Database Systems
CSE 414

Lecture 6: Nested Queries in SQL
Announcements

• WQ2 is due on Sunday 11pm
  – no late days

• HW2 is due on Tuesday 11pm
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 nested queries when possible; keep in mind that sometimes it’s impossible
  – (though use in FROM is often not as bad)
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

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

What happens if the subquery returns more than one city?
We get a runtime error

• (SQLite simply ignores the extra values)
1. Subqueries in SELECT

Product \((\text{pname, price, cid})\)
Company \((\text{cid, cname, city})\)

For each product return the city where it is manufactured

\[
\text{SELECT } X.\text{pname}, (\text{SELECT } Y.\text{city} \text{ FROM Company } Y \text{ WHERE } Y.\text{cid}=X.\text{cid}) \text{ as City} \\
\text{FROM } \text{Product } X
\]

What happens if the subquery returns more than one city?
We get a runtime error
• (SQLite simply ignores the extra values)
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
```

We have “unnested” the query

```
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

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
```
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
2. Subqueries in FROM

Find all products whose prices is > 20 and < 500

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

Unnest this query!

```sql
SELECT pname
FROM Product
WHERE price > 20 AND price < 500
```
2. Subqueries in FROM

- We will see that sometimes we really need a subquery
  - will see most compelling examples next lecture
  - in that case, we can 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 < 100

Using EXISTS:

```
SELECT DISTINCT C.cname  
FROM Company C  
WHERE EXISTS (SELECT *  
              FROM Product P  
              WHERE C.cid = P.cid and P.price < 100)
```
3. Subqueries in WHERE

Find all companies that make some products with price < 100

Using **IN**

```
SELECT DISTINCT C.cname
FROM Company C
WHERE C.cid IN (SELECT P.cid
    FROM Product P
    WHERE P.price < 100)
```
3. Subqueries in WHERE

Find all companies that make **some** products with price < 100

Using **ANY**:

```
SELECT DISTINCT C.cname
FROM Company C
WHERE 100 > ANY (SELECT price
    FROM Product P
    WHERE P.cid = C.cid)
```

Existential quantifiers

Not supported in sqlite
3. Subqueries in WHERE

Find all companies that make some products with price < 100

```sql
SELECT DISTINCT C.cname
FROM Company C, Product P
WHERE C.cid = P.cid and P.price < 100
```

Existential quantifiers are easy!
3. Subqueries in WHERE

Find all companies where all their products have price < 100

same as:

Find all companies that make only products with price < 100

Universal quantifiers are hard!
3. Subqueries in WHERE

Find all companies where all their products have price < 100

1. Find the other companies: i.e. with some product >= 100

```sql
SELECT DISTINCT C.cname
FROM Company C
WHERE C.cid IN (SELECT P.cid
FROM Product P
WHERE P.price >= 100)
```

2. Find all companies where all their products have price < 100

```sql
SELECT DISTINCT C.cname
FROM Company C
WHERE C.cid NOT IN (SELECT P.cid
FROM Product P
WHERE P.price >= 100)
```
3. Subqueries in WHERE

Find all companies where all their products have price < 100

Using EXISTS:

```
SELECT DISTINCT C.cname
FROM Company C
WHERE NOT EXISTS (SELECT * 
    FROM Product P 
    WHERE P.cid = C.cid and P.price >= 100)
```
3. Subqueries in WHERE

Find all companies where all their products have price < 100

Using **ALL**:

```
SELECT DISTINCT C.cname
FROM Company C
WHERE 100 >= ALL (SELECT price
                    FROM Product P
                    WHERE P.cid = C.cid)
```

Not supported in sqlite
Question for Database Fans and their Friends

• Can we unnest the *universal quantifier* query?
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
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.

```sql
SELECT a_1, a_2, ..., a_k
FROM   R_1 AS x_1, R_2 AS x_2, ..., R_n AS x_n
WHERE  Conditions

for x_1 in R_1 do
    for x_2 in R_2 do
        ....
        for x_n in R_n do
            if Conditions
                output (a_1, ..., a_k)
```
Monotone Queries

- The query:

Find all companies where all their products have price < 100

is not monotone

Consequence: we cannot write it as a SELECT-FROM-WHERE query without nested subqueries
Queries that must be nested
(that is, cannot be SFW queries)

• Queries with universal quantifiers or negation

• Queries that use aggregates in certain ways
  – Note: sum(..) etc. are NOT monotone
  – select count(*) from R is not monotone!