT, FROM, WHERE, CASE clauses and aggregates (GROUP BY)
- Write queries on multiple tables using JOINS and Subqueries
- Explain primary and foreign keys
- Create and dump tables
- Download SQL Table to CSV