Introduction to Data Management CSE 344

Lectures 4: Aggregates in SQL

Announcements

- Did you remember the web quiz yesterday?
- HW 1 is due Tuesday (tomorrow), 11pm

- Next web quiz is out – due next Sunday
- HW2 coming out on Wednesday

Outline

- Inner joins (6.2, review)
- Outer joins (6.3.8)
- Aggregations (6.4.3 – 6.4.6)
- Examples, examples, examples…

(Inner) Joins

```
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

(Inner) Joins

```
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

(Inner) joins

Company(cname, country)
Product(pname, price, category, manufacturer)
– manufacturer is foreign key

```
SELECT DISTINCT cname
FROM    Product, Company
WHERE   country = 'USA' AND category = 'gadget' AND
        manufacturer = cname
```

(Inner) joins

```
SELECT DISTINCT cname
FROM    Product, Company
WHERE   country = 'USA' AND category = 'gadget' AND
        manufacturer = cname
```

Product

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
Camera	Photo	Hitachi
OneClick	Photo	Hitachi

Company

cname	country
GizmoWorks	USA
Canon	Japan
Hitachi	Japan

(Inner) joins

```
SELECT DISTINCT cname
FROM    Product, Company
WHERE   country = 'USA' AND category = 'gadget' AND
        manufacturer = cname
```

Product

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
Camera	Photo	Hitachi
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cname	country
GizmoWorks	USA
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(Inner) joins

```
SELECT DISTINCT cname
FROM    Product, Company
WHERE   country = 'USA' AND category = 'gadget' AND
        manufacturer = cname
```

Product

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
Camera	Photo	Hitachi
OneClick	Photo	Hitachi

Company

cname	country
GizmoWorks	USA
Canon	Japan
Hitachi	Japan

(Inner) joins

```
SELECT DISTINCT cname
FROM    Product, Company
WHERE   country = 'USA' AND category = 'gadget' AND
        manufacturer = cname
```

Product

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
Camera	Photo	Hitachi
OneClick	Photo	Hitachi

Company

cname	country
GizmoWorks	USA
Canon	Japan
Hitachi	Japan

pname	category	manufacturer	cname	country
Gizmo	gadget	GizmoWorks	GizmoWorks	USA

(Inner) joins

```
SELECT DISTINCT cname
FROM    Product, Company
WHERE   country = 'USA' AND category = 'gadget' AND
        manufacturer = cname
```

Product

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
Camera	Photo	Hitachi
OneClick	Photo	Hitachi

Company

cname	country
GizmoWorks	USA
Canon	Japan
Hitachi	Japan

(Inner) joins

```
SELECT DISTINCT cname
FROM    Product, Company
WHERE   country = 'USA' AND category = 'gadget' AND
        manufacturer = cname
```

Product

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
Camera	Photo	Hitachi
OneClick	Photo	Hitachi

Company

cname	country
GizmoWorks	USA
Canon	Japan
Hitachi	Japan

(Inner) joins

```
SELECT DISTINCT cname
FROM    Product, Company
WHERE   country = 'USA' AND category = 'gadget' AND
        manufacturer = cname
```

```
SELECT DISTINCT cname
FROM    Product JOIN Company
ON country = 'USA' AND category = 'gadget' AND
    manufacturer = cname
```

Self-Joins and Tuple Variables

- Find all companies that manufacture both products in the ‘gadgets’ category and in the ‘photo’ category
- Just joining Product with Company is insufficient: instead need to join Product, with Product, with Company
- When a relation occurs twice in the FROM clause we call it a *self-join*; in that case we must use tuple variables (why?)

Self-joins

```
SELECT DISTINCT z.cname
FROM    Product x, Product y, Company z
WHERE   z.country = 'USA'
    AND   x.category = 'gadget'
    AND   y.category = 'photo'
    AND   x.manufacturer = cname
    AND   y.manufacturer = cname;
```

Product

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
SingleTouch	photo	Hitachi
MultiTouch	Photo	GizmoWorks

Company

cname	country
GizmoWorks	USA
Hitachi	Japan

Self-joins

```
SELECT DISTINCT z.cname
FROM    Product x, Product y, Company z
WHERE   z.country = 'USA'
    AND   x.category = 'gadget'
    AND   y.category = 'photo'
    AND   x.manufacturer = cname
    AND   y.manufacturer = cname;
```

Product

x

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
SingleTouch	photo	Hitachi
MultiTouch	Photo	GizmoWorks

Company

cname	country
GizmoWorks	USA
Hitachi	Japan

Self-joins

```
SELECT DISTINCT z.cname
FROM    Product x, Product y, Company z
WHERE   z.country = 'USA'
    AND   x.category = 'gadget'
    AND   y.category = 'photo'
    AND   x.manufacturer = cname
    AND   y.manufacturer = cname;
```

Product

x

y

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
SingleTouch	photo	Hitachi
MultiTouch	Photo	GizmoWorks

Company

cname	country
GizmoWorks	USA
Hitachi	Japan

Self-joins

```
SELECT DISTINCT z.cname
FROM    Product x, Product y, Company z
WHERE   z.country = 'USA'
    AND   x.category = 'gadget'
    AND   y.category = 'photo'
    AND   x.manufacturer = cname
    AND   y.manufacturer = cname;
```

Product

x

y

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
SingleTouch	photo	Hitachi
MultiTouch	Photo	GizmoWorks

Company

z

cname	country
GizmoWorks	USA
Hitachi	Japan

Self-joins

```
SELECT DISTINCT z.cname
FROM    Product x, Product y, Company z
WHERE   z.country = 'USA'
    AND   x.category = 'gadget'
    AND   y.category = 'photo'
    AND   x.manufacturer = cname
    AND   y.manufacturer = cname;
```

Product

x

y

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
SingleTouch	photo	Hitachi
MultiTouch	Photo	GizmoWorks

Company

z

cname	country
GizmoWorks	USA
Hitachi	Japan

Self-joins

```
SELECT DISTINCT z.cname
FROM    Product x, Product y, Company z
WHERE   z.country = 'USA'
    AND   x.category = 'gadget'
    AND   y.category = 'photo'
    AND   x.manufacturer = cname
    AND   y.manufacturer = cname;
```

Product

x

y

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
SingleTouch	photo	Hitachi
MultiTouch	Photo	GizmoWorks

Company

z

cname	country
GizmoWorks	USA
Hitachi	Japan

Self-joins

```
SELECT DISTINCT z.cname
FROM    Product x, Product y, Company z
WHERE   z.country = 'USA'
    AND   x.category = 'gadget'
    AND   y.category = 'photo'
    AND   x.manufacturer = cname
    AND   y.manufacturer = cname;
```

Product

x

y

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
SingleTouch	photo	Hitachi
MultiTouch	Photo	GizmoWorks

Company

z

cname	country
GizmoWorks	USA
Hitachi	Japan

x.pname	x.category	x.manufacturer	y.pname	y.category	y.manufacturer	z.cname	z.country
Gizmo	gadget	GizmoWorks	MultiTouch	Photo	GizmoWorks	GizmoWorks	USA

Self-joins

```
SELECT DISTINCT z.cname
FROM    Product x, Product y, Company z
WHERE   z.country = 'USA'
    AND   x.category = 'gadget'
    AND   y.category = 'photo'
    AND   x.manufacturer = cname
    AND   y.manufacturer = cname;
```

Product

x

y

pname	category	manufacturer
Gizmo	gadget	GizmoWorks
SingleTouch	photo	Hitachi
MultiTouch	Photo	GizmoWorks

Company

z

cname	country
GizmoWorks	USA
Hitachi	Japan

x.pname	x.category	x.manufacturer	y.pname	y.category	y.manufacturer	z.cname	z.country
Gizmo	gadget	GizmoWorks	MultiTouch	Photo	GizmoWorks	GizmoWorks	USA

Outer joins

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?

Outer joins

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
```

```
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 lec04-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;
```

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'
```

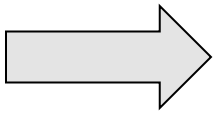
What do they mean ?

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'
```



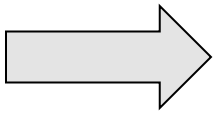
90 (= 60+30)

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.

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

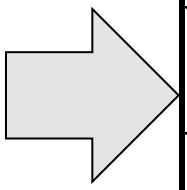
FWGS

WHERE price > 1

3. 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
```

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
```