SQL: Queries, Constraints, Triggers Part 1

Chapter 5.1-5.4

Structured Query Language (SQL)

- Introduced in 1974 by IBM
- "De facto" standard db query language
- Caveats
  - Standard has evolved (major revisions in 1992 and 1999)
  - Semantics and Syntax may vary slightly among DBMS implementations
  - Example sqlite's version of the CREATE VIEW on pg. 90

```
CREATE VIEW ActiveStudents
AS SELECT S.sname AS name, S.login AS login, C.cname AS club, C.jyear AS since
FROM Students S, Clubs C
WHERE S.sname = C.mname AND S.gpa > 3
```

Baby Example Instances

- We will start with these instances of the Sailors and Reserves relations in our examples.
- If the key for the Reserves relation contained only the attributes *sid* and *bid*, how would the semantics differ?

Sailors:

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

Reserves:

sid	bid	day
22	101	10/10/96
58	103	11/12/96

Basic SQL Query

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

- *target-list* A list of attributes of relations in *relation-list*
- *relation-list* A list of relation names (possibly with a *range-variable* after each name).
- *qualification* Comparisons (Attr *op* const or Attr1 *op* Attr2, where *op* is one of $<, >, =, \leq, \geq, \neq$) combined using AND, OR and NOT.
- DISTINCT is an optional keyword indicating that the answer should not contain duplicates. Default is that duplicates are *not* eliminated!

Conceptual Evaluation Strategy

- Semantics of an SQL query defined in terms of the following *conceptual evaluation strategy*:
  - Compute the cross-product of the *relation-list*.
  - Select (σ) tuples if they satisfy *qualifications*.
  - Project (π) attributes that in the *target-list*.
  - If DISTINCT is specified, eliminate duplicate rows.
- This strategy is probably the least efficient way to compute a query! An optimizer will find more efficient strategies to compute *the same answers*.

Example of Conceptual Evaluation

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

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96
31	lubber	8	55.5	58	103	11/12/96
58	rusty	10	35.0	22	101	10/10/96
58	rusty	10	35.0	58	103	11/12/96

A Note on Range Variables

- Really needed only if the same relation appears twice in the FROM clause. The previous query can also be written as:

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

OR

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

It is good style, however, to use range variables always!

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?

Expressions and Strings

```
SELECT  S.age, S.age-5 AS age1, 2*S.age AS age2
FROM  Sailors S
WHERE  S.sname LIKE '_us%'
```

- Illustrates use of arithmetic expressions and string pattern matching: *Find triples (of ages of sailors and two fields defined by expressions) for sailors whose names begin and end with B and contain at least three characters.*
- AS renames fields (ρ) in result. (Some SQL implementations allow the use of '*newalias=expr*' as well)
- LIKE is used for string matching. "_" stands for any one character and "%" stands for 0 or more arbitrary characters.

More Examples

- "Infant" Sailors/Reserves/Boats instance

Sailors:

sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Reserves:

sid	bid	day
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Boats:

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

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

- Two approaches
- UNION: Can be used to compute the union of any two *union-compatible* sets of tuples (which are themselves the result of SQL queries).
- If we replace OR by AND in the first version, what do we get?
- Also available: EXCEPT (What do we get if we replace UNION by EXCEPT?)

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

```
SELECT  S.sid
FROM  Sailors S, Boats B, Reserves R
WHERE  S.sid=R.sid AND R.bid=B.bid
            AND B.color='red'
UNION
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 *<u>and</u>* *a green boat*

- Solution 1: Multiple instancing of the same relation in the relation-list using another variable
- Solution 2: INTERSECT: Can be used to compute the intersection of any two *union-compatible* sets of tuples.
- Included in the SQL/92 standard, but some systems don't support it.
- Contrast symmetry of the UNION and INTERSECT queries with the first version.

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

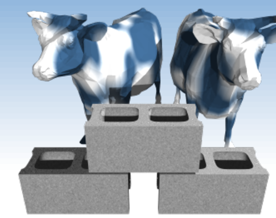
```
SELECT  S.sid
FROM  Sailors S, Boats B, Reserves R
WHERE  S.sid=R.sid AND R.bid=B.bid
            AND B.color='red'
INTERSECT
SELECT  S.sid
FROM  Sailors S, Boats B, Reserves R
WHERE  S.sid=R.sid AND R.bid=B.bid
            AND B.color='green'
```

Nested Queries

Find 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)
```

- *A very powerful feature of SQL*: a WHERE clause can itself contain an SQL query! (Actually, so can FROM and HAVING clauses.)
- To find sailors who've *not* reserved #103, use NOT IN.
- To understand semantics of nested queries, think of a *nested loops* evaluation: *For each Sailors tuple, check the qualification by computing the subquery.*

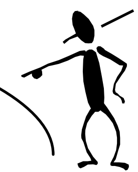


Nested Queries with Correlation

Find 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)
```

Correlation is when inner SELECTs reference relation variables of outer SELECTs



- EXISTS is another set comparison operator, like IN. It selects tuples where its argument is a non-empty set.
- You can also use NOT EXISTS to return those sailors who have not reserved boat #103
- Illustrates why, in general, a subquery must be re-evaluated for each Sailors tuple.

More on Set-Comparison Operators

- Also available: *op* ANY, *op* ALL, *op* IN $>, <, =, \geq, \leq, \neq$
- 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')
```

INTERSECT Queries Using IN

Find sid's of sailors who've reserved both 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'
        AND S.sid IN  (SELECT  S2.sid
                       FROM  Sailors S2, Boats B2, Reserves R2
                       WHERE  S2.sid=R2.sid AND R2.bid=B2.bid
                              AND  B2.color='green')
```

- Similarly, EXCEPT queries re-written using NOT IN.
- To find *names* (not *sid*'s) of Sailors who've reserved both red and green boats, just replace *S.sid* by *S.sname* in SELECT clause. (What about INTERSECT query?)

Division in SQL

Find sailors who've reserved all boats.

```
SELECT  S.sname
FROM  Sailors S
WHERE  NOT EXISTS
           ((SELECT  B.bid
             FROM  Boats B)
            EXCEPT
             (SELECT  R.bid
              FROM  Reserves R
              WHERE  R.sid=S.sid))
```

- For each sailor we first construct a list of all boats then remove from that list all boats reserved by the sailor.
- If the resulting list is empty, select the tuple

Division in SQL, version 2

Find sailors who've reserved all boats.

- The hard way, without EXCEPT:

```
SELECT  S.sname
FROM  Sailors S
WHERE  NOT EXISTS  (SELECT  B.bid
                    FROM  Boats B
                    WHERE  NOT EXISTS  (SELECT  R.bid
                                        FROM  Reserves R
                                        WHERE  R.bid=B.bid
                                           AND R.sid=S.sid))
```

Sailors S such that ...

there is no boat B without ...

a Reserves tuple showing S reserved B

Next Time

- We've covered the portion of SQL that has the same power as relation algebra
- Next time we will consider some important extensions, that cannot be expressed in relational algebra, but are nonetheless useful tools for and a natural additions to query specification