SQL Aggregate Queries

CS430/630
Lecture 8

Slides based on "Database Management Systems" 3rd ed, Ramakrishnan and Gehrke

Aggregate Operators

Significant extension of relational algebra

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

A is a single column

Result is **single** value obtained by applying aggregate over all qualifying tuples

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

Aggregate Queries Examples

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

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

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

Aggregate + nested!

Common Mistake with Aggregates

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

Illegal Query!

- Can't have both aggregates and non-aggregates in SELECT
  - Exception: GROUP BY (later in this class)
- Reason: it is not guaranteed that there is only one tuple with the MAX value

Grouping Results

- So far, aggregates applied to all (qualifying) tuples
  - We may want to apply them to each of several groups
- *"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

```
SELECT MIN (S.age)              SELECT MIN (S.age)
FROM Sailors S                  FROM Sailors S
WHERE S.rating = 1       ...    WHERE S.rating = 10

SELECT MIN (S.age)
FROM Sailors S
WHERE S.rating = 2
```

How to achieve this?

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

Conceptual Evaluation

1. Compute cross-product of *relation-list*
2. Discard tuples that fail *qualification*, '*unnecessary*' fields are deleted
3. Remaining tuples are partitioned into groups by the value of attributes in *grouping-list*
4. Discard groups that fail *group-qualification*
   - Expressions in *group-qualification* must have a *single value per group*!
   - An attribute in *group-qualification* that is not an argument of an aggregate operation must appear in *grouping-list* (unless EVERY or ANY used)
5. Generate single answer tuple per qualifying group

GROUPBY Query Example

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

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

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
96	frodo	3	25.5

GROUPBY Conceptual Evaluation Example

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

rating	age
7	45.0
1	33.0
8	55.5
8	25.5
10	35.0
7	35.0
~~10~~	~~16.0~~
9	35.0
3	25.5
3	63.5
3	25.5

rating	age
~~1~~	~~33.0~~
3	25.5
3	63.5
3	25.5
7	45.0
7	35.0
8	55.5
8	25.5
~~9~~	~~35.0~~
~~10~~	~~35.0~~

rating	minage
3	25.5
7	35.0
8	25.5

More Group Qualification Functions

- So far, we have seen group qualification based on a property of the group
  - E.g., aggregate function computed for entire group
- But recent SQL standard version allow group qualification based on a property of individual records
  - EVERY(condition):TRUE if condition holds for every group tuple
  - ANY(condition):TRUE if condition holds for some group tuple

Find age of the youngest sailor with age ≥ 18, for each rating with at least 2 such sailors and with every sailor under 60.

HAVING COUNT (*) > 1 AND EVERY (S.age <=60)

rating	age
7	45.0
1	33.0
8	55.5
8	25.5
10	35.0
7	35.0
~~10~~	~~16.0~~
9	35.0
3	25.5
3	63.5
3	25.5

rating	age
~~1~~	~~33.0~~
~~3~~	~~25.5~~
~~3~~	~~63.5~~
~~3~~	~~25.5~~
7	45.0
7	35.0
8	55.5
8	25.5
~~9~~	~~35.0~~
~~10~~	~~35.0~~

rating	minage
7	35.0
8	25.5

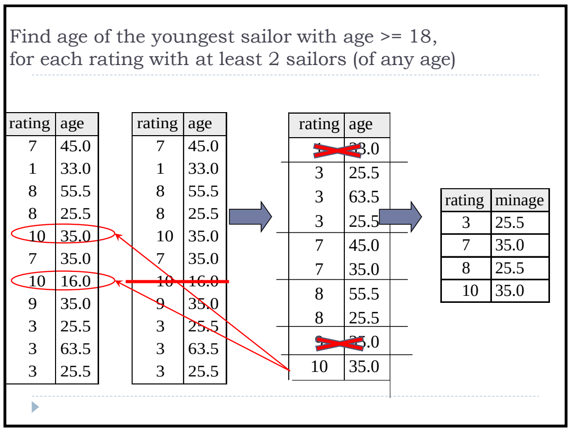
Pay attention to order of steps!

- HAVING executes AFTER WHERE

"Find 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  COUNT (*) > 1
```

WRONG!!!



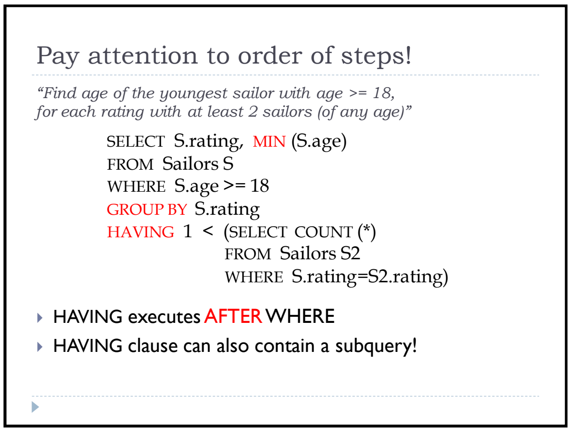
Find age of the youngest sailor with age >= 18, for each rating with at least 2 sailors (of any age)

rating	age
7	45.0
1	33.0
8	55.5
8	25.5
10	35.0
7	35.0
10	16.0
9	35.0
3	25.5
3	63.5
3	25.5

rating	age
7	45.0
1	33.0
8	55.5
8	25.5
10	35.0
7	35.0
~~10~~	~~16.0~~
9	35.0
3	25.5
3	63.5
3	25.5

rating	age
~~1~~	~~33.0~~
3	25.5
3	63.5
3	25.5
7	45.0
7	35.0
8	55.5
8	25.5
~~9~~	~~35.0~~
10	35.0

rating	minage
3	25.5
7	35.0
8	25.5
10	35.0

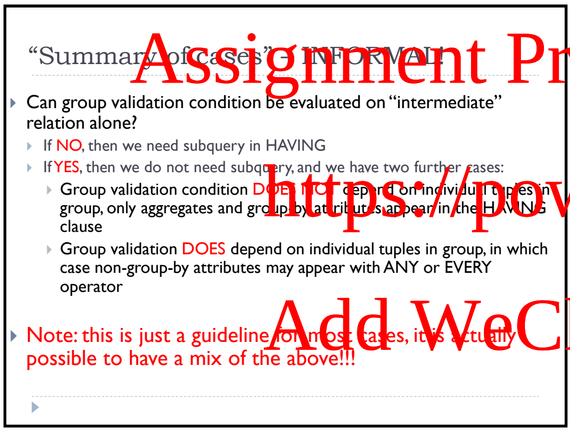


Pay attention to order of steps!

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

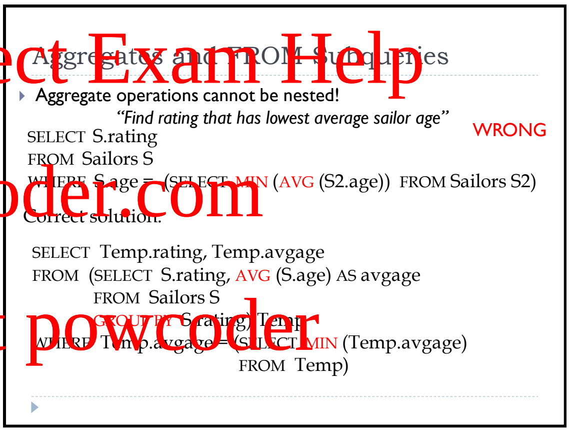
```
SELECT  S.rating,  MIN (S.age)
FROM  Sailors S
WHERE  S.age >= 18
GROUP BY  S.rating
HAVING  1  <  (SELECT  COUNT (*)
               FROM  Sailors S2
               WHERE  S.rating=S2.rating)
```

- HAVING executes AFTER WHERE
- HAVING clause can also contain a subquery!



"Summary of cases" – INFORMAL!

- Can group validation condition be evaluated on "intermediate" relation alone?
  - If NO, then we need subquery in HAVING
  - If YES, then we do not need subquery, and we have two further cases:
    - Group validation condition DOES NOT depend on individual tuples in group, only aggregates and group-by attributes appear in the HAVING clause
    - Group validation DOES depend on individual tuples in group, in which case non-group-by attributes may appear with ANY or EVERY operator
- Note: this is just a guideline for most cases, it is actually possible to have a mix of the above!!!



Aggregates and FROM-Subqueries

- Aggregate operations cannot be nested!

"Find rating that has lowest average sailor age"

WRONG

```
SELECT  S.rating
FROM  Sailors S
WHERE  S.age =  (SELECT  MIN (AVG (S2.age))  FROM Sailors S2)
```

Correct solution:

```
SELECT  Temp.rating, Temp.avgage
FROM  (SELECT  S.rating, AVG (S.age) AS avgage
          FROM  Sailors S
          GROUP BY  S.rating) Temp
WHERE  Temp.avgage = (SELECT  MIN (Temp.avgage)
                      FROM  Temp)
```