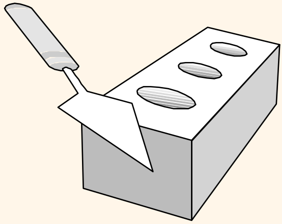
SQL Queries

Chapter 5

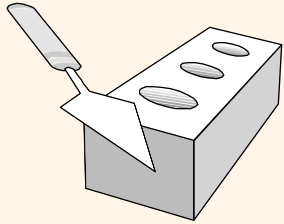
The Structured Query Language



- Developed by IBM (system R) in the 1970s
- *The* most widely used language for creating, manipulating, and querying relational DBMS.
- Need for a standard since it is used by many vendors
- Standards:
  - SQL-86
  - SQL-89 (minor revision)
  - SQL-92 (major revision)
  - SQL-99 (major extensions, current standard)

Example Instances

- Sailor (sid, sname, rating, age)
- Reserve (sid, bid, day)
- Boat (bid, color)



- We will use these instances of the Sailors and Reserves relations in our examples.

S1

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

R1

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

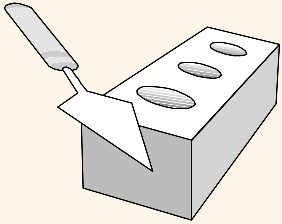
S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Basic SQL Query

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

- *relation-list* A list of relation names
- *target-list* A list of attributes of relations in *relation-list*
- *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:
  1. Compute the cross-product of *relation-list*.
  2. Discard resulting tuples if they fail *qualifications*.
  3. Delete attributes that are not in *target-list*.
  4. 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

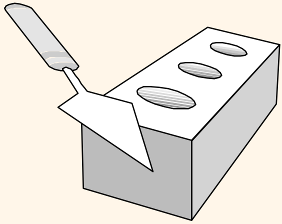
Expressions and Strings

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

- 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 and = are two ways to name fields in result.
- LIKE is used for string matching. `_' stands for any one character and `%' stands for 0 or more arbitrary characters.

Find sailors who've reserved at least one boat

- Sailor (<u>sid</u>, sname, rating, age)
- Reserve (<u>sid</u>, <u>bid</u>, day)
- Boat (<u>bid</u>, color)



```
SELECT R.sid
FROM Reserves R
```

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

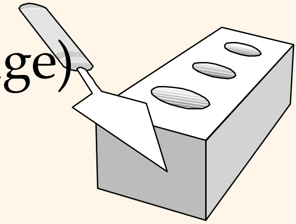
- Would adding DISTINCT to this query make a difference?

Find the names of sailors who have reserved a red boat

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

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

- Sailor (sid, sname, rating, age)
- Reserve (sid, bid, day)
- Boat (bid, color)



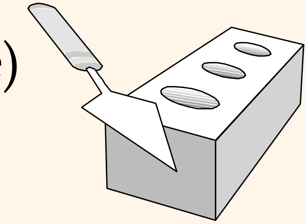
- UNION: Can be used to compute the union of any two *union-compatible* sets of tuples (which are themselves the result of SQL queries).
- If we replace OR by AND in the first version, what do we get?
- Also available: EXCEPT (What do we get if we replace UNION by EXCEPT?)

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

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

- Sailor (sid, sname, rating, age)
- Reserve (sid, bid, day)
- Boat (bid, color)



- 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 how much the other versions differ.

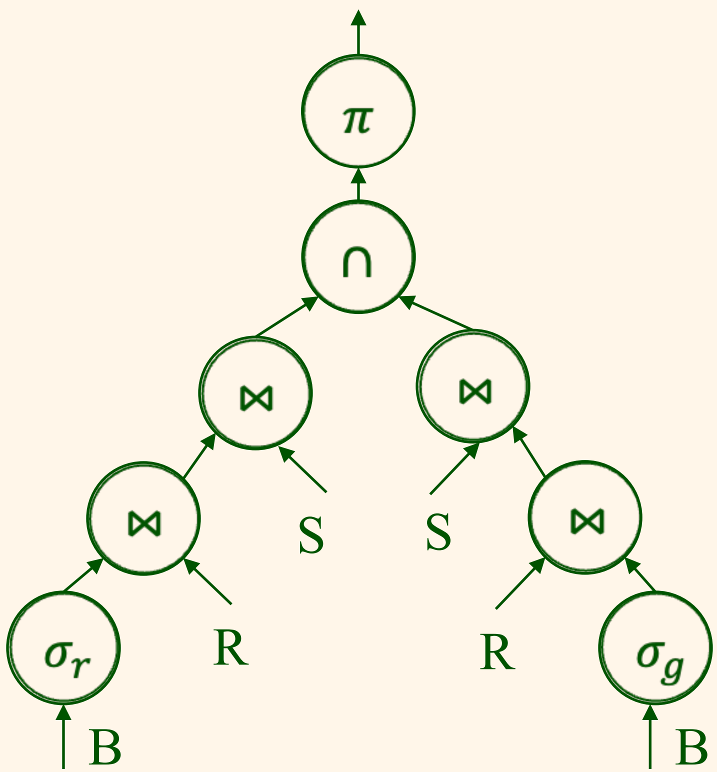
```
SELECT  S.sid, S.sname
FROM  Sailors S, Boats B1, Reserves R1,
        Boats B2, Reserves R2
WHERE  S.sid=R1.sid AND R1.bid=B1.bid
  AND  S.sid=R2.sid AND R2.bid=B2.bid
  AND B1.color='red' AND B2.color='green'
```

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

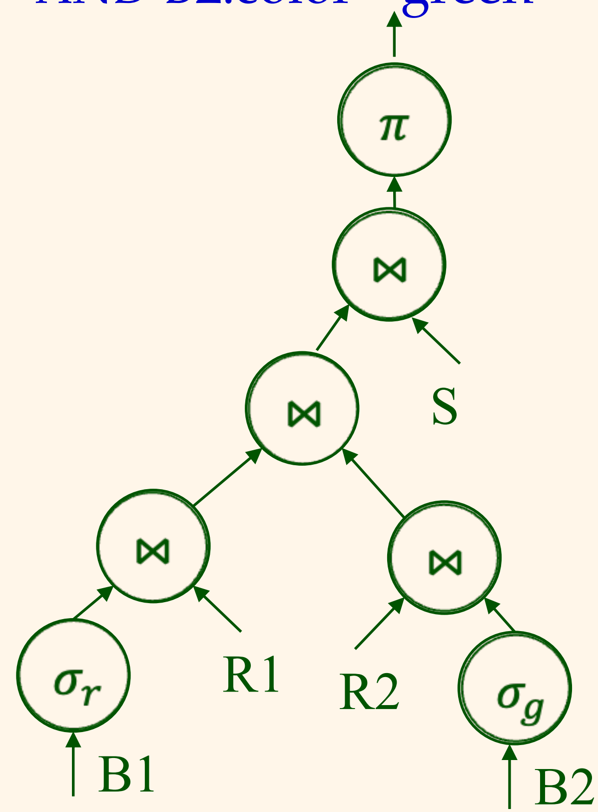
```
SELECT  S.sid, S.sname
FROM  Sailors S, Boats B, Reserves R
WHERE  S.sid=R.sid AND R.bid=B.bid
         AND B.color='red'
```

INTERSECT

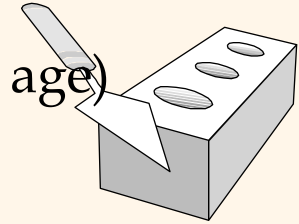
```
SELECT  S.sid, S.sname
FROM  Sailors S, Boats B, Reserves R
WHERE  S.sid=R.sid AND R.bid=B.bid
         AND B.color='green'
```




```
SELECT  S.sid, S.sname
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'
```



Find sid's and names of sailors who've reserved red boats but not green boats



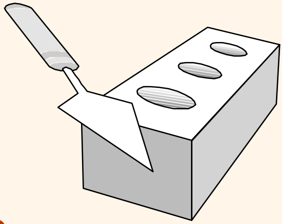
- Sailor (sid, sname, rating, age)
- Reserve (sid, bid, day)
- Boat (bid, color)

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

- EXCEPT: Can be used to compute the difference of any two *union-compatible* sets of tuples
- Many systems recognize the keyword MINUS instead of EXCEPT

Nested Queries

- Sailor (sid, sname, rating, age)
- Reserve (sid, bid, day)
- Boat (bid, color)



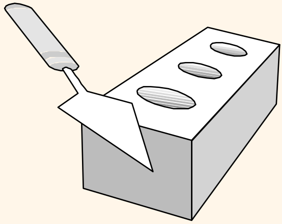
Find names of sailors who've reserved boat #103

```
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 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

- Sailor (sid, sname, rating, age)
- Reserve (sid, bid, day)
- Boat (bid, color)

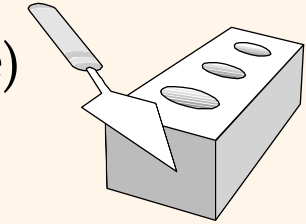


Find names of sailors who've NOT reserved boat #103

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

Nested Queries

- Sailor (sid, sname, rating, age)
- Reserve (sid, bid, day)
- Boat (bid, color)

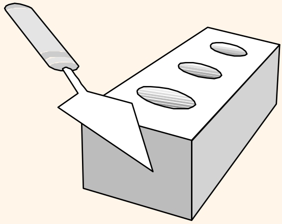


Find names of sailors who've not reserved a red boat

```
SELECT  S.sname
FROM  Sailors S
WHERE  S.sid NOT IN   (SELECT  R.sid
                        FROM  Reserves R
                        WHERE  R.bid IN ( SELECT B.bid
                                          FROM Boats B
                                          WHERE B.color ='red'
                                          )
                        )
```

Nested Queries with Correlation

- Sailor (sid, sname, rating, age)
- Reserve (sid, bid, day)
- Boat (bid, color)

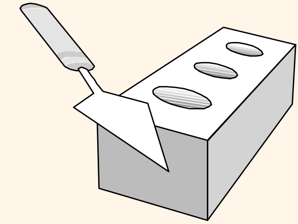


Find names of sailors who've reserved boat #103:

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

- EXISTS is another set comparison operator, like IN.
- If UNIQUE is used, and * is replaced by *R.bid*, finds sailors with at most one reservation for boat #103.
- Illustrates why, in general, subquery must be re-computed for each Sailors tuple.

More on Set-Comparison Operators



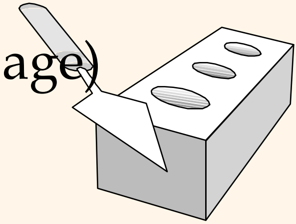
- Sailor (sid, sname, rating, age)
- Reserve (sid, bid, day)
- Boat (bid, color)

- We've already seen IN, EXISTS and UNIQUE. Can also use NOT IN, NOT EXISTS and NOT UNIQUE.
- 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')
```

Rewriting INTERSECT Queries Using IN

- Sailor (sid, sname, rating, age)
- Reserve (sid, bid, day)
- Boat (bid, color)

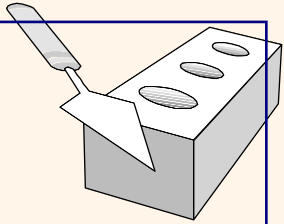


Find sid of sailors who've reserved both a red and a green boat:

```
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.
- Useful if your system does not support INTERSECT or EXCEPT

Division in SQL



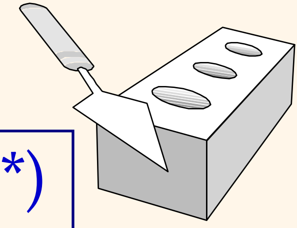
```
SELECT  S.sname
FROM  Sailors S
WHERE  NOT EXISTS
            ((SELECT  B.bid
              FROM  Boats B)
             EXCEPT
             (SELECT  R.bid
              FROM  Reserves R
              WHERE  R.sid=S.sid))
```

Find sailors who've reserved all boats.

- Let's do it 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))
```

Aggregate Operators



- Significant extension of relational algebra.

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

sid	sname	rating	age
28	Bob	10	35
31	Bob	10	20
44	guppy	5	50
58	rusty	10	35

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

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

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

```
SELECT COUNT (DISTINCT S.rating)
FROM Sailors S
WHERE S.sname='Bob'
```

```
SELECT MAX (S.age)
FROM Sailors S
```

Find name and age of the oldest sailor(s)

- The first query is illegal! (We'll look into the reason a bit later, when we discuss GROUP BY.)
- The third query is equivalent to the second query, and is allowed in the SQL/92 standard, but is not supported in some systems.

```
SELECT  S.sname, MAX (S.age)
FROM  Sailors S
```

```
SELECT  S.sname, S.age
FROM  Sailors S
WHERE  S.age =
          (SELECT  MAX (S2.age)
           FROM  Sailors S2)
```

```
SELECT  S.sname, S.age
FROM  Sailors S
WHERE  (SELECT  MAX (S2.age)
           FROM  Sailors S2)
           = S.age
```

Motivation for Grouping

- So far, we've applied aggregate operators to all (qualifying) tuples. Sometimes, we want to apply them to each of several *groups* of tuples.
- Consider: *Find the age of the youngest sailor for each rating level.*
  - Suppose we know that rating values go from 1 to 10; we can write 10 queries that look like this (!):

For i = 1, 2, ... , 10:

```
SELECT  MIN (S.age)
FROM  Sailors S
WHERE  S.rating = i
```

  - In general, we don't know how many rating levels exist, and what the rating values for these levels are!

Queries With GROUP BY *and* HAVING

```
SELECT      [DISTINCT] target-list
FROM        relation-list
WHERE       qualification
GROUP BY    grouping-list
HAVING      group-qualification
```

- The *target-list* contains (i) attribute names (ii) terms with aggregate operations (e.g., MIN (*S.age*)).
  - The attribute list (i) must be a subset of *grouping-list*. Intuitively, each answer tuple corresponds to a *group*, and these attributes must have a single value per group. (A *group* is a set of tuples that have the same value for all attributes in *grouping-list*.)