Introduction to Database Systems CSE 444

Lecture 03: SQL

April 4, 2008

Outline

- Subqueries (6.3)
- Aggregations (6.4.3 – 6.4.6)
- Examples, examples, examples…

Read the entire chapter 6 !

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	Date	Price	Quantity
Bagel	10/21	1	20
Banana	10/3	0.5	10
Banana	10/10	1	10
Bagel	10/25	1.50	20

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

⇨ 50 (= 20+30)

Grouping and Aggregation

Purchase(product, date, price, quantity)

Find total sales after 10/1/2005 per product.

```
SELECT        product, Sum(price*quantity) AS TotalSales
FROM           Purchase
WHERE         date > ‘10/1/2005’
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	Date	Price	Quantity
Bagel	10/21	1	20
Bagel	10/25	1.50	20
Banana	10/3	0.5	10
Banana	10/10	1	10

3. SELECT

Product	Date	Price	Quantity
Bagel	10/21	1	20
Bagel	10/25	1.50	20
Banana	10/3	0.5	10
Banana	10/10	1	10

⇨

Product	TotalSales
Bagel	50
Banana	15

```
SELECT      product, Sum(price*quantity) AS TotalSales
FROM        Purchase
WHERE       date > ‘10/1/2005’
GROUP BY  product
```

GROUP BY v.s. Nested Quereis

```
SELECT      product, Sum(price*quantity) AS TotalSales
FROM        Purchase
WHERE       date > ‘10/1/2005’
GROUP BY  product
```

```
SELECT DISTINCT  x.product, (SELECT Sum(y.price*y.quantity)
                             FROM    Purchase y
                             WHERE x.product = y.product
                                   AND y.date > ‘10/1/2005’)
                            AS TotalSales
FROM        Purchase x
WHERE       x.date > ‘10/1/2005’
```

Another Example

What does it mean ?

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

HAVING Clause

Same query, except that we consider only products that had at least 30 buyers.

```
SELECT      product, Sum(price * quantity)
FROM        Purchase
WHERE       date > ‘10/1/2005’
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

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

General form of Grouping and Aggregation

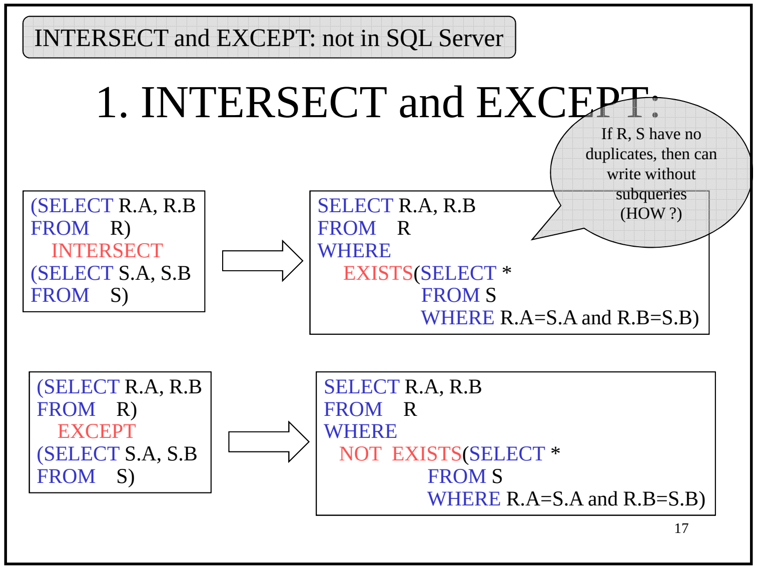
SELECT S
FROM $R_1,\ldots,R_n$
WHERE C1
GROUP BY $a_1,\ldots,a_k$
HAVING C2

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. Quantifiers
3. Aggregation v.s. subqueries
4. Two examples (study at home)



INTERSECT and EXCEPT: not in SQL Server

1. INTERSECT and EXCEPT:

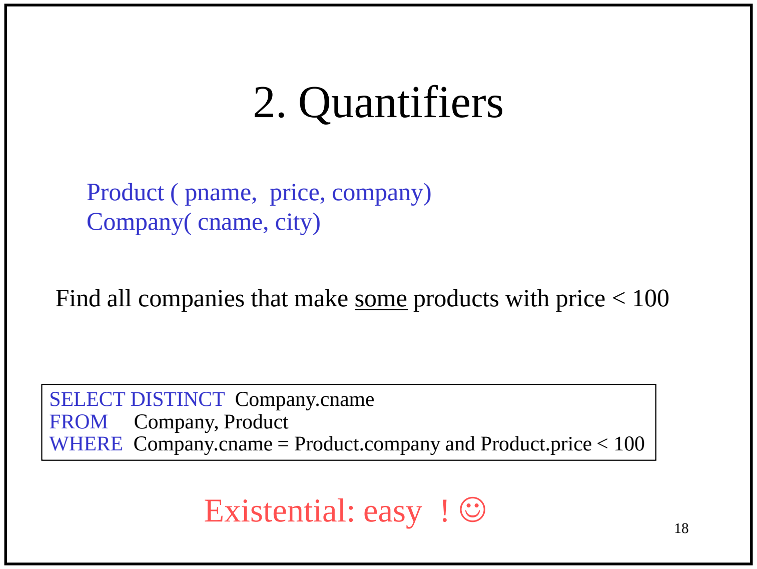
If R, S have no duplicates, then can write without subqueries (HOW ?)

```
(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)
```

```
(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)
```



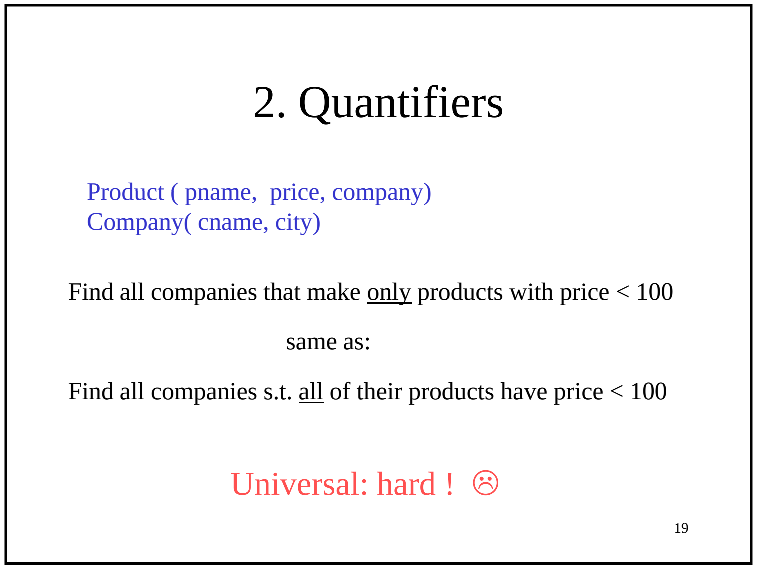
2. Quantifiers

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

Find all companies that make <u>some</u> products with price < 100

```
SELECT DISTINCT  Company.cname
FROM     Company, Product
WHERE  Company.cname = Product.company and Product.price < 100
```

Existential: easy ! ☺



2. Quantifiers

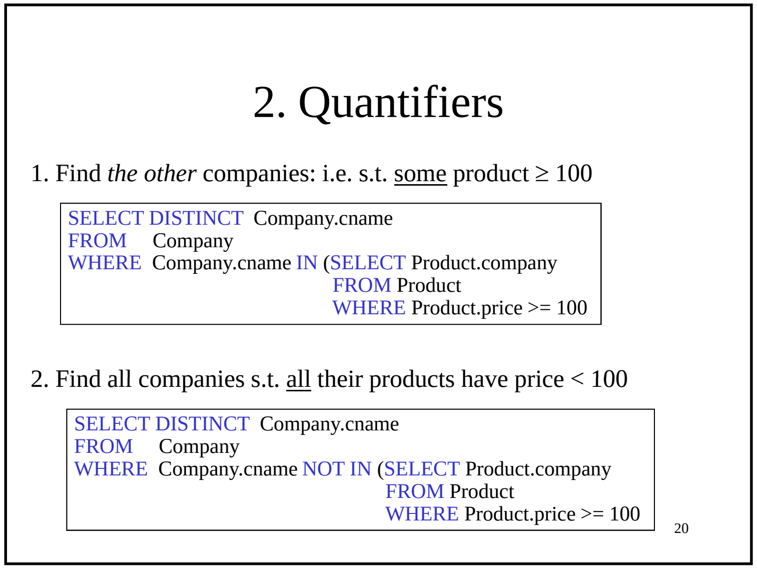
Product (pname, price, company)
Company(cname, city)

Find all companies that make <u>only</u> products with price < 100

same as:

Find all companies s.t. <u>all</u> of their products have price < 100

Universal: hard ! ☹



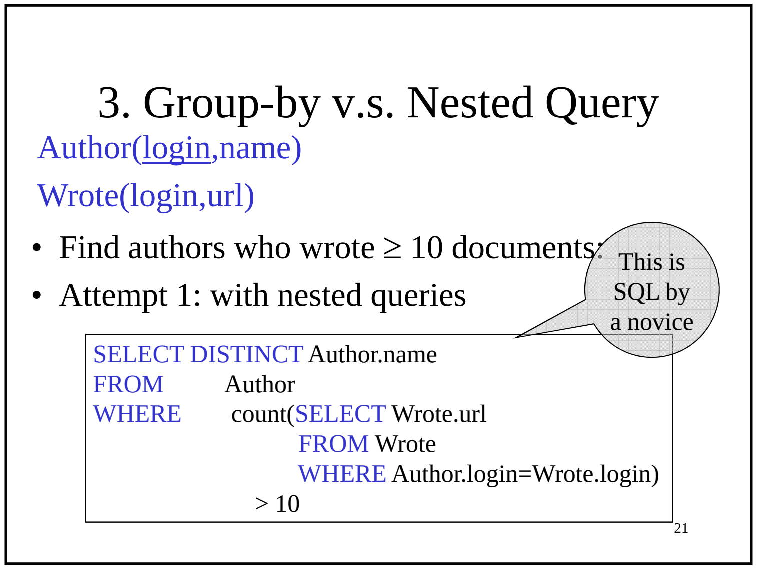
2. Quantifiers

1. Find *the other* companies: i.e. s.t. <u>some</u> product ≥ 100

```
SELECT DISTINCT  Company.cname
FROM    Company
WHERE  Company.cname IN (SELECT Product.company
                                    FROM Product
                                    WHERE Product.price >= 100
```

2. Find all companies s.t. <u>all</u> their products have price < 100

```
SELECT DISTINCT  Company.cname
FROM     Company
WHERE  Company.cname NOT IN (SELECT Product.company
                                         FROM Product
                                         WHERE Product.price >= 100
```



3. Group-by v.s. Nested Query

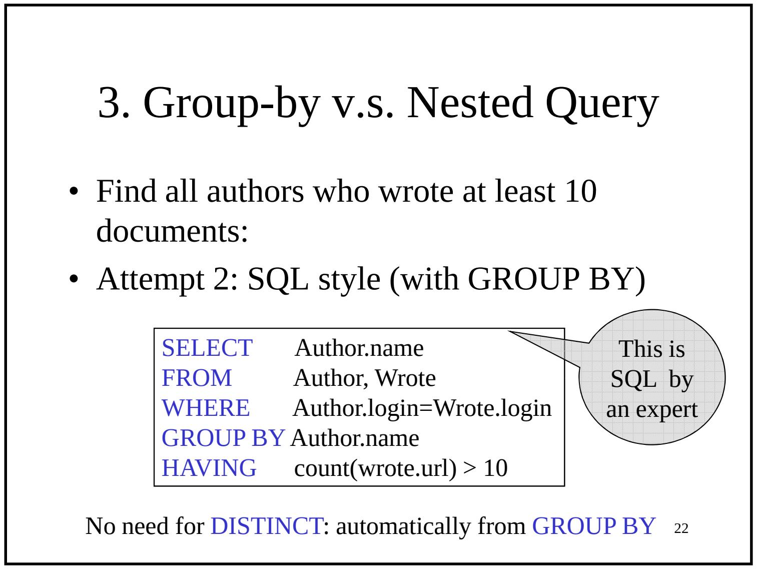
Author(login,name)

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
```



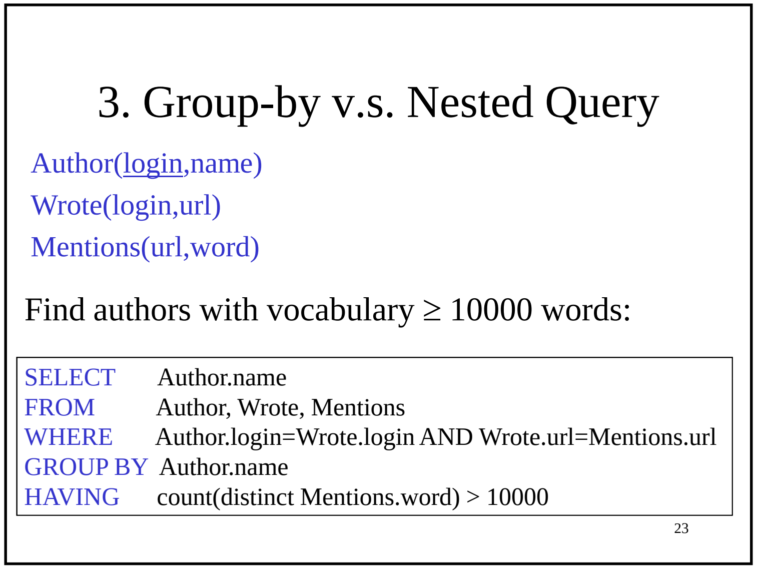
3. Group-by v.s. Nested Query

- 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

No need for DISTINCT: automatically from GROUP BY



3. Group-by v.s. Nested Query

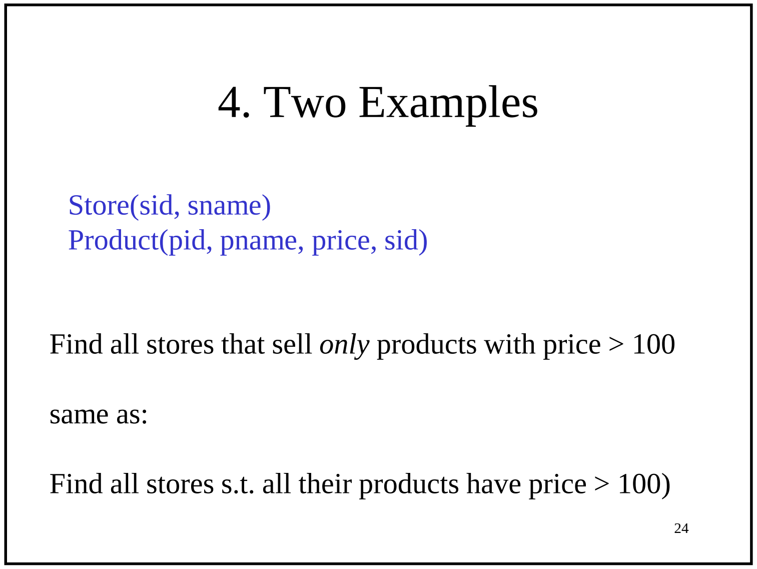
Author(login,name)

Wrote(login,url)

Mentions(url,word)

Find authors with vocabulary ≥ 10000 words:

```
SELECT      Author.name
FROM        Author, Wrote, Mentions
WHERE       Author.login=Wrote.login AND Wrote.url=Mentions.url
GROUP BY  Author.name
HAVING      count(distinct Mentions.word) > 10000
```



4. Two Examples

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

Find all stores that sell *only* products with price > 100

same as:

Find all stores s.t. all their products have price > 100)

```
SELECT Store.name
FROM    Store, Product
WHERE  Store.sid = Product.sid
GROUP BY  Store.sid, Store.name
HAVING 100 < min(Product.price)
```

Why both ?

Almost equivalent…

```
SELECT Store.name
FROM    Store
WHERE
   100 < ALL (SELECT Product.price
                   FROM product
                   WHERE Store.sid = Product.sid)
```

```
SELECT Store.name
FROM    Store
WHERE  Store.sid NOT IN
              (SELECT Product.sid
               FROM Product
               WHERE  Product.price <= 100)
```

Two Examples

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

For each store,
find its most expensive product

Two Examples

This is easy but doesn't do what we want:

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

Better:

```
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)
```

But may return multiple product names per store

Two Examples

Finally, choose some pid arbitrarily, if there are many with highest price:

```
SELECT Store.sname, max(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)
GROUP BY Store.sname
```