More SQL

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

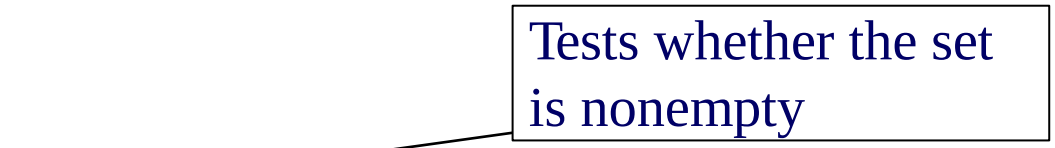
sid	*bid*	*day*
22	101	10/10/04
22	102	10/10/04
22	103	10/08/04
22	104	10/07/04
31	102	11/10/04
31	103	11/06/04
31	104	11/12/04
64	101	09/05/04
64	102	09/08/04
74	103	09/08/04

Boats

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

Correlated Nested Queries (Revisit)

Find names of sailors who have reserved boat 103




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

(For finding sailors who have **not** reserved boat 103, we would use NOT EXISTS)

Correlated Nested Query

Find the names of sailors who have 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));
```

Correlated Nested Query 2

Alternatively,

Find the names of sailors who have reserved ALL boats

```
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 ));
```

ANY and ALL operators

Find sailors whose rating is better than some sailor named Horatio

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

Using ALL operator

*Find sailors whose rating is better than **every** sailor named Horatio*

Note that IN is equivalent to = ANY
NOT IN is equivalent to <> ALL

```
SELECT S.sid
FROM Sailors S
WHERE S.rating > ALL(SELECT S2.rating
                     FROM Sailors S2
                     WHERE S2.sname='Horatio');
```

What if there were no sailor called Horatio?

Last time we saw…
Example of MAX operator

Find the name and age of the oldest sailor

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

But this is illegal in SQL!!

If the SELECT clause uses aggregate operation, it must ONLY use aggregate operations unless we use GROUP BY/HAVING

Correct SQL Query for MAX

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

Alternatively…

```
SELECT S.sname, S.age
FROM Sailors S
WHERE ROWNUM <= 1
ORDER BY S.age DESC;
```

Banking Examples

branch (branch-id, branch-city, assets)

customer (customer-id, customer-name, customer-city)

account (account-number, branch-id, balance)

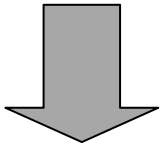
loan (loan-number, branch-id, amount)

depositor (customer-id, account-number)

borrower (customer-id, loan-number)

IN…Example I

"*Find the account numbers opened at branches of the bank in Fairfax*"



SELECT A.account-number

FROM account A

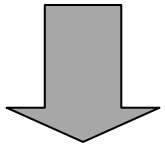
WHERE A.branch-id IN (SELECT B.branch-id

FROM branch B

WHERE B.branch-city= 'Fairfax')

IN…Example 2

"Find the account numbers opened at branches 101 and 102 of the bank"



SELECT A.account-number

FROM A.account

WHERE A.branch-id IN ('101', '102')

EXISTS

The *EXISTS* predicate is TRUE if and only if the Subquery returns a non-empty set.

The *NOT EXISTS* predicate is TRUE if and only if the Subquery returns an empty set.

The *NOT EXISTS* can be used to implement the SET DIFFERENCE operator from relational algebra.

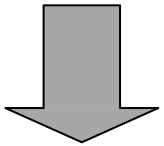
EXISTS…Example 1

"Select all the account balances where the account has been opened in a branch in Fairfax "

```
SELECT A.account-balance
FROM account A
WHERE EXISTS (SELECT *
              FROM branch B
              WHERE B.branch-city= 'Fairfax'
                    AND B.branch-id=A.branch-id)
```

EXISTS…Example 2

"Select all the account balances where the account has not been opened in a Fairfax branch "



SELECT A.account-balance

FROM account A

WHERE NOT EXISTS (SELECT *

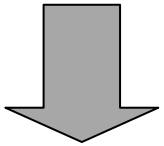
FROM branch B

WHERE B.branch-city= 'Fairfax'

AND B.branch-id=A.branch-id)

EXISTS…Example 3

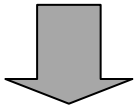
"*Find customers who opened accounts in all branches in Fairfax*"



```
SELECT C.customer-id
FROM customer C
WHERE NOT EXISTS (SELECT B.branch-id
                  FROM branch B
                  WHERE B.branch-city= 'Fairfax'
                  EXCEPT
                  SELECT A.branch-id
                  FROM depositor D, account A
                  WHERE D.customer-id = C.customer-id AND
                        D.account-number = A.account-number)
```

Quantified Comparison Predicate
Example 1

"*Select account numbers of the accounts with the minimum balance*"



SELECT A.account-number

FROM account A

WHERE A.balance <= ALL (SELECT A2.balance
FROM account A2)

Aggregate Functions in SQL… revisited

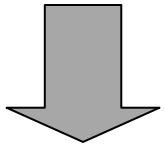
- SQL provides five built-in aggregate functions that operate on sets of column values in tables:

- *COUNT( ), MAX( ), MIN( ), SUM( ), AVG( ).*

- With the exception of *COUNT( )*, these set functions must operate on sets that consist of simple values-that is, sets of numbers or sets of character strings, rather than sets of rows with multiple values.

Aggregate Functions in SQL
Example 1

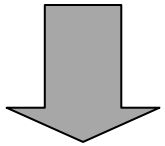
"Select the total amount of balance of the account in branches located in Fairfax"



```
SELECT SUM(A.balance) AS total_amount
FROM account A, branch B
WHERE B.branch-city= 'Fairfax' AND
      B.branch-id= A.branch-id
```

Aggregate Functions in SQL
Example 2

"*Select the total number of opened accounts*"



SELECT COUNT(A.account-number)

FROM account A

OR

SELECT COUNT(*)
FROM account

GROUP BY and HAVING

- 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.*
  - In general, we don't know how many rating levels exist, and what the rating values for these levels are!
  - Suppose we know that rating values go from 1 to 10; we can write 10 queries that look like this (!):

For $i = 1, 2, \ldots, 10$:

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

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*.)

Conceptual Evaluation

- The cross-product of *relation-list* is computed, tuples that fail *qualification* are discarded, `*unnecessary*' fields are deleted, and the remaining tuples are partitioned into groups by the value of attributes in *grouping-list*.
- The *group-qualification* is then applied to eliminate some groups. Expressions in *group-qualification* must have a *single value per group*!
  - In effect, an attribute in *group-qualification* that is not an argument of an aggregate op also appears in *grouping-list*. (SQL does not exploit primary key semantics here!)
- One answer tuple is generated per qualifying group.

Find the age of the youngest sailor with age >= 18, for each rating with at least 2 such sailors

```
SELECT  S.rating,  MIN (S.age)
FROM  Sailors S
WHERE  S.age >= 18
GROUP BY  S.rating
HAVING  COUNT (*) > 1
```

- Only S.rating and S.age are mentioned in the SELECT, GROUP BY or HAVING clauses; other attributes `*unnecessary*' .
- 2nd column of result is unnamed. (Use AS to name it.)

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
71	zorba	10	16.0
64	horatio	7	35.0
29	brutus	1	33.0
58	rusty	10	35.0

rating	age
1	33.0
7	45.0
7	35.0
8	55.5
10	35.0

rating	
7	35.0

Answer relation

Find the age of the youngest sailor with age >= 18, for each rating with at least 2 sailors (of any age)

```
SELECT  S.rating,  MIN (S.age)
FROM  Sailors S
WHERE  S.age >= 18
GROUP BY  S.rating
HAVING  1  <  (SELECT  COUNT (*)
                FROM  Sailors S2
                WHERE  S.rating=S2.rating)
```

- Shows HAVING clause can also contain a subquery.
- Compare this with the query where we considered only ratings with 2 sailors over 18

For each red boat, find the number of reservations for this boat

```
SELECT  B.bid,  COUNT (*) AS scount
FROM  Boats B, Reserves R
WHERE  R.bid=B.bid AND B.color= 'red'
GROUP BY  B.bid
```

- Grouping over a join of two relations.
- What do we get if we remove *B.color= 'red'* from the WHERE clause and add a HAVING clause with this condition?

```
SELECT  B.bid,  COUNT (*) AS scount
FROM  Boats B, Reserves R
WHERE  R.bid=B.bid
GROUP BY  B.bid
HAVING B.color= 'red'
```

Illegal!

Can be rewritten using EVERY in HAVING:

```
SELECT  B.bid,  COUNT (*) AS scount
FROM  Boats B, Reserves R
WHERE  R.bid=B.bid
GROUP BY  B.bid
HAVING EVERY(B.color= 'red')
```

Find those ratings for which the average age is the minimum over all ratings

```
SELECT  S.rating
FROM  Sailors S
GROUP BY S.rating
HAVING AVG(S.age) =   (SELECT  MIN (AVG (S2.age))
                       FROM Sailors S2
                       Group by rating);
```

Can use nested aggregates with Group By

Null Values

- We use *null* when the column value is either *unknown* or *inapplicable*.
- A comparison with at least one null value always returns *unknown*.
- SQL also provides a special comparison operator *IS NULL* to test whether a column value is *null*.
- To incorporate nulls in the definition of duplicates we define that two rows are duplicates if corresponding rows are equal or both contain *null*.

Deal withthe null value

- Special operators needed to check if value is/is not *null*.
  - “is null” always true or false (never unknown)
  - “is not null”
- Is *rating>8* true or false when *rating* is equal to *null*?
  - Actually, it’s unknown.
  - Three-valued logic

Three valued logic

AND	False	True	Unknown
False	False	False	False
True	False	True	Unknown
Unknown	False	Unknown	Unknown

OR	False	True	Unknown
False	False	True	Unknown
True	True	True	True
Unknown	Unknown	True	Unknown

	NOT
False	True
True	False
Unknown	Unknown

Other issues with the null value

- WHERE and HAVING clause eliminate rows that don't evaluate to true (i.e., rows evaluate to false or unknown).
- All of +, -, *, / return null if any argument is null
- Can force "no nulls" while creating a table
  - sname char(20) NOT NULL
  - primary key is always not null
- Aggregate functions ignore nulls (except count (*))
- DISTINCT treats all nulls as the same

Aggregates with NULL

sid	sname	rating	age
22	dustin	7	45
31	lubber	8	55
58	rusty	10	35

R1

sid	sname	rating	age
22	dustin	7	45
31	lubber	null	55
58	rusty	10	35

R2

What do you get for

- SELECT count(*) from R1?
- SELECT count(rating) from R1?

What do you get for

- SELECT count(*) from R2?
- SELECT count(rating) from R2?

- Aggregate functions ignore nulls (except count (*))

Aggregates with NULL

- COUNT, SUM, AVG, MIN, MAX (with or without DISTINCT)
  - Discards null values first
  - Then applies the aggregate
  - Except count(*)
- If only applied to null values, the result is null

sid	sname	rating	age
22	dustin	7	45
31	lubber	null	55
58	rusty	10	35

R2

SELECT sum(rating) from R2?

Ans: …

sid	sname	rating	age
22	dustin	null	45
31	lubber	null	55
58	rusty	null	35

R3

SELECT sum(rating) from R3?

Ans: …

General Constraints: CHECK

- Useful when more general ICs than keys are involved
- Constraints can be named
- Not checked if table is empty
- Standalone CHECK for single table only

```
CREATE TABLE Sailors
(sid INTEGER,
sname CHAR(10),
rating INTEGER, age REAL,
PRIMARY KEY (sid),
CHECK ( rating >= 1
  AND rating <= 10 )
```

```
CREATE TABLE Sailors
(sid INTEGER,
 sname CHAR(10),
 rating INTEGER,  age REAL,
 PRIMARY KEY (sid),
 CONSTRAINT RatingRange
   CHECK ( rating >= 1
   AND rating <= 10 ))
```

Complex Constraints: Assertions

- Table constraints apply to only one table
- Assertions are constraints that are separate from **CREATE TABLE** statements
  - Similar to domain constraints, they are separate statements in the DB schema
  - Assertions are tested **whenever the DB is updated**
    - Therefore they may introduce significant overhead

Note: Not supported in Oracle

Assertions

Example

- Number of boats plus number of sailors is < 100
  - Not associated with a particular table.
  - Constraint may apply to multiple tables.

```
CREATE ASSERTION smallClub
CHECK (
(SELECT COUNT (S.sid) FROM Sailors S)
+
(SELECT COUNT (B.bid) FROM Boats B) < 100)
```

Assertion Limitations

- There are some constraints that cannot be modeled with table constraints or assertions
  - What if there were participation constraints between customers and accounts?
    - Every customer must have at least one account and every account must be held by at least one customer
  - An assertion *could* be created to check this situation
    - But would prevent new customers or accounts being added!

Views

- A view is just a relation, but we store a definition, rather than a set of tuples

```
CREATE VIEW YoungActiveStudents (name, grade)
  AS SELECT S.name, E.grade
     FROM Students S, Enrolled E
     WHERE S.sid = E.sid and S.age < 21
```

- Views can be dropped using the DROP VIEW command
- Views and Security: Views can be used to present necessary information (or a summary), while hiding details in underlying relation(s)
  - the above view hides courses "cid" from E

Create a new table from a query on other tables

SELECT… INTO.... FROM.... WHERE

```
SELECT S.name, E.grade
INTO YoungActiveStudents
FROM Students S, Enrolled E
WHERE S.sid = E.sid and S.age<21
```

Outer Joins

- Let R and S be two tables. The outer join preserves the rows of R and S that have no matching rows according to the join condition and outputs them with nulls at the non- applicable columns.
- There exist three different variants: *left outer join*, *right outer join* and *full outer join*.

Outer joins

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

(left outer-join)

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

=

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

Outer Joins in Oracle

```
Select *
From Sailor S, Reserve R
Where S.sid = R.sid(+);
```

How about:

```
Select  S.sid,  count(R.bid)
From  Sailor  S, Reserve  R
Where S.sid = R.sid(+)
Group by S.sid;
```

OR

```
Select S.sid, count(*)
From Sailor S, Reserve R
Where S.sid = R.sid(+)
Group by S.sid;
```

More Outer Joins

- Left outer join

  + sign on the right in Oracle:

  Select * from R, S where R.id=S.id(+)

- Right outer join

  + sign on the left in Oracle:

  Select * from R, S where R.id(+)=S.id

- Full outer join
  - Not implemented in Oracle 8
  - Added for Oracle 9 (or later)
    - Use full text instead of +'s: "full outer join", "left outer join", "right outer join", "inner join"

Insertion of a tuple

INSERT INTO R(A1,…,An) VALUES (v1,…,vn)

- Example:

```
INSERT INTO Emp (ename, dno, sal)
VALUES ('Tom', 123, 45000)
```

- Can drop attribute names if we provide all of them in order.

```
INSERT INTO Emp
VALUES ('Tom', 123, 45000)
```

- If we don't provide all attributes, they will be filled with NULL.

```
INSERT INTO Emp (ename,sal)
VALUES ('Tom', 45000)
```

Insertion of a query's result

INSERT INTO relation (subquery);

```
CREATE TABLE LowIncomeEmp(ename char(12),
                          dno int,
                          sal float);
INSERT INTO LowIncomeEmp
        ( SELECT *
          FROM emp
          WHERE sal <= 30K AND dno = 123;
        );

INSERT INTO LowIncomeEmp
        ( SELECT ename, dno, sal * 1.1        → salary increased by 10%
          FROM emp
          WHERE sal <= 30K AND dno = 123;
        );
```

- Note the order of querying and inserting: subquery first.

Delete

DELETE FROM relation [WHERE conditions];

- Example:

```
DELETE
FROM   emp
WHERE  dno = 123;

DELETE
FROM   emp;
```

→ all tuples will be deleted

- There is no way to delete only a single occurrence of a tuple that appears twice in a relation.

Delete (cont)

- Delete all employees working in a department with only one employee.

```
DELETE
FROM    emp AS E1
WHERE  NOT EXISTS
            (SELECT ename
            FROM emp
            WHERE dno = E1.dno AND ename <> E1.ename);
```

- Note the relation renaming “E1”

Update

UPDATE relation SET assignments WHERE condition

- "Change employees in dept 123 to dept 345."

```
UPDATE emp
SET dno = 345
WHERE  dno = 123;
```

- "Cut the salaries that are more than 100K by 10%."

```
UPDATE emp
SET sal = sal * 0.9
WHERE  sal > 100000;
```

- Multiple assignments separated by ","

```
UPDATE emp
SET dno = 345, sal = sal * 1.1
WHERE  dno = 123;
```

Conceptual order in query evaluation

- The cross products of the tables in the *FROM* clause are evaluated.
- Rows not satisfying the *WHERE* clause are eliminated.
- The remaining rows are grouped in accordance with the *GROUP BY* clause.
- Groups not satisfying the *HAVING* clause are then eliminated.
- The expressions in the *SELECT* list are evaluated.
- If the keyword *DISTINCT* is present, duplicate rows are now eliminated.
- Evaluate *UNION, INTERSECT* and *EXCEPT* for Subqueries up to this point.
- Finally, the set of all selected rows is sorted if the *ORDER BY* is present.

Conclusion

- Nested queries are a very powerful feature in SQL; they help us write shorter and more efficient queries.
- Post processing on the result of queries is supported.
- Aggregation is the most complex "post processing"
  - "Group by" clause partition the results into groups
  - "Having" clause puts condition on groups (just like Where clause on tuples).