

# Database Systems

## CSE 414

### Lectures 5: Grouping & Aggregation

# Announcements

- HW2 is out
  - due next Tuesday 11pm
  - same format as HW1
  - uses joins, aggregation, grouping
- WQ2 due Sunday 11pm

# Outline

- Last time:
  - outer joins
  - how to aggregate over all rows
- Grouping & aggregations (6.4.3 – 6.4.6)

# Aggregation

Purchase(product, price, quantity)

Find number of bagels sold for more than \$1

```
SELECT      Sum(quantity) as TotalSold
FROM        Purchase
WHERE       price > 1 and product = 'bagel'
```

# Grouping and Aggregation

Purchase(product, price, quantity)

Find number sold for more than \$1 **for each product**

```
SELECT    product, Sum(quantity)
FROM      Purchase
WHERE     price > 1
GROUP BY  product
```

Let's see what this means...

# Grouping and Aggregation

1. Compute the `FROM` and `WHERE` clauses.
2. Group by the attributes in the `GROUP BY`
3. Compute the `SELECT` clause:  
grouped attributes and aggregates.

FWGS

# 1&2. FROM-WHERE-GROUPBY

Product	Price	Quantity
Bagel	3	20
Bagel	1.50	20
Banana	<del>0.5</del>	<del>50</del>
Banana	2	10
Banana	4	10

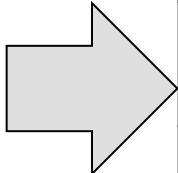
FWGS

WHERE price > 1

# 3. SELECT

FWGS

Product	Price	Quantity
Bagel	3	20
Bagel	1.50	20
Banana	<del>0.5</del>	<del>50</del>
Banana	2	10
Banana	4	10



Product	sum(quantity)
Bagel	40
Banana	20

```
SELECT product, Sum(quantity)
FROM Purchase
WHERE price > 1
GROUP BY product
```



Purchase(pid,product,price,quantity,month)

## Other Examples

Compare these  
two queries:

```
SELECT product, count(*)  
FROM Purchase  
GROUP BY product
```

```
SELECT month, count(*)  
FROM Purchase  
GROUP BY month
```

```
SELECT product,  
       sum(quantity) AS SumQuantity,  
       max(price) AS MaxPrice  
FROM Purchase  
GROUP BY product
```

How about  
this one?

# Need to be Careful...

```
SELECT product, max(quantity)
FROM Purchase
GROUP BY product
```

```
SELECT product, quantity
FROM Purchase
GROUP BY product
```

Product	Price	Quantity
Bagel	3	20
Bagel	1.50	20
Banana	0.5	50
Banana	2	10
Banana	4	10

sqlite is WRONG on  
this query.

Better DBMS (e.g. SQL Server)  
gives an error

Purchase(pid,product,price,quantity,month)

## Ordering Results

```
SELECT product, sum(price*quantity)
FROM Purchase
GROUP BY product
ORDER BY sum(price*quantity) DESC
```

FWGOS

Purchase(pid,product,price,quantity,month)

## Ordering Results

```
SELECT product, sum(price*quantity) as rev  
FROM Purchase  
GROUP BY product  
ORDER BY rev desc
```

FWGOS

Note: some SQL engines  
want you to say ORDER BY sum(price\*quantity)

Purchase(pid,product,price,quantity,month)

## HAVING Clause

Same query as earlier, except that we consider only products that had at least 30 sales.

```
SELECT    product, sum(price*quantity)
FROM      Purchase
WHERE     price > 1
GROUP BY product
HAVING    sum(quantity) > 30
```

FWGHOS

HAVING clause contains conditions on groups.

Purchase(pid,product,price,quantity,month)

## Exercise

Compute the total income per month

Show only months with less than 10 items sold

Order by quantity sold and display as "TotalSold"

```
SELECT    month, sum(price*quantity),  
          sum(quantity) as TotalSold  
FROM      Purchase  
GROUP BY  month  
HAVING    sum(quantity) < 10  
ORDER BY  sum(quantity)
```

FWGHOS

# WHERE vs HAVING

- WHERE condition is applied to individual rows
  - The rows may or may not contribute to the aggregate
  - No aggregates allowed here
- HAVING condition is applied to the entire group
  - Entire group is returned, or not at all
  - May use aggregate functions in the group

Purchase(pid,product,price,quantity,month)

## Mystery Query

What do they compute?

```
SELECT    month, sum(quantity), max(price)
FROM      Purchase
GROUP BY  month
```

```
SELECT    month, sum(quantity)
FROM      Purchase
GROUP BY  month
```

```
SELECT    month
FROM      Purchase
GROUP BY  month
```

Lesson:  
DISTINCT is  
a special case  
of GROUP BY



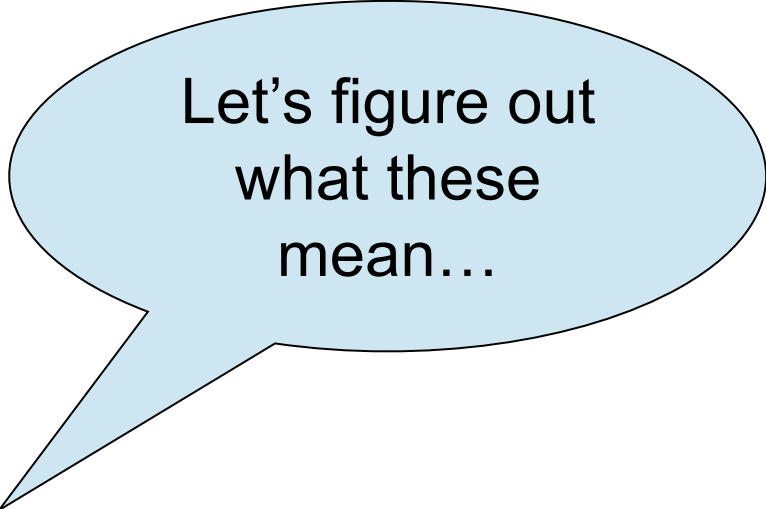
# Aggregates and Joins

```
create table Product(  
    pid int primary key,  
    pname varchar(15),  
    manufacturer varchar(15));  
  
insert into product values(1, 'bagel', 'Sunshine Co. ');  
insert into product values(2, 'banana', 'BusyHands ');  
insert into product values(3, 'gizmo', 'GizmoWorks ');  
insert into product values(4, 'gadget', 'BusyHands ');  
insert into product values(5, 'powerGizmo', 'PowerWorks ');
```

Purchase(pid,product,price,quantity,month)  
Product(pid,pname,manufacturer)

## Aggregate + Join Example

```
SELECT manufacturer, count(*)  
FROM Product, Purchase  
WHERE pname = product  
GROUP BY manufacturer
```



Let's figure out  
what these  
mean...

```
SELECT manufacturer, month, count(*)  
FROM Product, Purchase  
WHERE pname = product  
GROUP BY manufacturer, month
```

# Nested Loop Semantics for SFW

```
SELECT x1.a1, x2.a2, ... xm.am  
FROM   R1 as x1, R2 as x2, ... Rm as xm  
WHERE  Cond
```

for x1 in R1:

  for x2 in R2:

    ...

      for xm in Rm:

        if Cond(x1, x2...):

          output(x1.a1, x2.a2, ... xm.am)

Nested loop  
semantics

# Semantics for SFWGH

SELECT	S
FROM	$R_1, \dots, R_n$
WHERE	C1
GROUP BY	$a_1, \dots, a_k$
HAVING	C2

S = may contain attributes  $a_1, \dots, a_k$  and/or any aggregates but NO OTHER ATTRIBUTES

C1 = is any condition on the attributes in  $R_1, \dots, R_n$

C2 = is any condition on aggregate expressions and on attributes  $a_1, \dots, a_k$



Why ?

# Semantics for SFWGH

SELECT	S
FROM	$R_1, \dots, R_n$
WHERE	C1
GROUP BY	$a_1, \dots, a_k$
HAVING	C2

Evaluation steps:

1. Evaluate FROM-WHERE using Nested Loop Semantics
2. Group by the attributes  $a_1, \dots, a_k$
3. Apply condition C2 to each group (may have aggregates)
4. Compute aggregates in S and return the result

# Semantics for SFWGH

SELECT	S
FROM	$R_1, \dots, R_n$
WHERE	C1
GROUP BY	$a_1, \dots, a_k$
HAVING	C2

Execution order:

**FWGHOS**

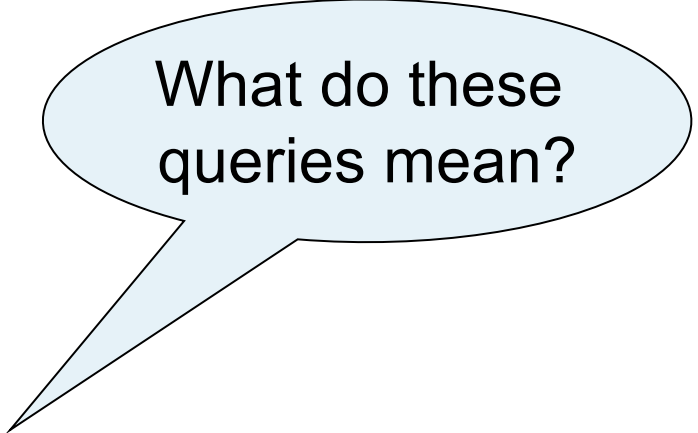
Evaluation steps:

1. Evaluate FROM-WHERE using Nested Loop Semantics
2. Group by the attributes  $a_1, \dots, a_k$
3. Apply condition C2 to each group (may have aggregates)
4. Compute aggregates in S and return the result

Purchase(pid,product,price,quantity,month)  
Product(pid,pname,manufacturer)

## Aggregate + Join Example

```
SELECT manufacturer, count(*)  
FROM Product, Purchase  
WHERE pname = product  
GROUP BY manufacturer
```



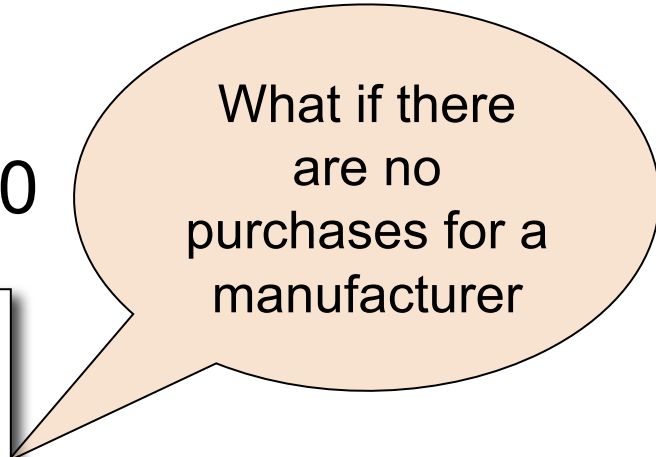
What do these queries mean?

```
SELECT manufacturer, month, count(*)  
FROM Product, Purchase  
WHERE pname = product  
GROUP BY manufacturer, month
```

# Empty Groups

- In the result of a group by query, there is one row per group in the result
- No group can be empty!
- In particular, `count(*)` is never 0

```
SELECT manufacturer, count(*)  
FROM Product, Purchase  
WHERE pname = product  
GROUP BY manufacturer
```



What if there  
are no  
purchases for a  
manufacturer



# Empty Group Solution: Outer Join

```
SELECT manufacturer, count(quantity)
FROM Product LEFT OUTER JOIN Purchase
ON pname = product
GROUP BY manufacturer
```

Why not count (\*)?

Purchase(pid,product,price,quantity,month)  
Product(pid,pname,manufacturer)

## Exercise:

Find all manufacturers with more than 10 items sold.  
Return manufacturer name and number of items sold.

```
SELECT manufacturer, sum(quantity)
FROM Product, Purchase
WHERE pname = product
GROUP BY manufacturer
HAVING sum(quantity) > 10
```

Purchase(pid,product,price,quantity,month)  
Product(pid,pname,manufacturer)

## Exercise:

Find all manufacturers with more than 1 distinct product sold  
Return the name of the manufacturer and  
number of distinct products sold

```
SELECT manufacturer, count(distinct product)
FROM Product, Purchase
WHERE pname = product
GROUP BY manufacturer
HAVING count(distinct product) > 1
```

Purchase(pid,product,price,quantity,month)  
Product(pid,pname,manufacturer)

## Exercise:

Find all products with more than 2 purchases  
Return the name of the product and max price it was sold

```
SELECT pname max(price)
FROM Product, Purchase
WHERE pname = product
GROUP BY pname
HAVING COUNT(*) > 2
```

Purchase(pid,product,price,quantity,month)  
Product(pid,pname,manufacturer)

## Exercise:

Find all manufacturers with at least 5 purchases in one month  
Return manufacturer name, month, and number of items sold

```
SELECT manufacturer, month, sum(quantity)
FROM Product, Purchase
GROUP BY manufacturer, month
HAVING count(*) > 2
```