SQL Queries and Subqueries

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September 04, 2008

Basic SQL Query

SELECT [DISTINCT] target-list
FROM relation-list
WHERE qualification;

- Relation-list: A list of relation names (possibly with range-variable after each name).
- Target-list: A list of attributes of relations in relation-list
- Qualification: conditions on attributes
- DISTINCT: optional keyword for duplicate removal.
  - Default = no duplicate removal!

SQL Comparison Operators

Comparison Operator	Meaning
=	Equal to
<	Less than
>	Greater than
<=	Less than or equal to
>=	Greater than or equal to
< >	Not equal to (used by most implementations of SQL)
!=	Not equal to (used by some implementations of SQL)

How to evaluate a query?

SELECT [DISTINCT] target-list
FROM relation-list
WHERE qualification;

- Conceptual query evaluation using relational operators:
  1) Compute the cross-product of relation-list.
  2) Discard resulting tuples if they fail qualifications.
  3) Delete attributes that are not in target-list. (called column-list)
  4) If DISTINCT is specified, eliminate duplicate rows.

SELECT S.sname
FROM ***Sailors S, Reserves R***
WHERE S.sid=R.sid AND R.bid=103;

Example of Conceptual Evaluation (1)

SELECT S.sname
FROM Sailors S, Reserves R
WHERE S.sid=R.sid AND R.bid=103;

(1) Compute the cross-product of relation-list.

Sailors

sid	*sname*	*rating*	*age*
22	*dustin*	*7*	*45.0*
31	*lubber*	*8*	*55.5*
58	*rusty*	*10*	*35.0*

x

Reserves

sid	*bid*	*day*
22	*101*	*10/10/96*
58	*103*	*11/12/96*

Example of Conceptual Evaluation (2)

SELECT S.sname
FROM Sailors S, Reserves R
WHERE S.sid=R.sid AND R.bid=103;

(2) Discard tuples if they fail qualifications.

Sailors X Reserves

S.sid	*sname*	*rating*	*age*	*R.sid*	*bid*	*day*
22	*dustin*	*7*	*45.0*	*22*	*101*	*10/10/96*
22	*dustin*	*7*	*45.0*	*58*	*103*	*11/12/96*
31	*lubber*	*8*	*55.5*	*22*	*101*	*10/10/96*
31	*lubber*	*8*	*55.5*	*58*	*103*	*11/12/96*
58	*rusty*	*10*	*35.0*	*22*	*101*	*10/10/96*
58	*rusty*	*10*	*35.0*	*58*	*103*	*11/12/96*

Example of Conceptual Evaluation (3)

SELECT S.sname
FROM Sailors S, Reserves R
WHERE S.sid=R.sid AND R.bid=103;

(3) Delete attribute columns that are not in target-list.

sname
rusty

Sailors X Reserves

(sid)	*sname*	*rating*	*age*	*(sid)*	*bid*	*day*
22	*dustin*	*7*	*45.0*	*22*	*101*	*10/10/96*
22	*dustin*	*7*	*45.0*	*58*	*103*	*11/12/96*
31	*lubber*	*8*	*55.5*	*22*	*101*	*10/10/96*
31	*lubber*	*8*	*55.5*	*58*	*103*	*11/12/96*
58	*rusty*	*10*	*35.0*	*22*	*101*	*10/10/96*
58	*rusty*	*10*	*35.0*	*58*	*103*	*11/12/96*

Renaming / Aliasing

Consider the following SALESREPS relation

Empl_num	name	age	Rep_office	manager
105	Bill	37	13	104
104	Bob	33	12	106
106	Sam	52	11	NULL

How do we determine the name of Bob's manager?

Aliasing

```
SELECT s2.name
FROM SALESREPS s1, SALESREPS s2
WHERE s1.name='Bob' AND
                s1.manager=s2.empl_num;
```

- Aliases must be used here.
- The row referenced by s1 is intended to be Bob…
- …while s2 will be his manager's.
- Remember, first FROM, then WHERE, then SELECT

Relational Design Example

- Students (PID: *string*, Name: *string*, Address: *string*)
- Professors (PID: *string*, Name: *string*, Office: *string*, Age: *integer*, DepartmentName: *string*)
- Courses (Number: integer, DeptName: *string*, CourseName: *string*, Classroom: *string*, Enrollment: *integer*)
- Teach (ProfessorPID: *string*, Number: *integer*, DeptName: *string*)
- Take (StudentPID: *string*, Number: *integer*, DeptName: *string*, Grade: *string*, ProfessorEvaluation: integer)
- Departments (Name: *string*, ChairmanPID: *string*)
- PreReq (Number: *integer*, DeptName: *string*, PreReqNumber: *integer,* PreReqDeptName: *string*)

Motivation for Subqueries

- Find the name of the professor who teaches “CS 4604.”

```
SELECT Name
FROM Professors, Teach
WHERE (PID = ProfessorPID) AND (Number = ‘4604’)
      AND(DeptName = ‘CS’) ;
```

- Do we need to take the natural join of two big relations just to get a relation with one tuple?
- Can we rewrite the query without using a join?

Nesting

- A query can be put inside another query
- Most commonly in the WHERE clause
- Sometimes in the FROM clause (depending on the software)
- This subquery is executed first (if possible)

Subquery Example

- Find the name of the professor who teaches “CS 4604.”

```
SELECT Name
FROM Professors
WHERE PID =
        (SELECT ProfessorPID
        FROM Teach
        WHERE (Number = 4604) AND (DeptName = ’CS’)
        );
```

- When using =, the subquery must return a single tuple

Conditions Involving Relations

- SQL includes a number of operators that apply to a relation and produce a boolean result.
- These operators are very useful to apply on results of sub-queries.
- Let R be a relation and t be a tuple with the same set of attributes.
  - EXISTS R is true if and only if R contains at least one tuple.
  - t IN R is true if and only if t equals a tuple in R.
  - t > ALL R is true if and only if R is unary (has one attribute) and t is greater than every value in R.
    - Can use any of the other five comparison operators.
    - If we use <>, R need not be unary.
  - t > ANY R (which is unary) is true if and only if t is greater than at least one value in R.
- We can use NOT to negate EXISTS, ALL, and ANY.

Subqueries Using Conditions

- Find the departments of the courses taken by the student with name ‘Suri’.

```
SELECT DeptName
FROM Take
WHERE StudentPID IN
                    ( SELECT PID
                      FROM Students
                      WHERE (Name = ‘Suri’)
                    );
```

Correlated vs Uncorrelated

- The previous subqueries did not depend on anything outside the subquery
  - …and thus need to be executed just once.
  - These are called uncorrelated.
- A correlated subquery depends on data from the outer query
  - … and thus has to be executed for each row of the outer table(s)

Correlated Subqueries

- Find course names that have been used for two or more courses.

```
SELECT CourseName
FROM Courses AS First
WHERE CourseName IN
                    (SELECT CourseName
                    FROM Courses
                    WHERE (Number <> First.Number)
                    AND (DeptName <> First.DeptName)
                    );
```

Evaluating Correlated Subqueries

```
SELECT CourseName
FROM Courses AS First
WHERE CourseName IN
                    (SELECT CourseName
                    FROM Courses
                    WHERE (Number <> First.Number)
                    AND (DeptName <> First.DeptName)
                    );
```

- Evaluate query by looping over tuples of First, and for each tuple evaluate the subquery.
- Scoping rules: an attribute in a subquery belongs to one of the tuple variables in that subquery's FROM clause, or to the immediately surrounding subquery, and so on.

Subqueries in FROM clauses

- Can use a subquery as a relation in a FROM clause.
- We must give such a relation an alias using the AS keyword.
- Let us find different ways of writing the query “Find the names of Professors who have taught the student whose first name is ’Suri’.”
- The old way:

```
SELECT Professors.Name
FROM Professors, Take, Teach, Students
WHERE (Professors.PID = Teach.ProfessorPID)
        AND (Teach.CourseNumber = Take.CourseNumber)
        AND (Teach.DeptName = Take.DeptName)
        AND (Take.StudentPID = Student.PID)
        AND (Student.Name = ’Suri %’);
```

- “Find the names of (Professors who have taught (courses taken by (student with first name ’Suri’))).”

```
 SELECT Name
FROM Professors
WHERE PID IN
            (SELECT ProfessorPID
              FROM Teach
              WHERE (Number, DeptName) IN
                                          ( SELECT Number, DeptName
                                            FROM TakeWHERE StudentPID IN
                                                                        (SELECT PID
                                                                         FROM Students
                                                                  WHERE Name = ’Suri %’)
                                          )
            );
```

Aggregate Operators

- *COUNT (*)*
- *COUNT ([DISTINCT] A)*
  - A is a column
- *SUM ([DISTINCT] A)*
- *AVG ([DISTINCT] A)*
- *MAX (A)*
- *MIN (A)*
- Count the number of sailors

```
SELECT COUNT (*)
FROM Sailors S
```

Find the average age of sailors with rating = 10

Sailors(sid: integer, sname: string, rating: integer, age: real)

SELECT AVG (S.age)
FROM Sailors S
WHERE S.rating=10

Count the number of different sailor names

Sailors(sid: integer, sname: string, rating: integer, age: real)

```
SELECT COUNT (DISTINCT S.sname)
FROM Sailors S
```

Find the age of the oldest sailor

Sailors(sid: integer, sname: string, rating: integer, age: real)

```
SELECT MAX(S.AGE)
FROM Sailors S
```

Find name and age of the oldest sailor(s)

SELECT S.sname, MAX (S.age)
FROM Sailors S

- This is illegal, but why?
  - Cannot combine a column with a value

SELECT S.sname, S.age
FROM Sailors S
WHERE S.age = (SELECT MAX (S2.age) FROM Sailors S2)

GROUP BY and *HAVING*

- So far, aggregate operators are applied to all (qualifying) tuples.
  - Can we apply them to each of several groups of tuples?
- Example: find the age of the youngest sailor for each rating level.
  - In general, we don't know how many rating levels exist, and what the rating values for these levels are!
  - Suppose we know that rating values go from 1 to 10; we can write 10 queries that look like this:

For $i = 1, 2, \ldots, 10$:

```
SELECT  MIN (S.age)
FROM  Sailors S
WHERE  S.rating = i
```

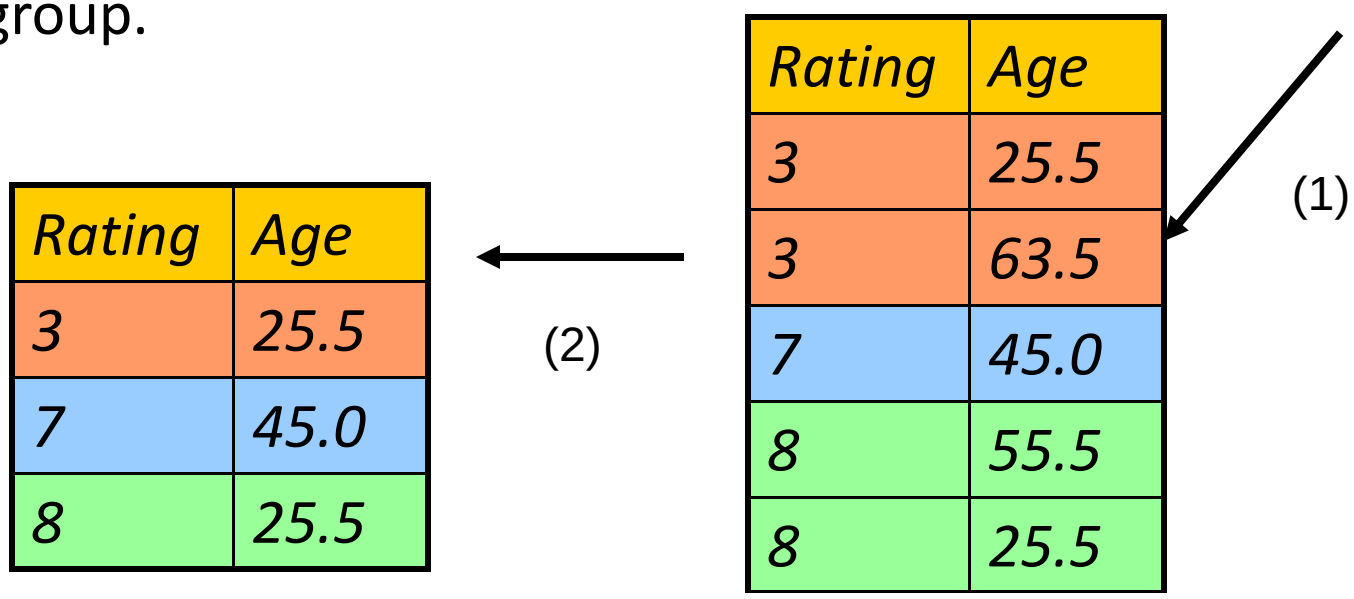
Find the age of the youngest sailor for each rating level

SELECT S.rating, MIN (S.age) as age
FROM Sailors S
GROUP BY S.rating

(1) The sailors tuples are put into "same rating" groups.

(2) Compute the Minimum age for each rating group.

Sid	*Sname*	*Rating*	*Age*
22	*Dustin*	*7*	*45.0*
31	*Lubber*	*8*	*55.5*
85	*Art*	*3*	*25.5*
32	*Andy*	*8*	*25.5*
95	*Bob*	*3*	*63.5*



Find the age of the youngest sailor for each rating level that has at least 2 members

```
SELECT S.rating, MIN (S.age) as
       minage
FROM Sailors S
GROUP BY S.rating
HAVING COUNT(*) > 1
```

Sid	Sname	Rating	Age
22	Dustin	7	45.0
31	Lubber	8	55.5
85	Art	3	25.5
32	Andy	8	25.5
95	Bob	3	63.5

1. The sailors tuples are put into "same rating" groups.
2. Eliminate groups that have < 2 members.
3. Compute the Minimum age for each rating group.

Rating	Minage
3	25.5
8	25.5

Rating	Age
3	25.5
3	63.5
7	45.0
8	55.5
8	25.5

Queries With *GROUP BY* and *HAVING*

SELECT [DISTINCT] target-list
FROM relation-list
WHERE qualification
GROUP BY grouping-list
HAVING group-qualification

SELECT S.rating, MIN (S.age) as age
FROM Sailors S
GROUP BY S.rating
HAVING S.rating > 5

- The *target-list* contains (i) attribute names (ii) terms with aggregate operations (e.g., AVG (*S.age*)).
- The attribute list (e.g., *S.rating*) in *target-list* must be in *grouping-list*.
- The attributes in group-qualification must be in *grouping-list*.

Starwars Exercises

char(name, race, homeworld, affiliation)

planets(name, type, affiliation)

timetable(cname, pname, movie, arrival, departure)

- Which planet does Princess Leia go to in movie3?

```
SELECT distinct pname
FROM timetable
WHERE cname ='Princess Leia' and movie=3;
```

Starwars Exercises

char(name, race, homeworld, affiliation)
planets(name, type, affiliation)
timetable(cname, pname, movie, arrival, departure)

- How many humans stay on Dagobah in movie 3?

```
SELECT count(*)
FROM timetable, characters
WHERE movie=3 and pname ='Dagobah' and
        timetable.cname=characters.name and
        characters.race='Human';
```

Starwars Exercises

char(name, race, homeworld, affiliation)
planets(name, type, affiliation)
timetable(cname, pname, movie, arrival, departure)

- Who has been to his/her homeworld in movie 2?

```
SELECT distinct c.name
FROM characters c, timetable t
WHERE c.name=t.cname and t.pname=c.homeworld and
        movie=2;
```

Starwars Exercises

char(name, race, homeworld, affiliation)
planets(name, type, affiliation)
timetable(cname, pname, movie, arrival, departure)

- Find distinct names of the planets visited by those of race "droid".

```
SELECT distinct t.pname
FROM char c, timetable t
WHERE c.name=t.cname and c.race='droid';
```

Starwars Exercises

char(name, race, homeworld, affiliation)
planets(name, type, affiliation)
timetable(cname, pname, movie, arrival, departure)

- For each character and for each neutral planet, how much time total did the character spend on the planet?

```
SELECT c.name, p.name, SUM(t.departure-t.arrival) as amount
FROM  characters c, timetable t, planets p
WHERE t.cname=c.name and t.pname=p.name and
        p.affiliation='neutral'
GROUP BY c.name, p.name;
```