Introduction to Data Management CSE 344

Lecture 5: Grouping and Query Evaluation

Announcements

- Web quiz 2 is open: due Tuesday 11pm
- Homework 2 is released: Wednesday 11pm
  - TA office hours

Review

- Selection
- Projection
- Join
  - Inner and outer
- Aggregates

Today

- Aggregations and grouping (6.4.3 – 6.4.6)
- Order of query evaluation

Grouping and Aggregation

```
Purchase(product, price, quantity)
```

Find total quantities for all sales over $1, by product.

Grouping and Aggregation

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

Product	TotalSales
Bagel	40
Banana	20

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

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
```

What does it mean ?

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

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

Need to be Careful…

```
SELECT   product
FROM     Purchase
GROUP BY product
```

```
SELECT   quantity
FROM     Purchase
```

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

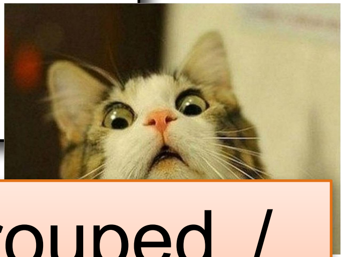
Product
Bagel
Banana

+

???

Quantity
20
20
50
10
10

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



Can't project a non-grouped / non-aggregated column!

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.

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

Grouping and Aggregation

```
Purchase(product, price, quantity)
```

Find total quantities for all sales over $1, by product.

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

How is this query processed?

Grouping and Aggregation

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

$\boxed{\text{FWGS}}^{\text{TM}}$

1,2: From, Where

FWGS

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

WHERE price > 1

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

3,4. Grouping, Select

FWGS

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

Product	TotalSales
Bagel	40
Banana	20

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

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

Ordering Results

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

$\boxed{\text{FWGOS}}$ TM

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

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

HAVING Clause

Same query as before, 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
```

HAVING clause contains conditions on aggregates.

General form of Grouping and Aggregation

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

Why ?

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

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 of SQL With Group-By

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

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)
```

Exercise

Compute the total income per month
Show only months with less than 10 items sold
Order by quantity sold and display as “TotalSold”

```
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”

```
FROM     Purchase
```

```
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”

```
FROM      Purchase
GROUP BY  month
```

`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"

```
FROM       Purchase
GROUP BY   month
HAVING    sum(quantity) < 10
```

```
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
```

`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)
```

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
```

```
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

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

Aggregate + Join Example

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

What do these queries mean?

manufacturer	month	count(*)
canon	1	10
canon	2	20
sony	4	50

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

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

Empty Groups

FWGHOS

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

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

What if there are no purchases for a manufacturer

Empty Group Solution: Outer Join

```
SELECT x.manufacturer, count(y.pid)
FROM Product x LEFT OUTER JOIN Purchase y
ON x.pname = y.product
GROUP BY x.manufacturer
```