Database Systems
CSE 414

Lectures 5: Grouping & Aggregation

Announcements

- HW1 is due next Monday, 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.

$\boxed{\text{FWGS}}$

1&2. FROM-WHERE-GROUPBY

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

FWGS

WHERE price > 1

FWGS

3. SELECT

Product	Price	Quantity
Bagel	3	20
Bagel	1.50	20
Banana	~~0.5~~	~~50~~
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 allows this query to be executed with strange behavior.

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)
```

$\boxed{\text{FWGHOS}}$

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,…,R_n
WHERE     C1
GROUP BY  a_1,…,a_k
HAVING    C2
```

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

Why ?

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

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

Semantics for SFWGH

```
SELECT    S
FROM      R1,…,Rn
WHERE     C1
GROUP BY  a1,…,ak
HAVING    C2
```

Evaluation steps:

1. Evaluate FROM-WHERE using Nested Loop Semantics
2. Group by the attributes $a_1,\ldots,a_k$
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        R1,…,Rn
WHERE       C1
GROUP BY    a1,…,ak
HAVING      C2
```

Execution order:

FWGHOS

Evaluation steps:

1. Evaluate FROM-WHERE using Nested Loop Semantics
2. Group by the attributes $a_1,\ldots,a_k$
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
WHERE pname = product
GROUP BY manufacturer, month
HAVING count(*) >= 5
```