Lecture 03: SQL

Friday, April 2nd, 2010

Announcements

- New IMDB database: use imdb_new instead of imdb
- Up to date, and much larger !
- Make following change to Project 1 / Question 5: consider *only* movies made in 2010

Outline

- Aggregations (6.4.3 – 6.4.6)
- Examples, examples, examples…
- Nulls (6.1.6)
- 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
```

What do they mean ?

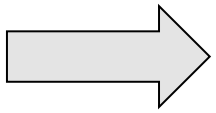
```
SELECT  Sum(price * quantity)
FROM    Purchase
WHERE   product = 'bagel'
```

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

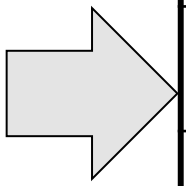
3. Compute the SELECT clause: grouped attributes and aggregates.

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
```

GROUP BY v.s. Nested Quereis

```
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

What does it mean ?

```
SELECT      product,
            sum(quantity) AS SumSales
            max(price) AS MaxQuantity
FROM        Purchase
GROUP BY product
```

HAVING Clause

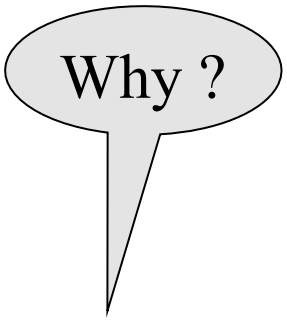
Same query, except that we consider only products that had at least 100 buyers.

```
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 $R_1,\ldots,R_n$
WHERE C1
GROUP BY $a_1,\ldots,a_k$
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

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

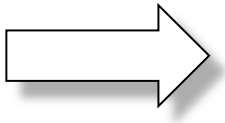
2. Unnesting Aggregates

3. Finding witnesses

INTERSECT and EXCEPT: not in some DBMS

INTERSECT and EXCEPT:

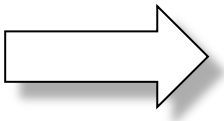
```
(SELECT R.A, R.B
FROM   R)
   INTERSECT
(SELECT S.A, S.B
FROM   S)
```



```
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
```

Equivalent queries

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

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

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

This is SQL by a novice

```
SELECT DISTINCT Author.name
FROM        Author
WHERE       count(SELECT 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
```

This is SQL by an expert

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, Store.sname) 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
heigth=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 Persons 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 Persons

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 the both left and right tuples even if there's no match