

# Introduction to Data Management

## CSE 344

### Lecture 6: Nested Queries in SQL

# Announcements

- Webquiz 2 is due on Sunday
- Homework 2 is due on Tuesday

# Lecture Goals

- Today we will learn how to write (even) more powerful SQL queries
- Reading: Ch. 6.3

# Subqueries

- A subquery is a SQL query nested inside a larger query
- Such inner-outer queries are called nested queries
- A subquery may occur in:
  - A SELECT clause
  - A FROM clause
  - A WHERE clause
- Rule of thumb: avoid writing nested queries when possible; keep in mind that sometimes it's impossible

# Subqueries...

- Can return a single constant and this constant can be compared with another value in a WHERE clause
- Can return relations that can be used in various ways in WHERE clauses
- Can appear in FROM clauses, followed by a tuple variable that represents the tuples in the result of the subquery
- Can appear as computed values in a SELECT clause

# 1. Subqueries in SELECT

Product (pname, price, cid)

Company(cid, cname, city)

For each product return the city where it is manufactured

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SELECT X.pname, (SELECT Y.city
                  FROM Company Y
                  WHERE Y.cid=X.cid) as City
FROM Product X
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What happens if the subquery returns more than one city ?

We get a runtime error

(SQLite simply ignores the extra values)



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Product (pname, price, cid)

Company(cid, cname, city)

# 1. Subqueries in SELECT

Whenever possible, don't use a nested queries:

```
SELECT X.pname, (SELECT Y.city  
                  FROM Company Y  
                  WHERE Y.cid=X.cid) as City  
FROM Product X
```

||

```
SELECT X.pname, Y.city  
FROM Product X, Company Y  
WHERE X.cid=Y.cid
```

Product (pname, price, cid)

Company(cid, cname, city)

# 1. Subqueries in SELECT

Whenever possible, don't use a nested queries:

```
SELECT X.pname, (SELECT Y.city  
                  FROM Company Y  
                  WHERE Y.cid=X.cid) as City  
FROM Product X
```

||

```
SELECT X.pname, Y.city  
FROM Product X, Company Y  
WHERE X.cid=Y.cid
```

We have  
“unnested”  
the query

Product (pname, price, cid)

Company(cid, cname, city)

# 1. Subqueries in SELECT

Compute the number of products made by each company

```
SELECT DISTINCT C.cname, (SELECT count(*)  
                           FROM Product P  
                           WHERE P.cid=C.cid)  
FROM Company C
```

Product (pname, price, cid)

Company(cid, cname, city)

# 1. Subqueries in SELECT

Compute the number of products made by each company

```
SELECT DISTINCT C.cname, (SELECT count(*)  
                           FROM Product P  
                           WHERE P.cid=C.cid)  
FROM Company C
```

Better: we can  
unnest by using  
a GROUP BY

```
SELECT C.cname, count(*)  
FROM Company C, Product P  
WHERE C.cid=P.cid  
GROUP BY C.cname
```

Product (pname, price, cid)

Company(cid, cname, city)

# 1. Subqueries in SELECT

But are these really equivalent?

```
SELECT DISTINCT C.cname, (SELECT count(*)  
                           FROM Product P  
                           WHERE P.cid=C.cid)  
FROM Company C
```

```
SELECT C.cname, count(*)  
FROM Company C, Product P  
WHERE C.cid=P.cid  
GROUP BY C.cname
```

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

# 1. Subqueries in SELECT

But are these really equivalent?

```
SELECT DISTINCT C.cname, (SELECT count(*)  
                           FROM Product P  
                           WHERE P.cid=C.cid)  
FROM Company C
```

```
SELECT C.cname, count(*)  
FROM Company C, Product P  
WHERE C.cid=P.cid  
GROUP BY C.cname
```

No! Different results if a company has no products

```
SELECT C.cname, count(pname)  
FROM Company C LEFT OUTER JOIN Product P  
ON C.cid=P.cid  
GROUP BY C.cname
```



Product (pname, price, cid)

Company(cid, cname, city)

## 2. Subqueries in FROM

Find all products whose prices is  $> 20$  and  $< 500$

```
SELECT X.pname
FROM (SELECT * FROM Product AS Y WHERE price > 20) as X
WHERE X.price < 500
```

Unnest this query !

## 2. Subqueries in FROM

At the end of the lecture we will see that sometimes we really need a subquery and one option will be to put it in the FROM clause.

Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies that make some products with price < 200

Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies that make some products with price < 200

Existential quantifiers

Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies that make some products with price < 200

Existential quantifiers

Using **EXISTS**:

```
SELECT DISTINCT C.cname
FROM   Company C
WHERE  EXISTS (SELECT *
                FROM Product P
                WHERE C.cid = P.cid and P.price < 200)
```

Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies that make some products with price < 200

Existential quantifiers

Using **IN**

```
SELECT DISTINCT C.cname
FROM   Company C
WHERE  C.cid IN (SELECT P.cid
                  FROM   Product P
                  WHERE  P.price < 200)
```

Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies that make some products with price < 200

Existential quantifiers

Using **ANY**:

```
SELECT DISTINCT C.cname
FROM   Company C
WHERE  200 > ANY (SELECT price
                  FROM   Product P
                  WHERE  P.cid = C.cid)
```

Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies that make some products with price < 200

Existential quantifiers

Using **ANY**:

```
SELECT DISTINCT C.cname
FROM   Company C
WHERE  200 > ANY (SELECT price
                  FROM   Product P
                  WHERE  P.cid = C.cid)
```

Not supported  
in sqlite



Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies that make some products with price < 200

Existential quantifiers

Now let's unnest it:

```
SELECT DISTINCT C.cname  
FROM   Company C, Product P  
WHERE  C.cid= P.cid and P.price < 200
```

Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies that make some products with price < 200

Existential quantifiers

Now let's unnest it:

```
SELECT DISTINCT C.cname
FROM   Company C, Product P
WHERE  C.cid= P.cid and P.price < 200
```

Existential quantifiers are easy ! 😊

Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies s.t. all their products have price < 200

same as:

Find all companies that make only products with price < 200

Product (pname, price, cid)

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Universal quantifiers

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Universal quantifiers

Universal quantifiers are hard ! ☹️

Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies s.t. all their products have price < 200

1. Find *the other* companies: i.e. s.t. some product  $\geq 200$

```
SELECT DISTINCT C.cname
FROM   Company C
WHERE  C.cid IN (SELECT P.cid
                  FROM   Product P
                  WHERE  P.price >= 200)
```

Product (pname, price, cid)

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### 3. Subqueries in WHERE

Find all companies s.t. all their products have price < 200

1. Find *the other* companies: i.e. s.t. some product  $\geq 200$

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SELECT DISTINCT C.cname
FROM   Company C
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```

2. Find all companies s.t. all their products have price < 200

```
SELECT DISTINCT C.cname
FROM   Company C
WHERE  C.cid NOT IN (SELECT P.cid
                     FROM   Product P
                     WHERE  P.price >= 200)
```

Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies s.t. all their products have price < 200

Universal quantifiers

Using **EXISTS**:

```
SELECT DISTINCT C.cname
FROM   Company C
WHERE  NOT EXISTS (SELECT *
                   FROM Product P
                   WHERE P.cid = C.cid and P.price >= 200)
```



Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies s.t. all their products have price < 200

Universal quantifiers

Using **ALL**:

```
SELECT DISTINCT C.cname
FROM   Company C
WHERE  200 >= ALL (SELECT price
                   FROM Product P
                   WHERE P.cid = C.cid)
```

Product (pname, price, cid)

Company(cid, cname, city)

### 3. Subqueries in WHERE

Find all companies s.t. all their products have price < 200

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Using **ALL**:

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SELECT DISTINCT C.cname
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Not supported  
in sqlite

# Question for Database Fans and their Friends

- Can we unnest the *universal quantifier* query ?

Product (pname, price, cid)

Company(cid, cname, city)

# Monotone Queries

- Definition A query Q is **monotone** if:
    - Whenever we add tuples to one or more input tables, the answer to the query will not lose any of the tuples
-

Product (pname, price, cid)

Company(cid, cname, city)

# Monotone Queries

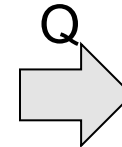
- Definition A query Q is **monotone** if:
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Product

pname	price	cid
Gizmo	19.99	c001
Gadget	999.99	c004
Camera	149.99	c003

Company

cid	cname	city
c002	Sunworks	Bonn
c001	DB Inc.	Lyon
c003	Builder	Lodz



A	B
Gizmo	Lyon
Camera	Lodz

Product (pname, price, cid)

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# Monotone Queries

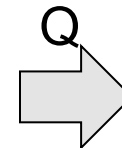
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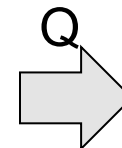
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pname	price	cid
Gizmo	19.99	c001
Gadget	999.99	c004
Camera	149.99	c003
iPad	499.99	c001

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cid	cname	city
c002	Sunworks	Bonn
c001	DB Inc.	Lyon
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# Monotone Queries

- Theorem: If Q is a SELECT-FROM-WHERE query that does not have subqueries, and no aggregates, then it is monotone.

# Monotone Queries

- Theorem: If Q is a SELECT-FROM-WHERE query that does not have subqueries, and no aggregates, then it is monotone.
- Proof. We use the nested loop semantics: if we insert a tuple in a relation  $R_i$ , this will not remove any tuples from the answer

```
SELECT a1, a2, ..., ak  
FROM R1 AS x1, R2 AS x2, ..., Rn AS xn  
WHERE Conditions
```

```
for x1 in R1 do  
  for x2 in R2 do  
    .....  
      for xn in Rn do  
        if Conditions  
          output (a1, ..., ak)
```



Product (pname, price, cid)

Company(cid, cname, city)

# Monotone Queries

- The query:

Find all companies s.t. all their products have price < 200  
is not monotone

Product (pname, price, cid)

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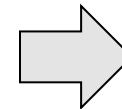
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cid	cname	city
c001	Sunworks	Bonn



cname
Sunworks

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# Monotone Queries

- The query:

Find all companies s.t. all their products have price  $< 200$   
is not monotone

pname	price	cid	cid	cname	city	cname
Gizmo	19.99	c001	c001	Sunworks	Bonn	Sunworks

pname	price	cid	cid	cname	city	cname
Gizmo	19.99	c001	c001	Sunworks	Bonn	
Gadget	999.99	c001				

- Consequence: we cannot write it as a SELECT-FROM-WHERE query without nested subqueries

# Queries that must be nested

- Queries with universal quantifiers or with negation

# Queries that must be nested

- Queries with universal quantifiers or with negation
- Queries that use aggregates in certain ways
  - Note: `sum(..)` and `count(*)` are NOT monotone, because they do not satisfy set containment
  - **`select count(*) from R`** is not monotone!