SQL: The Query Language Part II

15-415, Spring 2003, Lecture 12
R & G Chapter 5

> The important thing is not to stop questioning.
>
> Albert Einstein

Example Instances

Reserves

sid	bid	day
22	101	10/10/96
95	103	11/12/96

Sailors

sid	sname	rating	age
22	Dustin	7	45.0
31	Lubber	8	55.5
95	Bob	3	63.5

Boats

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

Queries With GROUP BY

- **To generate values for a column based on groups of rows, use aggregate functions in SELECT statements with the GROUP BY clause**

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

The *target-list* contains (i) list of column names & (ii) terms with aggregate operations (e.g., MIN (*S.age*)).

- column name list (i) **can contain only attributes from the *grouping-list*.**

Group By Examples

For each rating, find the average age of the sailors

```
SELECT  S.rating,  AVG (S.age)
FROM  Sailors S
GROUP BY  S.rating
```

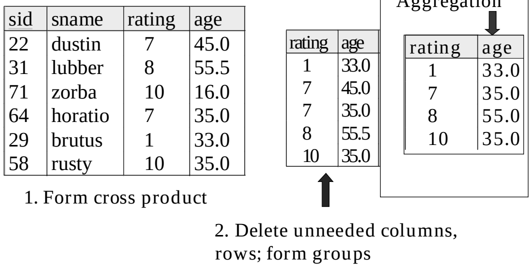
For each rating find the age of the youngest sailor with age ≥ 18

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

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*.**
- **One answer tuple is generated per qualifying group.**

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



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

1. Form cross product

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

2. Delete unneeded columns, rows; form groups

Answer Table

3. Perform Aggregation

rating	age
1	33.0
7	35.0
8	55.0
10	35.0

Find the number of reservations for each **red** boat.

```
SELECT B.bid, COUNT(*)AS numres
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.

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

b.bid	b.color	r.bid
101	blue	101
102	red	101
103	green	101
104	red	101
101	blue	102
102	red	102
103	green	102
104	red	102

1

b.bid	b.color	r.bid
102	red	102

2

b.bid	scount
102	1

answer

Queries With GROUP BY and HAVING

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

- **Use the HAVING clause with the GROUP BY clause to restrict which group-rows are returned in the result set**

Conceptual Evaluation

- Form groups as before.
- The *group-qualification* is then applied to eliminate some groups.
  - Expressions in *group-qualification* must have a *single value per group*!
  - That is, attributes in *group-qualification* must be arguments of an aggregate op or must also appear in the *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
```

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

2

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

3

rating	m-age	count
1	33.0	1
7	35.0	2
8	55.0	1
10	35.0	1

rating	
7	35.0

Answer relation

Find sailors who’ve reserved all boats.

- **Example in book, not using 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

Find sailors who’ve reserved all boats.

- **Can you do this using Group By and Having?**

```
SELECT  S.name
FROM  Sailors S, reserves R
WHERE  S.sid = R.sid
  GROUP BY S.name, S.sid
  HAVING
          COUNT(DISTINCT R.bid) =
                 ( Select COUNT (*) FROM Boats)
```

Note: must have both sid and name in the GROUP BY clause. Why?

```
SELECT  S.name, S.sid
FROM  Sailors S, reserves R
WHERE  S.sid = r.sid
          GROUP BY S.name, S.sid
          HAVING
               COUNT(DISTINCT R.bid) =
                      Select COUNT (*) FROM Boats
```

s.name	s.sid	r.sid	r.bid
Dustin	22	22	101
Lubber	31	22	101
Bob	95	22	101
Dustin	22	95	102
Lubber	31	95	102
Bob	95	95	102

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

Count (*) from boats = 4

s.name	s.sid	bcount
Dustin	22	1
Bob	95	1

Apply having clause to groups

→

s.name	s.sid

Sorting the Results of a Query

- **ORDER BY *column* [ASC | DESC] [, ...]**

```
SELECT  S.rating, S.sname, S.age
        FROM  Sailors S, Boats B, Reserves R
        WHERE  S.sid=R.sid
                AND R.bid=B.bid AND B.color=‘red’
        ORDER BY  S.rating, S.sname;
```

- **Extra reporting power obtained by combining with aggregation.**

```
SELECT  S.sid, COUNT (*) AS redrescnt
        FROM  Sailors S, Boats B, Reserves R
        WHERE  S.sid=R.sid
                AND R.bid=B.bid AND B.color=‘red’
        GROUP BY S.sid
        ORDER BY  redrescnt DESC;
```

INSERT

INSERT [INTO] *table_name* [(*column_list*)]
VALUES (value_list)

INSERT [INTO] *table_name* [(*column_list*)]
<select statement>

INSERT INTO Boats VALUES (105, ‘Clipper’, ‘purple’)
INSERT INTO Boats (bid, color) VALUES (99, ‘yellow’)

You can also do a “bulk insert” of values from one table into another:

INSERT INTO TEMP(bid)
SELECT r.bid FROM Reserves R WHERE r.sid = 22;
(must be type compatible)

DELETE & UPDATE

DELETE [FROM] *table_name*
[WHERE   *qualification]*

DELETE FROM Boats WHERE color = ‘red’

DELETE FROM Boats b
WHERE b. bid =
(SELECT r.bid FROM Reserves R WHERE r.sid = 22)

Can also modify tuples using UPDATE statement.

UPDATE Boats
SET Color = “green”
WHERE bid = 103;

Null Values

- **Field values in a tuple are sometimes *unknown* (e.g., a rating has not been assigned) or *inapplicable* (e.g., no spouse’s name).**
  - SQL provides a special value *null* for such situations.
- **The presence of *null* complicates many issues. E.g.:**
  - Special operators needed to check if value is/is not *null*.
  - Is *rating>8* true or false when *rating* is equal to *null*? What about AND, OR and NOT connectives?
  - We need a 3-valued logic (true, false and *unknown*).
  - Meaning of constructs must be defined carefully. (e.g., WHERE clause eliminates rows that don’t evaluate to true.)
  - New operators (in particular, *outer joins*) possible/needed.

Joins

```
SELECT (column_list)
FROM  table_name
  [INNER | {LEFT |RIGHT | FULL } OUTER] JOIN table_name
    ON qualification_list
WHERE …
```

Explicit join semantics needed unless it is an INNER join (INNER is default)

Inner Join

Only the rows that match the search conditions are returned.

```
SELECT s.sid, s.name, r.bid
FROM Sailors s INNER JOIN Reserves r
ON s.sid = r.sid
```

Returns only those sailors who have reserved boats

SQL-92 also allows:

```
SELECT s.sid, s.name, r.bid
FROM Sailors s NATURAL JOIN Reserves r
```

"NATURAL" means equi-join for each pair of attributes with the same name (may need to rename with "AS")

```
SELECT s.sid, s.name, r.bid
FROM Sailors s INNER JOIN Reserves r
ON s.sid = r.sid
```

sid	sname	rating	age
22	Dustin	7	45.0
31	Lubber	8	55.5
95	Bob	3	63.5

sid	bid	day
22	101	10/10/96
95	103	11/12/96

s.sid	s.name	r.bid
22	Dustin	101
95	Bob	103

Left Outer Join

Left Outer Join returns all matched rows, plus all unmatched rows from the table on the left of the join clause

(use nulls in fields of non-matching tuples)

```
SELECT s.sid, s.name, r.bid
FROM Sailors s LEFT OUTER JOIN Reserves r
ON s.sid = r.sid
```

Returns all sailors & information on whether they have reserved boats

```
SELECT s.sid, s.name, r.bid
FROM Sailors s LEFT OUTER JOIN Reserves r
ON s.sid = r.sid
```

sid	sname	rating	age
22	Dustin	7	45.0
31	Lubber	8	55.5
95	Bob	3	63.5

sid	bid	day
22	101	10/10/96
95	103	11/12/96

s.sid	s.name	r.bid
22	Dustin	101
95	Bob	103
31	Lubber	

Right Outer Join

Right Outer Join returns all matched rows, plus all unmatched rows from the table on the right of the join clause

```
SELECT r.sid, b.bid, b.name
FROM Reserves r RIGHT OUTER JOIN Boats b
ON r.bid = b.bid
```

Returns all boats & information on which ones are reserved.

```
SELECT r.sid, b.bid, b.name
FROM Reserves r RIGHT OUTER JOIN Boats b
ON r.bid = b.bid
```

sid	bid	day
22	101	10/10/96
95	103	11/12/96

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

r.sid	b.bid	b.name
22	101	Interlake
	102	Interlake
95	103	Clipper
	104	Marine

Full Outer Join

Full Outer Join returns all (matched or unmatched) rows from the tables on both sides of the join clause

SELECT r.sid, b.bid, b.name
FROM Reserves r FULL OUTER JOIN Boats b
ON r.bid = b.bid

Returns all boats & all information on reservations

```
SELECT r.sid, b.bid, b.name
FROM Reserves r FULL OUTER JOIN Boats b
ON r.bid = b.bid
```

sid	bid	day
22	101	10/10/96
95	103	11/12/96

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

r.sid	b.bid	b.name
22	101	Interlake
	102	Interlake
95	103	Clipper
	104	Marine

Note: in this case it is the same as the ROJ because bid is a foreign key in reserves, so all reservations must have a corresponding tuple in boats.

DDL – Create Table

- **CREATE TABLE *table_name***
  ({ *column_name data_type* [DEFAULT *default_expr*] [*column_constraint* [, ...]] | *table_constraint* } [, ...])
- **Data Types (PostgreSQL) include:**
  character(n) – fixed-length character string
  character varying(n) – variable-length character string
  smallint, integer, bigint, numeric, real, double precision
  date, time, timestamp, …
  serial - unique ID for indexing and cross reference
  …
- **PostgreSQL also allows OIDs, arrays, inheritance, rules…**
  conformance to the SQL-1999 standard is variable so we won't use these in the project.

Create Table (w/column constraints)

- **CREATE TABLE *table_name***
  ({ *column_name data_type* [DEFAULT *default_expr*] [*column_constraint* [, ...]] | *table_constraint* } [, ...])

Column Constraints:

- **[CONSTRAINT *constraint_name*]**
  { NOT NULL | NULL | UNIQUE | PRIMARY KEY | CHECK (*expression*) |
  REFERENCES *reftable* [(*refcolumn*)] [ON DELETE *action*] [ON UPDATE *action*] }

***action* is one of:**

NO ACTION, CASCADE, SET NULL, SET DEFAULT

***expression* for column constraint must produce a**

Create Table (w/table constraints)

- **CREATE TABLE *table_name***
  ({ *column_name data_type* [DEFAULT *default_expr*] [*column_constraint* [, ...]] | *table_constraint* } [, ...])

Table Constraints:

- **[CONSTRAINT *constraint_name*]**
  { UNIQUE (*column_name* [, ...]) |
  PRIMARY KEY (*column_name* [, ...]) |
  CHECK (*expression*) |
  FOREIGN KEY (*column_name* [, ...]) REFERENCES *reftable* [(*refcolumn* [, ...])] [ON DELETE *action*] [ON UPDATE *action*] }

Create Table (Examples)

```
CREATE TABLE films (
    code          CHAR(5) PRIMARY KEY,
    title         VARCHAR(40),
    did           DECIMAL(3),
    date_prod   DATE,
    kind          VARCHAR(10),
CONSTRAINT production UNIQUE(date_prod)
FOREIGN KEY did REFERENCES distributors
    ON DELETE NO ACTION
);
CREATE TABLE distributors (
    did     DECIMAL(3) PRIMARY KEY,
    name    VARCHAR(40)
    CONSTRAINT con1 CHECK (did > 100 AND name <> ‘ ’)
);
```

Views

CREATE VIEW *view_name*
AS *select_statement*

Makes development simpler
Often used for security
Not instantiated - makes updates tricky

```
CREATE VIEW Reds
AS SELECT  B.bid,  COUNT (*) AS scount
   FROM Boats B, Reserves R
   WHERE  R.bid=B.bid AND   B.color=‘red’
    GROUP BY  B.bid
```

Views Instead of Relations in Queries

```
CREATE VIEW Reds
AS SELECT  B.bid,  COUNT (*) AS scount
   FROM Boats B, Reserves R
   WHERE  R.bid=B.bid AND   B.color=‘red’
    GROUP BY  B.bid
```

bid	scount
102	1

Reds

SELECT bname, scount
   FROM **Reds R**, Boats B
   WHERE R.bid=B.bid
      AND scount < 10

Discretionary Access Control

GRANT *privileges* ON *object* TO *users*
[WITH GRANT OPTION]

- **Object can be a Table or a View**
- **Privileges can be:**
  - **Select**
  - **Insert**
  - **Delete**
  - **References (cols) – allow to create a foreign key that references the specified column(s)**
  - **All**
- **Can later be REVOKEd**
- **Users can be single users or groups**
- **See Chapter 17 for more details.**