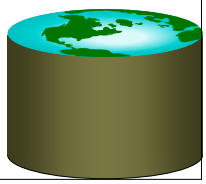
SQL: The Query Language Part 1

R &G - Chapter 5

Life is just a bowl of queries.

-Anon
(not Forrest Gump)



Relational Query Languages

- **Two sublanguages:**
  - DDL – Data Definition Language
    - Define and modify schema (at all 3 levels)
  - DML – Data Manipulation Language
    - Queries can be written intuitively.
- **DBMS is responsible for efficient evaluation.**
  - The key: precise semantics for relational queries.
  - Optimizer can re-order operations, without affecting query answer.
  - Choices driven by "cost model"

The SQL Query Language

- The most widely used relational query language.
- Standardized
  (although most systems add their own "special sauce" -- including PostgreSQL)
- We will study **SQL92** -- a basic subset

Example Database

Sailors

sid	sname	rating	age
1	Fred	7	22
2	Jim	2	39
3	Nancy	8	27

Boats

bid	bname	color
101	Nina	red
102	Pinta	blue
103	Santa Maria	red

Reserves

sid	bid	day
1	102	9/12
2	102	9/13

The SQL DDL

```
CREATE TABLE Sailors (sid INTEGER,
  sname CHAR(20), rating INTEGER, age REAL,
  PRIMARY KEY sid)

CREATE TABLE Boats (bid INTEGER,
  bname CHAR (20), color CHAR(10)
  PRIMARY KEY bid)

CREATE TABLE Reserves (sid INTEGER,
  bid INTEGER, day DATE,
  PRIMARY KEY (sid, bid, date),
  FOREIGN KEY sid REFERENCES Sailors,
  FOREIGN KEY bid REFERENCES Boats)
```

The SQL DML

Sailors

sid	sname	rating	age
1	Fred	7	22
2	Jim	2	39
3	Nancy	8	27

- Find all 18-year-old sailors:

```
SELECT *
  FROM  Sailors S
WHERE S.age=18
```

- To find just names and ratings, replace the first line:

```
SELECT S.sname, S.rating
```

Querying Multiple Relations

```
SELECT S.sname
  FROM  Sailors S, Reserves R
WHERE S.sid=R.sid AND R.bid=102
```

Sailors

sid	sname	rating	age
1	Fred	7	22
2	Jim	2	39
3	Nancy	8	27

Reserves

sid	bid	day
1	102	9/12
2	102	9/13

Basic SQL Query

```
SELECT    [DISTINCT] target-list
FROM      relation-list
WHERE     qualification
```

- *relation-list* : List of relation names
  - possibly with a *range variable* after each name
- *target-list* : List of attributes of tables in *relation-list*
- *qualification* : Comparisons combined using AND, OR and NOT.
- *DISTINCT* : optional keyword indicating that the answer should not contain duplicates.

Query Semantics

1. FROM : compute *cross product* of tables.
2. WHERE : Check conditions, discard tuples that fail.
3. SELECT : Delete unwanted fields.
4. DISTINCT *(optional)* : eliminate duplicate rows.

Note: Probably the least efficient way to compute a query!
- *Query optimizer* will find more efficient ways to get the *same answer*.

Find sailors who've reserved at least one boat

```
SELECT  S.sid
  FROM   Sailors S, Reserves R
WHERE  S.sid=R.sid
```

- Would adding DISTINCT to this query make a difference?
- What is the effect of replacing *S.sid* by *S.sname* in the SELECT clause?
  - Would adding DISTINCT to this variant of the query make a difference?

About Range Variables

- Needed when ambiguity could arise.
  - e.g., same table used multiple times in FROM ("self-join")

```
SELECT  x.sname, x.age, y.sname, y.age
  FROM  Sailors x, Sailors y
WHERE  x.age > y.age
```

Sailors

sid	sname	rating	age
1	Fred	7	22
2	Jim	2	39
3	Nancy	8	27

Arithmetic Expressions

```
SELECT S.age, S.age-5 AS age1, 2*S.age AS age2
 FROM   Sailors S
WHERE  S.sname = 'dustin'
```

```
SELECT  S1.sname AS name1, S2.sname AS name2
 FROM   Sailors S1, Sailors S2
WHERE  2*S1.rating = S2.rating - 1
```

String Comparisons

```
SELECT S.sname
 FROM   Sailors S
WHERE  S.sname LIKE 'B_%B'
```

`_' stands for any one character and `%' stands for 0 or more arbitrary characters.

Find sid's of sailors who've reserved a red **or** a green boat

```
SELECT R.sid
  FROM  Boats B, Reserves R
WHERE R.bid=B.bid AND
          (B.color='red' OR B.color='green')
```

... or:

```
SELECT R.sid
  FROM  Boats B, Reserves R
WHERE R.bid=B.bid AND B.color='red'
UNION
SELECT R.sid
  FROM  Boats B, Reserves R
WHERE R.bid=B.bid AND B.color='green'
```

Find sid's of sailors who've reserved a red **and** a green boat

~~SELECT R.sid~~
~~FROM Boats B,Reserves R~~
~~WHERE R.bid=B.bid AND~~
~~(B.color='red' AND B.color='green')~~

Find sid's of sailors who've reserved a red **and** a green boat

```
SELECT S.sid
  FROM  Sailors S, Boats B, Reserves R
WHERE S.sid=R.sid
          AND R.bid=B.bid
          AND B.color='red'
INTERSECT
SELECT S.sid
  FROM  Sailors S, Boats B, Reserves R
WHERE S.sid=R.sid
          AND R.bid=B.bid
          AND B.color='green'
```

Find sid's of sailors who've reserved a red **and** a green boat

- Could use a self-join:

```
SELECT R1.sid
  FROM  Boats B1, Reserves R1,
          Boats B2, Reserves R2
WHERE R1.sid=R2.sid
          AND R1.bid=B1.bid
          AND R2.bid=B2.bid
          AND (B1.color='red' AND B2.color='green')
```

Find sid's of sailors who have not reserved a boat

```
SELECT S.sid
 FROM   Sailors S
EXCEPT
SELECT S.sid
 FROM   Sailors S, Reserves R
WHERE  S.sid=R.sid
```

Nested Queries: IN

Names of sailors who've reserved boat #103:

```
SELECT  S.sname
  FROM  Sailors S
WHERE  S.sid IN (SELECT  R.sid
                 FROM    Reserves R
                 WHERE  R.bid=103)
```

Nested Queries: NOT IN

*Names of sailors who've **not** reserved boat #103:*

```
SELECT  S.sname
  FROM  Sailors S
WHERE  S.sid NOT IN (SELECT  R.sid
                     FROM    Reserves R
                     WHERE  R.bid=103)
```

Nested Queries with Correlation

Names of sailors who've reserved boat #103:

```
SELECT  S.sname
FROM  Sailors S
WHERE EXISTS
        (SELECT  *
         FROM  Reserves R
         WHERE R.bid=103 AND S.sid=R.sid)
```

- **Subquery must be recomputed for each Sailors tuple.**
  - Think of subquery as a function call that runs a query!
- **Also: NOT EXISTS.**

UNIQUE

*Names of sailors who've reserved boat #103 **exactly once**:*

```
SELECT  S.sname
FROM  Sailors S
WHERE UNIQUE
        (SELECT  *
         FROM  Reserves R
         WHERE R.bid=103 AND S.sid=R.sid)
```

More on Set-Comparison Operators

- we've seen: **IN, EXISTS, UNIQUE**
- can also have: **NOT IN, NOT EXISTS, NOT UNIQUE**
- other forms: ***op* ANY, *op* ALL**

- **Find sailors whose rating is greater than that of some sailor called Horatio:**

```
SELECT  *
  FROM  Sailors S
WHERE  S.rating > ANY (SELECT  S2.rating
                       FROM  Sailors S2
                       WHERE S2.sname='Horatio')
```

A Tough One

Find sailors who've reserved all boats.

```
SELECT  S.sname
FROM  Sailors S                    Sailors S such that ...
WHERE  NOT EXISTS (SELECT  B.bid                there is no boat B without
                   FROM  Boats B                ...
                   WHERE  NOT EXISTS (SELECT  R.bid
                                      FROM  Reserves R
                                      WHERE  R.bid=B.bid
                                        AND R.sid=S.sid))
```

a Reserves tuple showing S reserved B

Summary

- Relational model has well-defined query semantics
- SQL provides functionality close to basic relational model
  (some differences in duplicate handling, null values, set operators, …)
- Typically, many ways to write a query
  - DBMS figures out a fast way to execute a query, regardless of how it is written.