# More SQL: Aggregration

## Announcements

HW1 Solutions linked from README

Thursday: Project 1 Part 2
- Re-submit your ER diagram
  (helps to compare it with your SQL)

Tuesday: HW2

March 8th: Midterm: Includes up to Thursday

## Serious people can count: Aggregation

```
SELECT COUNT(*)
FROM   Sailors  S

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

SELECT  COUNT(DISTINCT  S.name)
FROM   Sailors  S
WHERE  S.name  LIKE 'D%'
```

COUNT([DISTINCT] A)
SUM([DISTINCT] A)
AVG([DISTINCT] A)
MAX/MIN(A)
STDDEV(A)
CORR(A,B)

PostgreSQL documentation
http://www.postgresql.org/docs/9.4/static/functions-aggregate.html

## Syntax: FUNCTION(*expression*)

Compute 1 value from set
Can include math (age * 2 + 5)
Can include DISTINCT

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

```
SELECT COUNT(*)
FROM  Sailors S
```
≠
```
SELECT COUNT(DISTINCT name)
FROM  Sailors S
```

## Name and age of oldest sailor(s)

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

All SELECT values must be aggregates
(except for GROUP BY)

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

```
SELECT S.name, S.age
FROM   Sailors S
WHERE  S.age >= ALL (SELECT  S2.age
                     FROM    Sailors S2)
```

## Multiple aggregates does work

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

```
        avg         | max
--------------------+-----
 5.6666666666666667 |  39
(1 row)
```

# GROUP BY

```
SELECT  count(*)
FROM    Reserves  R
```

Total number of reservations

What if want reservations per boat?
May not even know all our boats (depends on data)!
If we did, could write (awkward):

```
for boat in [0…10]
    SELECT  count(*)
    FROM    Reserves  R
    WHERE   R.bid = <boat>
```

# GROUP BY

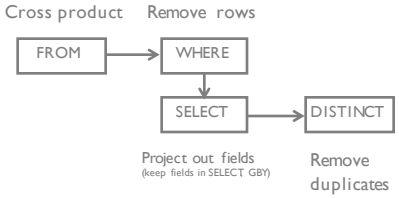
```
SELECT     [DISTINCT]  target-list
FROM       relation-list
WHERE      qualification
GROUP BY   grouping-list
```

*grouping-list:* expressions that define groups
set of tuples w/ same value for all attributes in grouping-list

*target-list* contains
*attribute-names* ⊆ *grouping-list*
*aggregation expressions*

# Conceptual Query Evaluation

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




# Conceptual Query Evaluation

SELECT [DISTINCT] *target-list*
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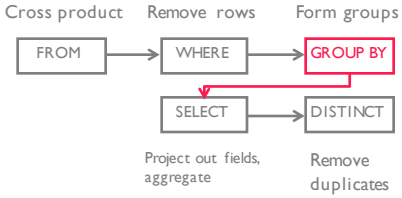



# GROUP BY

```
SELECT     bid,  count(*)
FROM       Reserves  R
GROUP BY   bid
```

Number of reservations for each boat

```
SELECT     bid,  count(*),  sid
FROM       Reserves  R
GROUP BY   bid
```

Also show an sid that reserved boat?

Expressions must have *one value per group:*
In *grouping-list*
aggregation

# HAVING

*group-qualification* used to remove groups
similar to WHERE clause
Expressions must have *one value per group*

```
SELECT     bid,  count(*)
FROM       Reserves  R
GROUP BY   bid
HAVING     bid > 50
```

# GROUP BY with HAVING

```
SELECT    bid, count(*)
FROM      Reserves R
GROUP BY  bid
HAVING    count(*) > 1
```

Reservations for each boat with more than 1 reservation

~~
```
SELECT    bid, count(*)
FROM      Reserves R
GROUP BY  bid
HAVING    sid > 42
```
~~

```
SELECT    bid, count(*)
FROM      Reserves R
WHERE     sid > 42
GROUP BY  bid
```

# GROUP BY

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

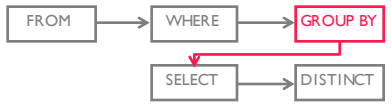
*grouping-qualification* boolean expression over group

if true, keep the group

# Conceptual Query Evaluation

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

Cross product | Remove rows | Form groups

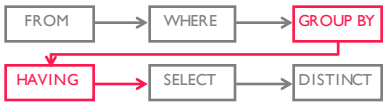



Project out fields, aggregate | Remove duplicates

# Conceptual Query Evaluation

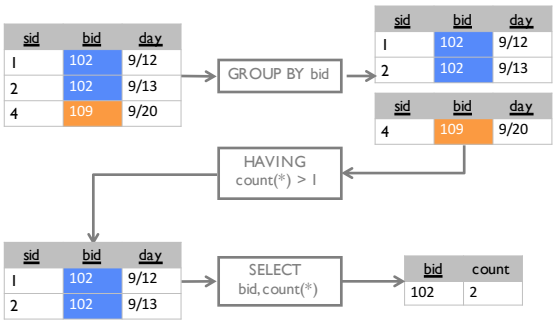
SELECT [DISTINCT] *target-list*
FROM *relation-list*
WHERE *qualification*
*GROUP BY grouping-list*
*HAVING group-qualification*

Cross product | Remove rows | Form groups




Remove groups | Project out fields, aggregate | Remove duplicates

# Conceptual Evaluation




# AVG age of sailors reserving red boats, by rating

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

## AVG age of sailors reserving red boats, by rating

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

## AVG age of sailors reserving red boats, by rating

```
SELECT    S.rating,  avg(S.age)  AS age
FROM      Sailors  S, Boats  B, Reserves  R
WHERE     S.sid  = R.sid  AND
          R.bid  = B.bid  AND
          B.color  = 'red'
GROUP BY  S.rating
```

What if move `B.color='red'` to HAVING clause?

## ORDER BY

```
SELECT    S.name
FROM      Sailors  S
ORDER BY  order-list  [ASC|DESC]
```

Order-list: expressions to determine precedence
Left to right: if tie, consider next expression
ASC: Ascending (lowest to highest; default)
DESC: Descending (highest to lowest)

## ORDER BY

```
SELECT    S.name,  S.rating,  S.age
FROM      Sailors  S
ORDER BY  S.rating  ASC,
          S.age  DESC
```

Sailors

| sid | name | rating | age |
|---|---|---|---|
| 1 | Eugene | 7 | 22 |
| 2 | Luis | 2 | 39 |
| 3 | Ken | 7 | 27 |

Result

| name | rating | age |
|---|---|---|
| Luis | 2 | 39 |
| Ken | 7 | 27 |
| Eugene | 7 | 22 |

## ORDER BY

```
SELECT    S.name,  S.rating,  S.age
FROM      Sailors  S
ORDER BY  S.rating  ASC,
          S.age  ASC
```

Sailors

| sid | name | rating | age |
|---|---|---|---|
| 1 | Eugene | 7 | 22 |
| 2 | Luis | 2 | 39 |
| 3 | Ken | 7 | 27 |

Result

| name | rating | age |
|---|---|---|
| Luis | 2 | 39 |
| Eugene | 7 | 22 |
| Ken | 7 | 27 |

## LIMIT

```
SELECT    S.name,  S.rating,  S.age
FROM      Sailors  S
ORDER BY  S.rating  ASC,
          S.age  DESC
LIMIT     2
```

Only the first 2 results

Sailors

| sid | name | rating | age |
|---|---|---|---|
| 1 | Eugene | 7 | 22 |
| 2 | Luis | 2 | 39 |
| 3 | Ken | 8 | 27 |

Result

| name | rating | age |
|---|---|---|
| Luis | 2 | 39 |
| Ken | 7 | 27 |

# LIMIT

```
SELECT    S.name,  (S.rating/2)::int,   S.age
FROM      Sailors  S
ORDER BY  (S.rating/2)::int   ASC,
          S.age  DESC
LIMIT     2 OFFSET  1
```

Only the first 2 results

Sailors

| sid | name | rating | age |
|---|---|---|---|
| 1 | Eugene | 7 | 22 |
| 2 | Luis | 2 | 39 |
| 3 | Ken | 8 | 27 |

Result

| name | rating | age |
|---|---|---|
| Ken | 7 | 27 |
| Eugene | 7 | 22 |

# LIMIT

```
SELECT    S.name,  S.rating,   S.age
FROM      Sailors  S
ORDER BY  S.rating  ASC,
          S.age  DESC
LIMIT     (SELECT  count(*)  / 2 FROM Sailors)
```

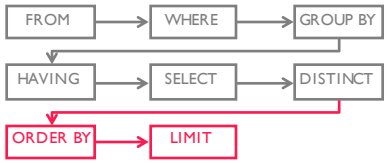
Can have expressions instead of constants

Result

| name | rating | age |
|---|---|---|
| Luis | 2 | 39 |

# ORDER BY, LIMIT

```
SELECT     [DISTINCT]  target-list
FROM       relation-list
WHERE      qualification
GROUP BY   grouping-list
HAVING     group-qualification
ORDER BY   order-list
LIMIT      limit-expr  [OFFSET  offset-expr]
```




# NULL

Field values sometimes unknown or inapplicable
- SQL provides a special value *null* for such situations.

The presence of null complicates many issues e.g.,
- Is age = null true or false?
- Is null = null true or false?
- Is null = 8 OR 1 = 1 true or false?

Special syntax "IS NULL" and "IS NOT NULL"
3 Valued Logic (true, false, unknown)

How does WHERE remove rows?
- if qualification doesn't evaluate to true

New operators (in particular, outer joins) possible/needed.

# NULL

(null > 0) = null
(null + 1) = null
(null = 0) = null
(null AND true) = null
null is null = true

## Some truth tables

| AND | T | F | NULL |
|---|---|---|---|
| T | T | F | NULL |
| F | F | F | F |
| NULL | NULL | F | NULL |

| OR | T | F | NULL |
|---|---|---|---|
| T | T | T | T |
| F | T | F | NULL |
| NULL | T | NULL | NULL |