Introduction to Database Systems
CSE 414

Lectures 4 and 5: Aggregates in SQL

Announcements

- First web quiz due tonight, 11 pm. No late days allowed.
- Homework 1 is due Wednesday, 11 pm. You can use a late day if you must, but you *really* don't want to do that this early in the quarter
- Next web quiz and homework coming shortly

More Announcements

- Course calendar updated with the likely schedule for the rest of the quarter
  - Assignment dates are almost certainly fixed
    - There will be additional web quizzes added
  - Midterm date: Monday, May 4 looks best. We could move it to Friday, May 1 if necessary.
    - Any strong preferences for either one?

Yet More Announcements, 4/8

- Next webquiz out now, due Monday by 11 pm
- HW2 will be posted later this afternoon – Movie database in sqlite, more complex queries, basic indexes (in lecture Friday)

- Sections Thur.: sql aggregate queries, hw2

- *Please* use the discussion board or staff mailing list, not email to individual TAs

Outline

- Outer joins (6.3.8)
- Aggregations (6.4.3 – 6.4.6)
- Examples, examples, examples…

Outerjoins

Product(name, category)
Purchase(prodName, store) -- prodName is foreign key

An "inner join":

```
SELECT Product.name, Purchase.store
FROM   Product, Purchase
WHERE  Product.name = Purchase.prodName
```

Same as:

```
SELECT Product.name, Purchase.store
FROM   Product JOIN Purchase ON
                  Product.name = Purchase.prodName
```

But some Products are not listed! Why?

Outerjoins

Product(name, category)
Purchase(prodName, store) -- prodName is foreign key

If we want to include products that never sold,
then we need an "outerjoin":

```
SELECT Product.name, Purchase.store
FROM   Product LEFT OUTER JOIN Purchase ON
                    Product.name = Purchase.prodName
```

Product

Name	Category
Gizmo	gadget
Camera	Photo
OneClick	Photo

Purchase

ProdName	Store
Gizmo	Wiz
Camera	Ritz
Camera	Wiz

Name	Store
Gizmo	Wiz
Camera	Ritz
Camera	Wiz
OneClick	NULL

Outer Joins

- Left outer join:
  - Include the left tuple even if there's no match
- Right outer join:
  - Include the right tuple even if there's no match
- Full outer join:
  - Include both left and right tuples even if there's no match

Aggregation in SQL

```
>sqlite3 lecture04

sqlite> create table Purchase
        (pid int primary key,
         product text,
         price float,
         quantity int,
         month varchar(15));

sqlite> -- download data.txt
sqlite> .import data.txt Purchase
```

Specify a filename where the database will be stored

Other DBMSs have other ways of importing data

Comment about SQLite

- One cannot load NULL values such that they are actually loaded as null values

- So we need to use two steps:
  - Load null values using some type of special value
  - Update the special values to actual null values

```
update Purchase
  set price = null
  where price = 'null'
```

Simple Aggregations

Five basic aggregate operations in SQL

```
select count(*) from Purchase
select sum(quantity) from Purchase
select avg(price) from Purchase
select max(quantity) from Purchase
select min(quantity) from Purchase
```

Except count, all aggregations apply to a single attribute

Aggregates and NULL Values

Null values are not used in aggregates

```
insert into Purchase
values(12, 'gadget', NULL, NULL, 'april')
```

Let's try the following

```
select count(*) from Purchase
select count(quantity) from Purchase

select sum(quantity) from Purchase

select sum(quantity)
from Purchase
where quantity is not null;
```

Counting Duplicates

COUNT applies to duplicates, unless otherwise stated:

```
SELECT  Count(product)
FROM    Purchase
WHERE   price > 4.99
```

same as Count(*) if no nulls

We probably want:

```
SELECT  Count(DISTINCT product)
FROM    Purchase
WHERE   price> 4.99
```

More Examples

```
SELECT  Sum(price * quantity)
FROM    Purchase
```

```
SELECT  Sum(price * quantity)
FROM    Purchase
WHERE   product = 'bagel'
```

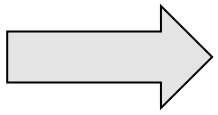
What do they mean ?

Simple Aggregations

Purchase

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

```
SELECT  Sum(price * quantity)
FROM    Purchase
WHERE   product = 'Bagel'
```



90 (= 60+30)

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
```

Let's see what this means…

Grouping and Aggregation

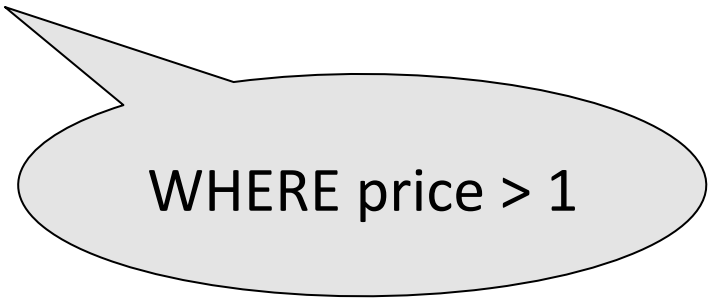
1. Compute the FROM and WHERE clauses.

2. Group by the attributes in the GROUPBY

3. Compute the SELECT clause:
   grouped attributes and aggregates.

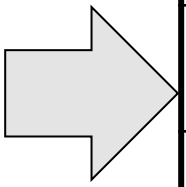
1&2. FROM-WHERE-GROUPBY

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



3. SELECT

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

sqlite is WRONG on this query.

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

Ordering Results

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

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
```

HAVING clause contains conditions on aggregates.

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

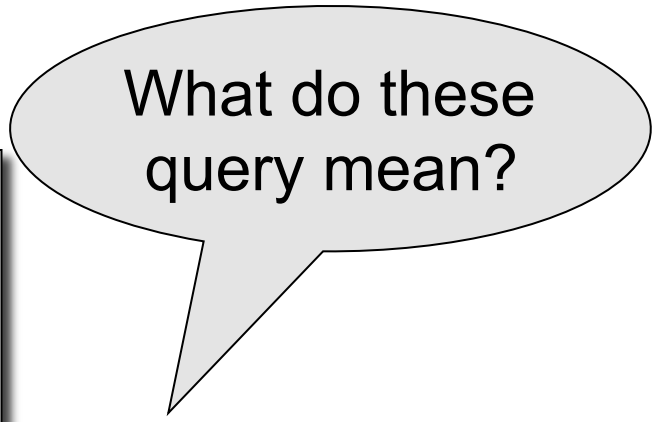
Aggregates and Joins

```
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');
```

Aggregate + Join Example

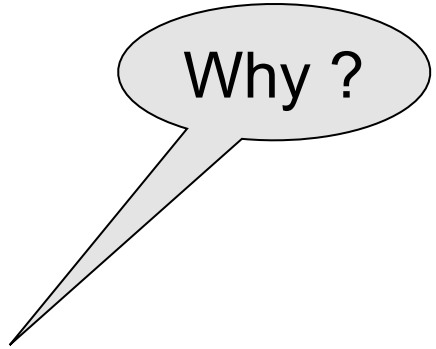
```
SELECT x.manufacturer, count(*)
FROM Product x, Purchase y
WHERE x.pname = y.product
GROUP BY  x.manufacturer
```




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

General form of Grouping and Aggregation

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



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
```

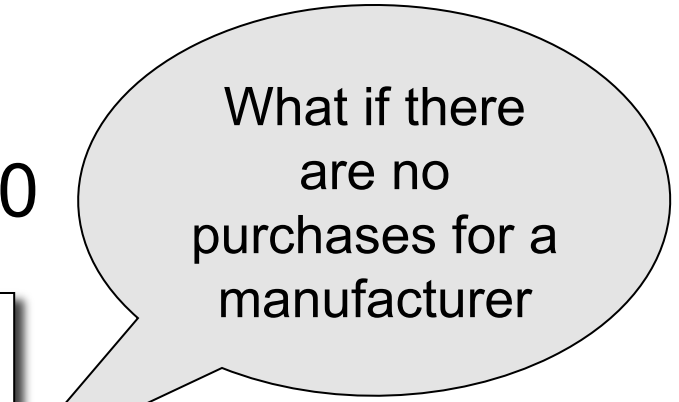
Evaluation steps:

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

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



Empty Groups: Example

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

5 groups in our example dataset

```
SELECT product, count(*)
FROM purchase
WHERE price > 2.0
GROUP BY product
```

3 groups in our example dataset

Empty Group Problem

```
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
```