More SQL: Aggregration

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

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

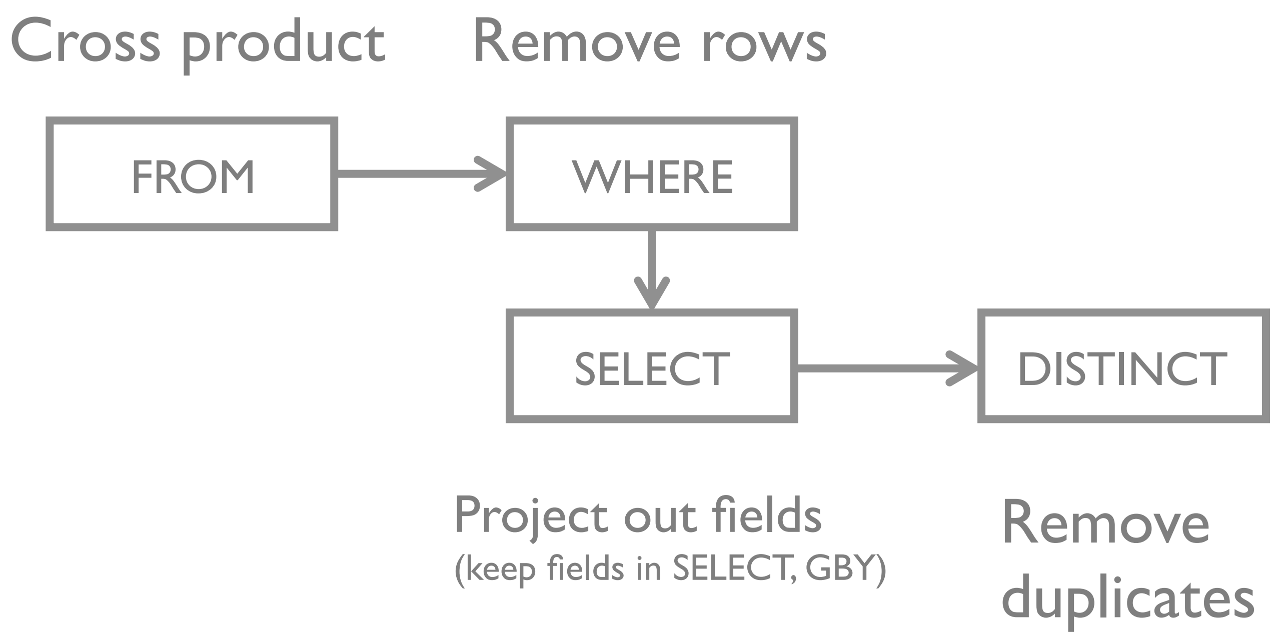
target-list contains

attribute-names ⊆ *grouping-list*

aggregation expressions

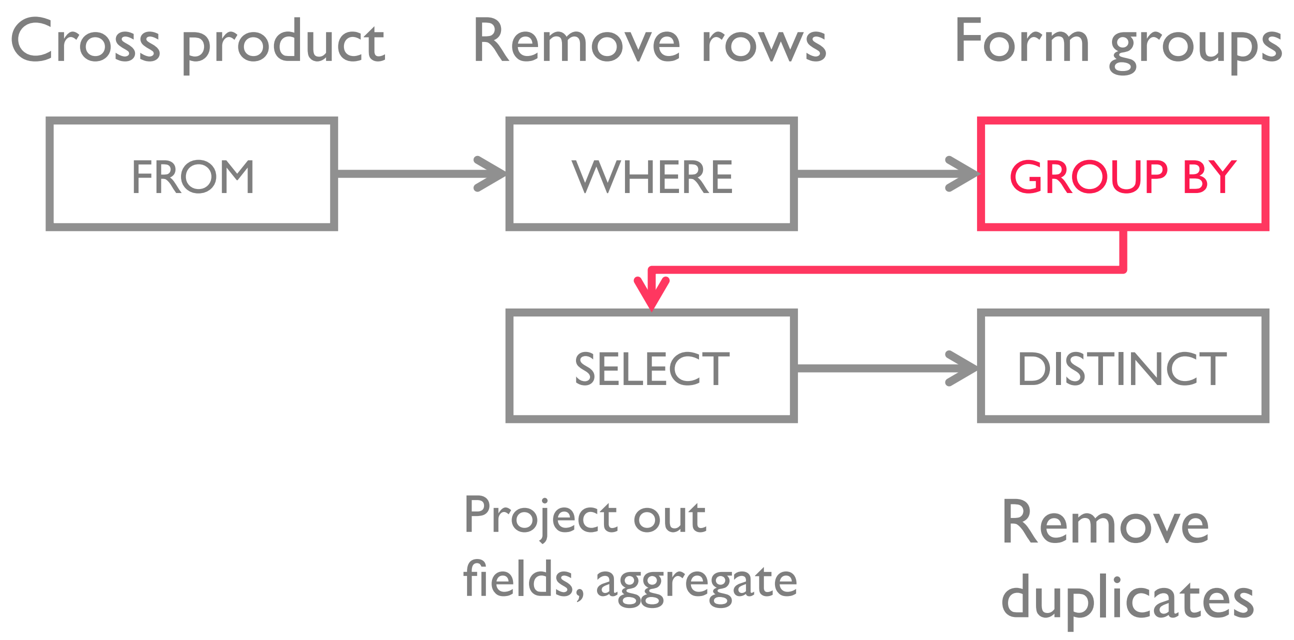
Conceptual Query Evaluation

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



Conceptual Query Evaluation

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



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

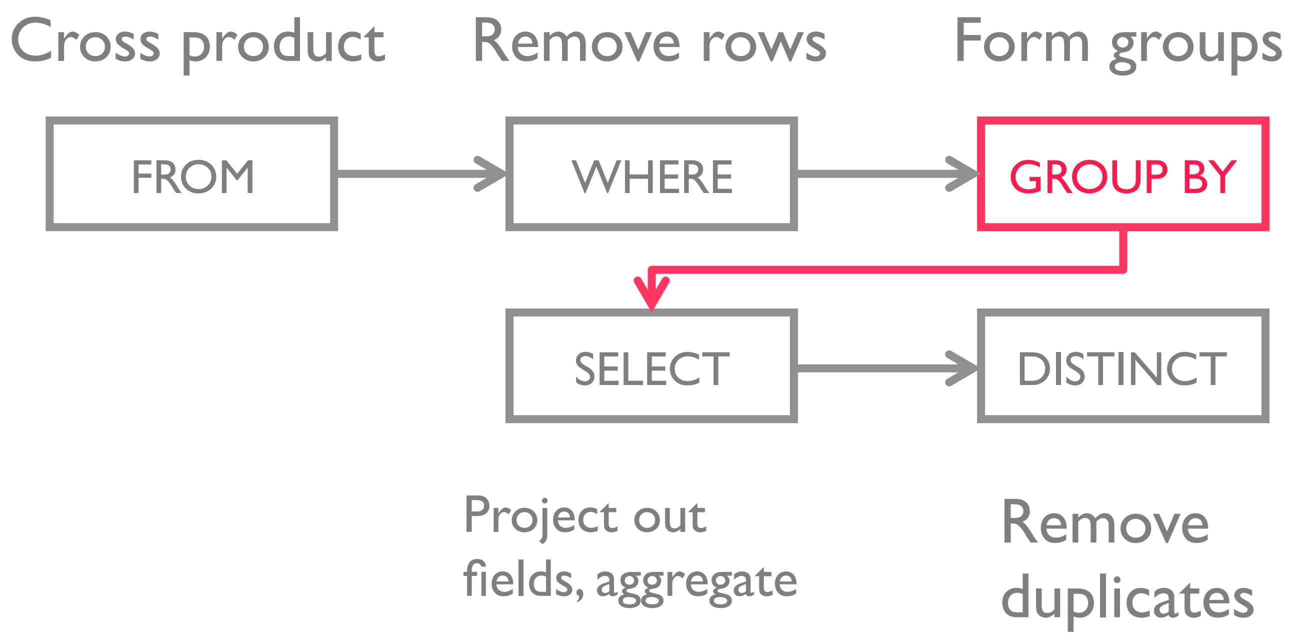
```
SELECT    [DISTINCT] target-list
FROM      relation-list
WHERE     qualification
GROUP BY  grouping-list
HAVING    group-qualification
```

grouping-qualification boolean expression over group

if true, keep the group

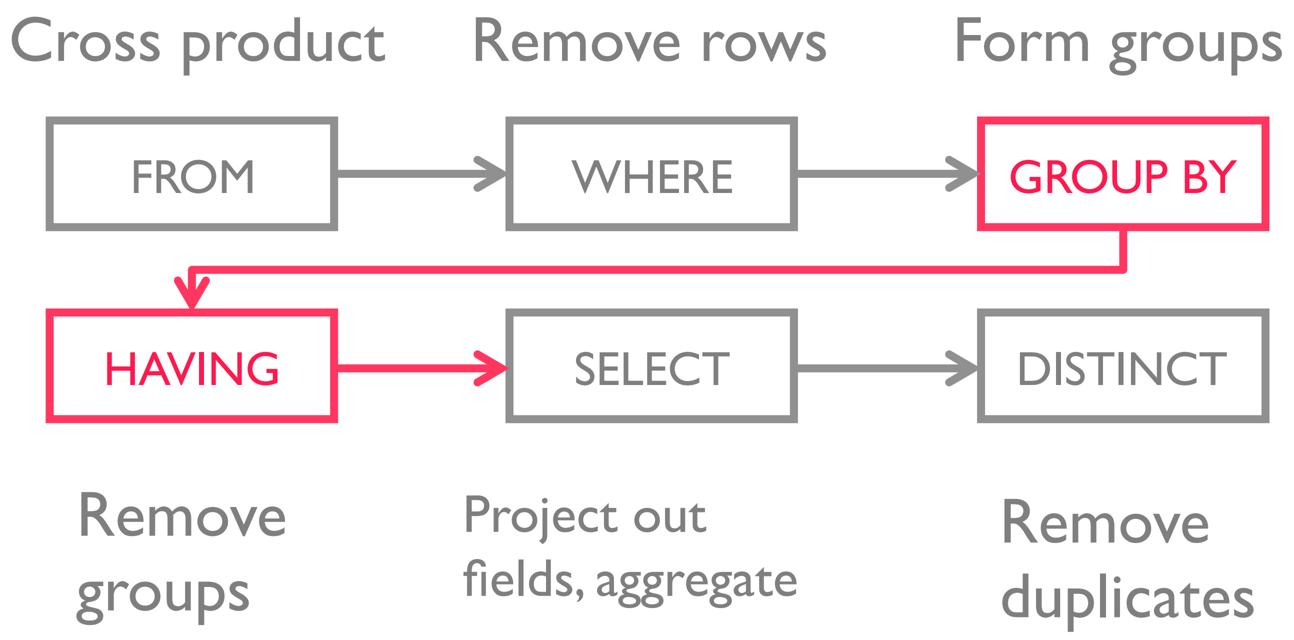
Conceptual Query Evaluation

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

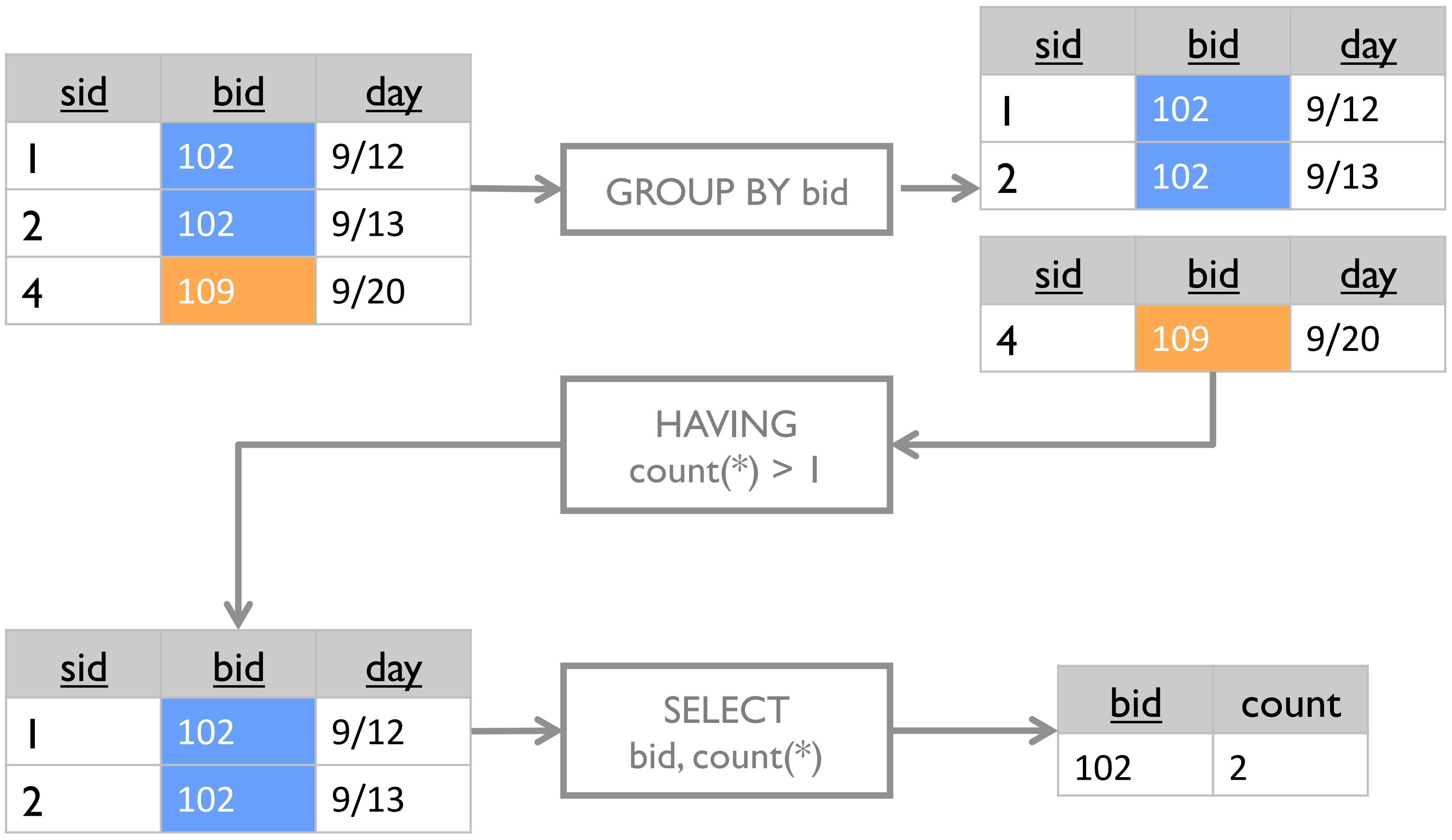


Conceptual Query Evaluation

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



Conceptual Evaluation



sid	bid	day
1	102	9/12
2	102	9/13
4	109	9/20

sid	bid	day
1	102	9/12
2	102	9/13

sid	bid	day
4	109	9/20

sid	bid	day
1	102	9/12
2	102	9/13

bid	count
102	2

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

<u>sid</u>	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)
```

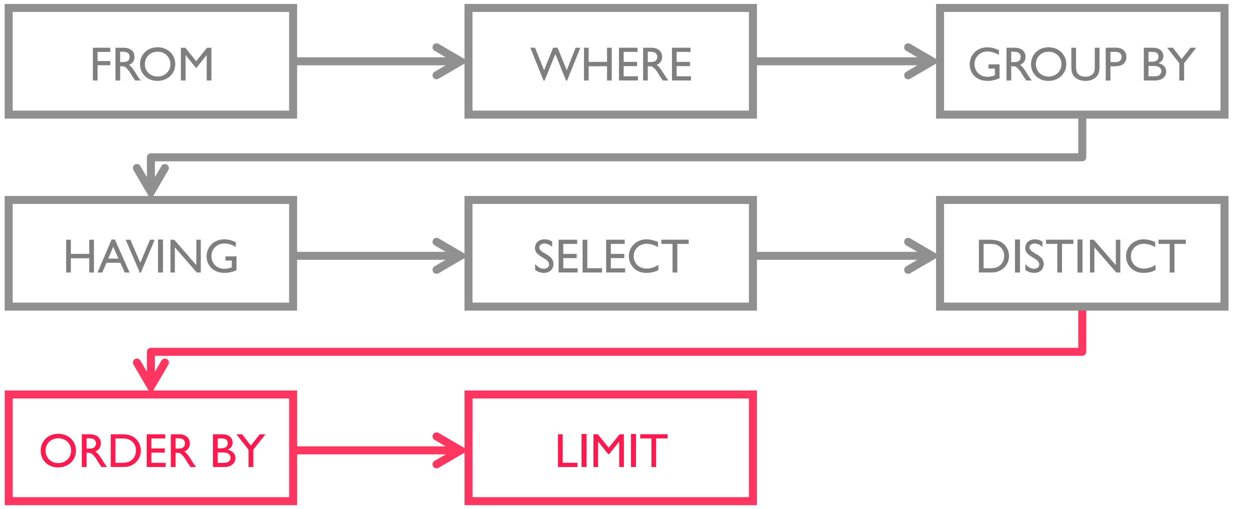
Can have expressions instead of constants

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]
```



$$\begin{tikzcd}
\boxed{\text{FROM}} \arrow[r] & \boxed{\text{WHERE}} \arrow[r] & \boxed{\text{GROUP BY}} \arrow[dll] \\
\boxed{\text{HAVING}} \arrow[r] & \boxed{\text{SELECT}} \arrow[r] & \boxed{\text{DISTINCT}} \arrow[dll] \\
\boxed{\text{ORDER BY}} \arrow[r] & \boxed{\text{LIMIT}} &
\end{tikzcd}$$

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