Introduction to Database Systems
CSE 444

Lecture 3: SQL (part 2)

Outline

- Aggregations (6.4.3 – 6.4.6)
- Examples, examples, examples…
- Nulls (6.1.6 - 6.1.7)
- Outer joins (6.3.8)

Aggregation

```
SELECT   avg(price)
FROM     Product
WHERE    maker='Toyota'
```

```
SELECT  count(*)
FROM    Product
WHERE   year > 1995
```

SQL supports several aggregation operations:

sum, count, min, max, avg

Except count, all aggregations apply to a single attribute

Aggregation: Count

COUNT applies to duplicates, unless otherwise stated:

```
SELECT  Count(category)
FROM    Product
WHERE   year > 1995
```

same as Count(*)

We probably want:

```
SELECT  Count(DISTINCT category)
FROM    Product
WHERE   year > 1995
```

More Examples

Purchase(product, date, price, quantity)

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

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

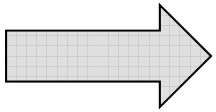
What do they mean ?

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 GROUP BY

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

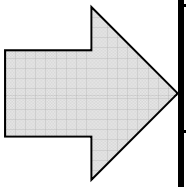
1&2. FROM-WHERE-GROUPBY

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

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

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
```

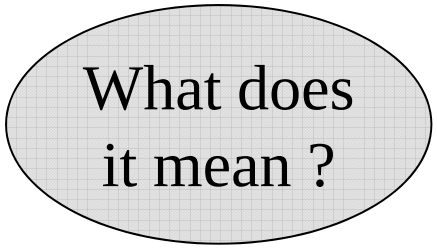
GROUP BY v.s. Nested Queries

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

```
SELECT DISTINCT  x.product, (SELECT Sum(y.quantity)
                             FROM     Purchase y
                             WHERE x.product = y.product
                                   AND price > 1)
                            AS TotalSales
FROM        Purchase x
WHERE       price > 1
```

Why twice ?

Another Example




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

HAVING Clause

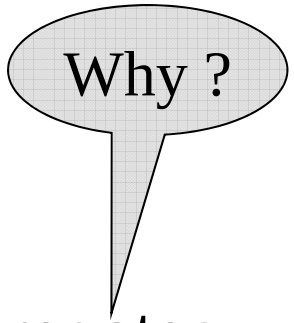
Same query as earlier, except that we consider only products that had at least 30 sales.

```
SELECT      product, Sum(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
```



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 $a_1,\ldots,a_k$

General form of Grouping and Aggregation

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

Evaluation steps:

1. Evaluate FROM-WHERE, apply condition C1
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

Advanced SQLizing

1. Getting around INTERSECT and EXCEPT
2. Unnesting Aggregates
3. Finding witnesses

INTERSECT and EXCEPT: not in some DBMSs

INTERSECT and EXCEPT:

```
(SELECT R.A, R.B
FROM   R)
   INTERSECT
(SELECT S.A, S.B
FROM   S)
```

```
SELECT R.A, R.B
FROM   R
WHERE
   EXISTS(SELECT *
          FROM S
          WHERE R.A=S.A and R.B=S.B)
```

Can unnest. How ?

```
(SELECT R.A, R.B
FROM   R)
   EXCEPT
(SELECT S.A, S.B
FROM   S)
```

```
SELECT R.A, R.B
FROM   R
WHERE
  NOT  EXISTS(SELECT *
              FROM S
              WHERE R.A=S.A and R.B=S.B)
```

Unnesting Aggregates

Product (pname, price, company)
Company(cname, city)

Find the number of companies in each city

```
SELECT DISTINCT city, (SELECT count(*)
                       FROM Company Y
                       WHERE X.city = Y.city)
FROM  Company X
```

```
SELECT city,  count(*)
FROM   Company
GROUP BY city
```

Equivalent queries

Note: no need for DISTINCT
(DISTINCT *is the same* as GROUP BY)

Unnesting Aggregates

Product (pname, price, company)
Company(cname, city)

Find the number of products made in each city

What if there are no products for a city?

```
SELECT DISTINCT X.city, (SELECT count(*)
                         FROM Product Y, Company Z
                         WHERE Z.cname=Y.company
                          AND Z.city = X.city)
FROM  Company X
```

```
SELECT X.city, count(*)
FROM Company X, Product Y
WHERE X.cname=Y.company
GROUP BY X.city
```

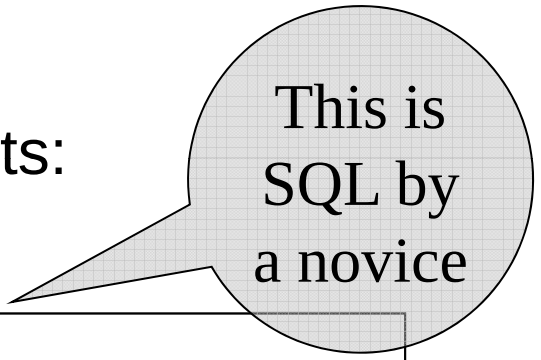
They are NOT equivalent ! (WHY?)

More Unnesting

Author(login,name)

Wrote(login,url)

- Find authors who wrote ≥ 10 documents:
- Attempt 1: with nested queries

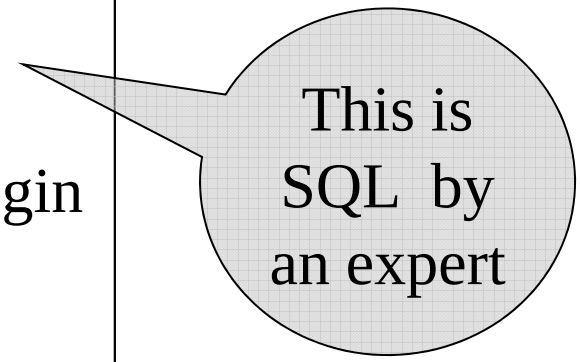



```
SELECT DISTINCT Author.name
FROM        Author
WHERE       (SELECT count(Wrote.url)
             FROM Wrote
             WHERE Author.login=Wrote.login)
              > 10
```

More Unnesting

- Find all authors who wrote at least 10 documents:
- Attempt 2: SQL style (with GROUP BY)

```
SELECT    Author.name
FROM      Author, Wrote
WHERE     Author.login=Wrote.login
GROUP BY  Author.name
HAVING    count(wrote.url) > 10
```



Finding Witnesses

Store(sid, sname)
Product(pid, pname, price, sid)

For each store,
find its most expensive products

Finding Witnesses

Finding the maximum price is easy…

```
SELECT Store.sid, max(Product.price)
FROM   Store, Product
WHERE  Store.sid = Product.sid
GROUP BY  Store.sid
```

But we need the *witnesses*, i.e. the products with max price

Finding Witnesses

To find the witnesses, compute the maximum price in a subquery

```
SELECT Store.sname, Product.pname
FROM Store, Product,
        (SELECT Store.sid AS sid, max(Product.price) AS p
         FROM   Store, Product
         WHERE  Store.sid = Product.sid
         GROUP BY  Store.sid) X
WHERE  Store.sid = Product.sid
       and Store.sid = X.sid and Product.price = X.p
```

Finding Witnesses

There is a more concise solution here:

```
SELECT Store.sname, x.pname
FROM   Store, Product x
WHERE  Store.sid = x.sid and
       x.price >=
           ALL (SELECT y.price
                FROM Product y
                WHERE Store.sid = y.sid)
```

NULLs in SQL

- Whenever we don't have a value, we can put a NULL
- Can mean many things:
  - Value does not exists
  - Value exists but is unknown
  - Value not applicable
  - Etc.
- The schema specifies for each attribute if can be null (*nullable* attribute) or not
- How does SQL cope with tables that have NULLs ?

Null Values

- If x = NULL then 4*(3-x)/7 is still NULL
- If x = NULL then x='Joe' is UNKNOWN
- In SQL there are three boolean values:

  FALSE = 0

  UNKNOWN = 0.5

  TRUE = 1

Null Values

- C1 AND C2 = min(C1, C2)
- C1 OR C2 = max(C1, C2)
- NOT C1 = 1 – C1

```
SELECT *
FROM Person
WHERE  (age < 25) AND
       (height > 6 OR weight > 190)
```

E.g.
age=20
height=NULL
weight=200

Rule in SQL: include only tuples that yield TRUE

Null Values

Unexpected behavior:

```
SELECT *
FROM   Person
WHERE  age < 25  OR  age >= 25
```

Some Person tuples are not included !

Null Values

Can test for NULL explicitly:

- x IS NULL
- x IS NOT NULL

```
SELECT *
FROM   Person
WHERE  age < 25  OR  age >= 25 OR age IS NULL
```

Now it includes all Person tuples

Outerjoins

Product(name, category)
Purchase(prodName, store)

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 Products that never sold will be lost !

Outerjoins

Product(name, category)
Purchase(prodName, store)

If we want the never-sold products, 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

Application

- Compute, for each product, the total number of sales in 'September'

  Product(name, category)

  Purchase(prodName, month, store)

```
SELECT Product.name, count(*)
FROM   Product, Purchase
WHERE  Product.name = Purchase.prodName
       and  Purchase.month = 'September'
GROUP BY Product.name
```

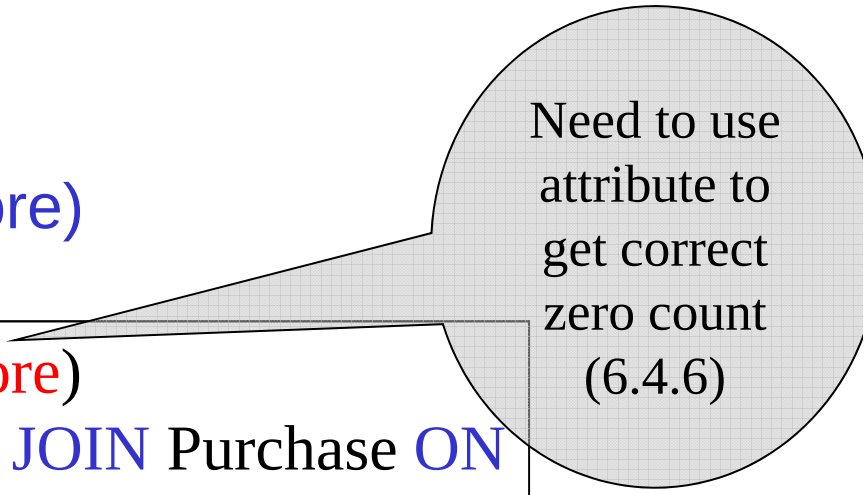
What's wrong ?

Application

- Compute, for each product, the total number of sales in 'September'

  Product(name, category)

  Purchase(prodName, month, store)




```
SELECT Product.name, count(store)
FROM   Product LEFT OUTER JOIN Purchase ON
           Product.name = Purchase.prodName
           and  Purchase.month = 'September'
GROUP BY Product.name
```

Now we also get the products who sold in 0 quantity

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