Module 12

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Objectives & Outline

Nested Subqueries

Subqueries in the Where Clause

Subqueries in the From Clause

Subqueries in the Select Clause

Modifications of the Database

Module Summary

Database Management Systems

Module 12: Intermediate SQL/1

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Module Recap

- SQL Examples Practiced

Module Objectives

- To understand nested subquery in SQL
- To understand processes for data modification

Module Outline

- Nested Subqueries
- Modifications of the Database

Nested Subqueries

Nested Subqueries

Nested Subqueries

- SQL provides a mechanism for the nesting of subqueries
- A **subquery** is a **select-from-where** expression that is nested within another query
- The nesting can be done in the following SQL query

  select $A_1, A_2, \ldots, A_n$
  from $r_1, r_2, \ldots, r_m$
  where P

  as follows:
  - A_i can be replaced by a subquery that generates a single value
  - r_i can be replaced by any valid subquery
  - P can be replaced with an expression of the form:

    B <operation> (subquery)

    where B is an attribute and <operation> to be defined later

Subqueries in the Where Clause

Subqueries in the Where Clause

- Typical use of subqueries is to perform tests:
  - For set membership
  - For set comparisons
  - For set cardinality

Set Membership

- Find courses offered in Fall 2009 and in Spring 2010. (**intersect** example)

```
select distinct course_id
from section
where semester =’Fall’ and year = 2009 and
        course_id in (select course_id
                      from section
                      where semester =’Spring’ and year = 2010);
```

- Find courses offered in Fall 2009 but not in Spring 2010. (**except** example)

```
select distinct course_id
from section
where semester =’Fall’ and year = 2009 and
        course_id not in (select  course_id
                          from section
                          where semester =’Spring’ and year = 2010);
```

Set Membership (2)

- Find the total number of (distinct) students who have taken course sections taught by the instructor with ID 10101

```
select count (distinct ID)
from takes
where (course_id, sec_id, semester, year) in
                              (select course_id, sec_id, semester, year
                              from teaches
                              where teaches.ID = 10101);
```

- Note: Above query can be written in simpler manner. The formulation above is simply to illustrate SQL features.

Set Comparison – “some” Clause

- Find names of instructors with salary greater than that of some (at least one) instructor in the Biology department

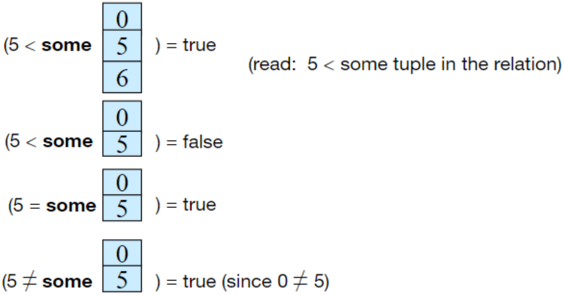
```
select distinct T.name
from instructor as T, instructor as S
where T.salary > S.salary and S.dept name = 'Biology';
```

- Same query using **some** clause

```
select name
from instructor
where salary > some (select salary
                     from instructor
                     where dept_name = 'Biology');
```

Definition of "some" Clause

- F <comp> **some** $r \Leftrightarrow \exists t \in r$ such that (F <comp> t)
  where <comp> can be: $<, \leq, >, \geq, =, \neq$
- **some** represents existential quantification



(5 < **some** $\begin{array}{|c|}\hline 0\\\hline 5\\\hline 6\\\hline\end{array}$) = true   (read: 5 < some tuple in the relation)

(5 < **some** $\begin{array}{|c|}\hline 0\\\hline 5\\\hline\end{array}$) = false

(5 = **some** $\begin{array}{|c|}\hline 0\\\hline 5\\\hline\end{array}$) = true

(5 ≠ **some** $\begin{array}{|c|}\hline 0\\\hline 5\\\hline\end{array}$) = true (since 0 ≠ 5)

(= **some**) ≡ **in**
However, (≠ **some**) ≢ **not in**

Set Comparison – “all” Clause

- Find the names of all instructors whose salary is greater than the salary of all instructors in the Biology department

```
select name
from instructor
where salary > all (select salary
                    from instructor
                    where dept_name = 'Biology');
```

Definition of “all” Clause

- F <comp> **all** $r \Leftrightarrow \forall t \in r$ such that (F <comp> t)
  Where <comp> can be: $<, \leq, >, \geq, =, \neq$
- **all** represents universal quantification

$$(5 < \textbf{all} \begin{array}{|c|}\hline 0 \\ \hline 5 \\ \hline 6 \\ \hline \end{array}) = \text{false}$$

$$(5 < \textbf{all} \begin{array}{|c|}\hline 6 \\ \hline 10 \\ \hline \end{array}) = \text{true}$$

$$(5 = \textbf{all} \begin{array}{|c|}\hline 4 \\ \hline 5 \\ \hline \end{array}) = \text{false}$$

$$(5 \neq \textbf{all} \begin{array}{|c|}\hline 4 \\ \hline 6 \\ \hline \end{array}) = \text{true (since } 5 \neq 4 \text{ and } 5 \neq 6)$$

($\neq$ **all**) $\equiv$ **not in**
However, (= **all**) $\not\equiv$ **in**

Test for Empty Relations: “exists”

- The **exists** construct returns the value **true** if the argument subquery is nonempty
  - **exists** $r \Leftrightarrow r \neq \emptyset$
  - **not exists** $r \Leftrightarrow r = \emptyset$

Use of “exists” Clause

- Yet another way of specifying the query “Find all courses taught in both the Fall 2009 semester and in the Spring 2010 semester”

```
select course_id
from section as S
where semester = 'Fall' and year = 2009 and
          exists (select *
                    from section as T
                    where semester = 'Spring' and year = 2010
                    and S.course_id = T.course_id);
```

- **Correlation name** – variable S in the outer query
- **Correlated subquery** – the inner query

Use of “not exists” Clause

- Find all students who have taken all courses offered in the Biology department.

```
select distinct S.ID, S.name
from student as S
where not exists ( (select course_id
                    from course
                    where dept_name = 'Biology')
                    except
                    (select T.course_id
                        from takes as T
                        where S.ID = T.ID));
```

  - First nested query lists all courses offered in Biology
  - Second nested query lists all courses a particular student took
- Note: $X - Y = \emptyset \Leftrightarrow X \subseteq Y$
- Note: Cannot write this query using $=$ **all** and its variants

Test for Absence of Duplicate Tuples: “unique”

- The **unique** construct tests whether a subquery has any duplicate tuples in its result
- The **unique** construct evaluates to “true” if a given subquery contains no duplicates
- Find all courses that were offered at most once in 2009

```
select  T.course_id
from course as T
where unique (select R.course_id
              from section as R
              where T.course_id = R.course_id
              and R.year = 2009);
```

Subqueries in the From Clause

Subqueries in the From Clause

- SQL allows a subquery expression to be used in the **from** clause
- Find the average instructors' salaries of those departments where the average salary is greater than $42,000

```
select dept_name, avg_salary
from (select dept_name, avg(salary) as avg_salary
        from instructor
        group by dept_name)
where avg_salary > 42000;
```

- Note that we do not need to use the **having** clause
- Another way to write above query

```
select dept_name, avg_salary
from (select dept_name, avg (salary)
        from instructor
        group by dept_name) as  dept_avg (dept_name, avg_salary)
where avg_salary > 42000;
```

With Clause

- The **with** clause provides a way of defining a temporary relation whose definition is available only to the query in which the **with** clause occurs
- Find all departments with the maximum budget

```
with max_budget(value) as
        (select max(budget)
         from department)
select department.name
from department, max_budget
where department.budget=max_budget.value;
```

Complex Queries using With Clause

- Find all departments where the total salary is greater than the average of the total salary at all departments

```
with dept_total (dept_name, value) as
        select dept_name, sum(salary)
        from instructor
        group by dept_name,
    dept_total_avg(value) as
        (select avg(value)
        from dept_total)
select dept_name
from dept_total, dept_total_avg
where dept_total.value > dept_total_avg.value;
```

Subqueries in the Select Clause

Scalar Subquery

- Scalar subquery is one which is used where a single value is expected
- List all departments along with the number of instructors in each department

```
select dept_name,
        (select count(*)
        from instructor
        where department.dept_name = instructor.dept_name)
        as num_instructors
        from department;
```

- Runtime error if subquery returns more than one result tuple

Modifications of the Database

Modifications of the Database

Modification of the Database

- Deletion of tuples from a given relation
- Insertion of new tuples into a given relation
- Updating of values in some tuples in a given relation

Deletion

- Delete all instructors

  delete from *instructor*

- Delete all instructors from the Finance department

  delete from *instructor*
  where *dept_name*= 'Finance';

- Delete all tuples in the *instructor* relation for those instructors associated with a department located in the Watson building

  delete from *instructor*
  where *dept_name* **in** (**select** *dept_name*
  from *department*
  where *building* = 'Watson');

Deletion (2)

- Delete all instructors whose salary is less than the average salary of instructors

```
delete from instructor
where salary < (select avg (salary)
                from instructor);
```

- Problem: as we delete tuples from deposit, the average salary changes
- Solution used in SQL:
  a) First, compute **avg** (salary) and find all tuples to delete
  b) Next, delete all tuples found above (without recomputing **avg** or retesting the tuples)

Insertion

- Add a new tuple to course

  insert into *course*
  values ('CS-437', 'Database Systems', 'Comp. Sci.', 4);

- or equivalently:

  insert into *course (course_id, title, dept_name, credits)*
  values ('CS-437', 'Database Systems', 'Comp. Sci.', 4);

- Add a new tuple to student with *tot_creds* set to null

  insert into *student*
  values ('3003', 'Green', 'Finance', *null*);

Insertion (2)

- Add all instructors to the *student* relation with *tot_creds* set to 0

  insert into *student*
  select *ID*, *name*, *dept_name*, 0
  from *instructor*

- The **select from where** statement is evaluated fully before any of its results are inserted into the relation
- Otherwise queries like

  insert into *table1* **select * from** *table1*

  would cause problem

Updates

- Increase salaries of instructors whose salary is over $100,000 by 3%, and all others by a 5%
  - Write two **update** statements:

```
update instructor
        set salary = salary * 1.03
        where salary > 100000;
update instructor
        set salary = salary * 1.05
        where salary <= 100000;
```

- The order is important
- Can be done better using the **case** statement (next slide)

Case Statement for Conditional Updates

- Same query as before but with **case** statement

```
update instructor
set salary = case
                 when salary <= 100000
                 then salary * 1.05
                 else salary * 1.03
                 end
```

Updates with Scalar Subqueries

- Recompute and update tot_creds value for all students

```
update student S
set tot_creds = (select sum(credits)
                 from takes, course
                 where takes.course_id = course.course_id and
                 S.ID = takes.ID and
                 takes.grade <> 'F' and
                 takes.grade is not null);
```

- Sets *tot_creds* to null for students who have not taken any course
- Instead of **sum**(*credits*), use:

```
    case
    when sum(credits) is not null then sum(credits)
    else 0
end
```

Module Summary

- Introduced nested subquery in SQL
- Introduced data modification

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