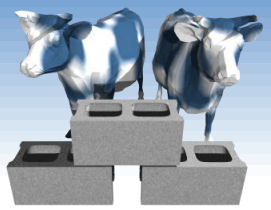
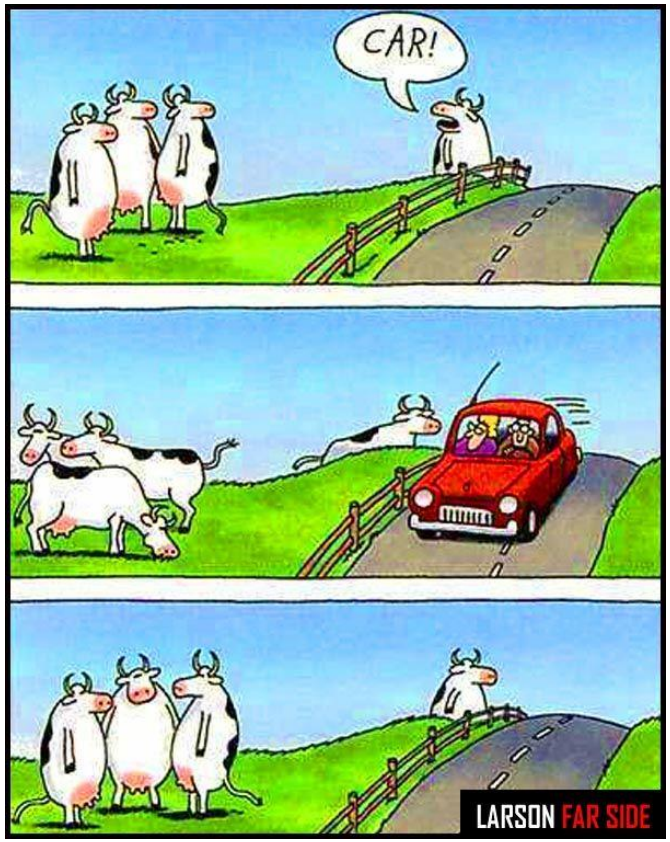
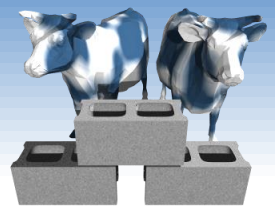


SQL: Basic Queries

Chapter 5.1-5.4

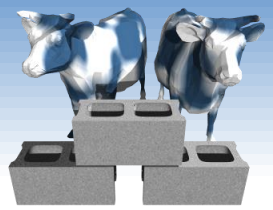


Structured Query Language (SQL)



- 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

"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?

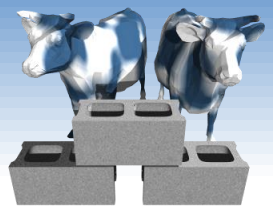
Sailors:

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

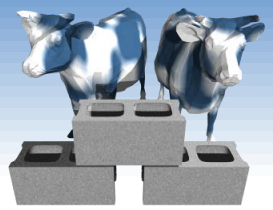


SELECT	[DISTINCT] *target-list*
FROM	*relation-list*
WHERE	*qualification*

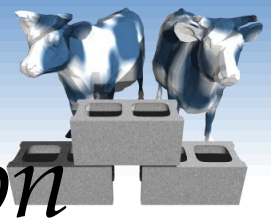
$<, >, =, \leq, \geq, \neq$

- *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 <, >, =, <=, >=, <>) combined using AND, OR and NOT.
- DISTINCT is an optional keyword indicating that the answer should not contain duplicates. By default 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*.

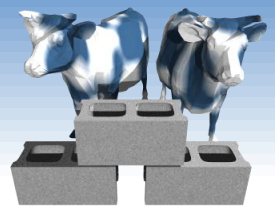


Example of Conceptual Evaluation

```
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

Table Aliases (Variables)



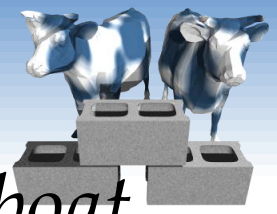
- Really needed only if the same relation appears twice in the FROM clause. The previous query can also be written as:

```
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
```

However, aliases also provide a convenient shorthand for referencing tables

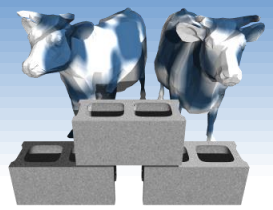


Find sailors who've reserved at least one boat

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

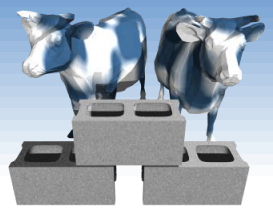
- Would adding DISTINCT to this query make a difference?
- What is the effect of replacing *S.sid* by *S.sname* in the SELECT clause? Would adding DISTINCT to this variant of the query make a difference?

Expressions and Strings



```
SELECT  S.age, S.age*12.0 AS ageMonths, 10-S.rating AS revRating
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 have 'us' as the second and third letter of their name.*
- AS renames fields (ρ) in result. (Some SQL implementations allow the use of '*newalias*=*expr*' as well)
- LIKE is used for approximate string matching. "_" stands for any one character and "%" stands for 0 or more arbitrary characters.



A more extensive example

- "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

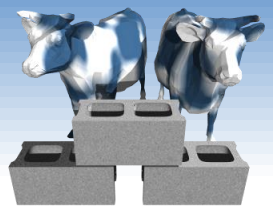
Reserves:

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

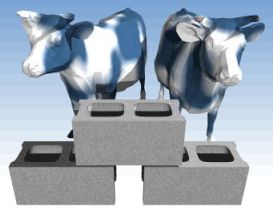


- Two approaches
- If we replace OR by AND in the first version, what do we get?
- UNION: Can be used to compute the union of any two *union-compatible* sets of tuples (which are themselves the result of SQL queries).
- Also available: EXCEPT (What do we get if we replace UNION by EXCEPT?)

```
SELECT  DISTINCT 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 and 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.
- Contrast symmetry of the UNION and INTERSECT queries with the first version.

```
SELECT DISTINCT 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"
```

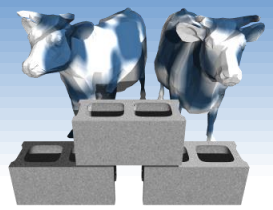
Nested Queries

Find names of sailors who've never reserved boat #103:

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

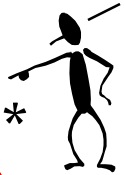
- *A very powerful feature of SQL*: a WHERE clause can itself contain an SQL query! (Actually, so can FROM and HAVING clauses.)
- To find sailors who've reserved #103, use IN.
- To understand semantics of nested queries, think of a *nested loops* evaluation: *For each Sailors tuple, check the qualification by computing the subquery.*

Nested Queries with Correlation



Find names of sailors who've reserved any boat:

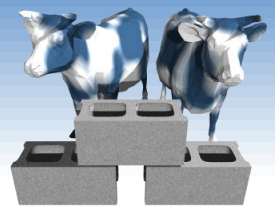
```
SELECT  S.sname
FROM  Sailors S
WHERE  EXISTS  (SELECT  *
                FROM  Reserves R
                WHERE  S.sid=R.sid)
```



Correlation is when inner SELECT references relation variables of outer SELECT

- EXISTS is another set comparison operator, like IN.
- Illustrates why, in general, a subquery must be re-evaluated for each Sailors tuple.

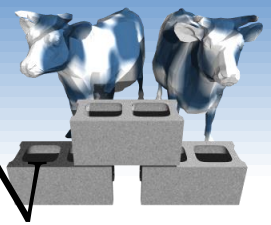
More on Set-Comparison Operators



- 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')
```

Not every SQL dialect supports ANY and ALL. However, IN is universal and can usually be used to achieve the desired effect



Rewriting INTERSECT Queries Using IN

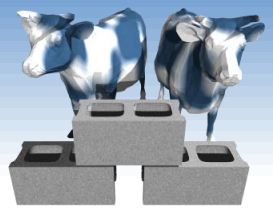
Find sid's of sailors who've reserved both a red and a green boat:

```
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.



- The hard way, without EXCEPT:

(1)

```
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)
```

All boats

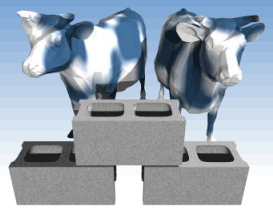
Boats reserved by a given Sailor

(2)

```
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