Rewriting *Minus* Queries Using *Not In*

```
SELECT S.sname
  FROM Sailors S, Boats B, Reserves R
 WHERE S.sid = R.sid and R.bid = B.bid
       and B.color = red
 MINUS
SELECT S.sname
  FROM Sailors S, Boats B, Reserves R
 WHERE S.sid = R.sid and R.bid = B.bid
       and B.color = green ;
```

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Rewriting *Minus* Queries Using *Not In*

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Division

- Consider: A(X,Y) and B(Y).

Then A÷B =

$$\{\langle x \rangle \mid (\forall \langle y \rangle \in B) \quad \langle x, y \rangle \in A\}$$

- In general, we require that the set of fields in B be contained in those of A.

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Suppliers from A who supply All Parts from B

sno	pno
S1	P1
S1	P2
S1	P3
S1	P4
S2	P1
S2	P2
S3	P2
S4	P2
S4	P4

A

÷

pno
P2

B1

=

sno

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Suppliers from A who supply All Parts from B

sno	pno
S1	P1
S1	P2
S1	P3
S1	P4
S2	P1
S2	P2
S3	P2
S4	P2
S4	P4

A

÷

pno
P2
P4

B2

=

sno

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Suppliers from A who supply All Parts from B

sno	pno
S1	P1
S1	P2
S1	P3
S1	P4
S2	P1
S2	P2
S3	P2
S4	P2
S4	P4

A

÷

pno
P1
P2
P4

B3

=

sno

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Sailors who Reserved all Boats

- To find the Sailors who reserved all boats:

$$(\pi_{sid,bid} \text{ Reserves}) \div (\pi_{bid} \text{ Boats})$$

- Division can be expressed using other relational algebra operators. How?

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Similar to Expression Containment

- Sailor S whose "set of boats reserved" contains the "set of all boats"
- Sailor S for which there does not exist a boat B in Boats that he did not reserve
- Sailor S for which there does not exist a boat B in Boats for which there is no reservation in Reserves

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Division in SQL (1)

```
SELECT S.sname
  FROM Sailors S
 WHERE NOT EXISTS(
          SELECT B.bid
            FROM Boats B
           WHERE NOT EXISTS(
                     SELECT R.bid
                       FROM Reserves R
                      WHERE R.bid=B.bid and
                            R.sid=S.sid))
```

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Division in SQL (2)

```
SELECT S.sname
  FROM Sailors S
 WHERE NOT EXISTS((SELECT B.bid
                     FROM Boats B)
                   MINUS
                  (SELECT R.bid
                     FROM Reserves R
                    WHERE R.sid = S.sid));
```

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Aggregation

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Aggregate Operators

- The aggregate operators available in SQL are:
  - COUNT(*)
  - COUNT([DISTINCT] A)
  - SUM([DISTINCT] A)
  - AVG([DISTINCT] A)
  - MAX(A)
  - MIN(A)

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Some Examples

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

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

```
SELECT COUNT(distinct color)
  FROM Boats
```

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Find Average Age for each Rating

- So far, aggregation has been applied to all tuples that passed the WHERE clause test.
- How can we apply aggregation to groups of tuples?

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Basic SQL Query

```
  SELECT [Distinct] target-list
    FROM relation-list
   WHERE condition
GROUP BY grouping-list
  HAVING group-condition;
```

- **target-list:** Fields appearing in grouping-list and aggregation operators
- **group-condition:** Can only constrain attributes appearing in grouping-list

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Evaluation

1. Compute cross product of relations in FROM
2. Tuples failing WHERE are thrown away
3. Tuples are partitioned into groups by values of *grouping-list* attributes
4. The *group-condition* is applied to eliminate groups
5. One answer in generated for each group

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Find Average Age for each Rating

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Sailors

sid	sname	rating	age
22	Dustin	7	45.0
31	Lubber	8	55.5
58	Rusty	10	35.0
63	Fluffy	7	44.0
78	Morley	7	31.0
84	Popeye	10	33.0

Sailors

sid	sname	rating	age
22	Dustin	7	45.0
63	Fluffy	7	44.0
78	Morley	7	31.0
31	Lubber	8	55.5
58	Rusty	10	35.0
84	Popeye	10	33.0

40 **55.5** **34**

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Find name and age of oldest Sailor

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

Wrong!!

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

Right!!

How else can this be done?

Hint: >= ALL

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What does this return?

```
  SELECT B.bid, COUNT(*)
    FROM Boats B, Reserves R
   WHERE R.bid=B.bid and B.color= red
GROUP BY B.bid
```

? What would happen if we put the condition about the color in the HAVING clause?

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Names of Boats that were not Reserved on more than 5 days

? Can we move the condition in the HAVING to the WHERE?

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The Color for which there are the most boats

```
  SELECT color
    FROM Boats B
GROUP BY color
  HAVING max(count(bid))
```

? What is wrong with this?

How would you fix it?

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Aggregation Instead of Exists

- Aggregation can take the place of exists.
- Example:

```
SELECT color
  FROM Boats B1
 WHERE not exists(
                SELECT *
                  FROM Boats B2
                 WHERE B1.bno<> B2.bno
                       and B1.color=B2.color)
```

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Aggregation Instead of Exists

```
  SELECT color
    FROM Boats B1
GROUP BY color
  HAVING count(bid) = 1
```

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Sub-queries and Views

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A Complex Query

- We would like to create a table containing 3 columns:
  - Sailor id
  - Sailor age
  - Age of the oldest Sailor

? How can this be done?

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Attempt 1

```
SELECT S.sid, S.age, MAX(S.age)
  FROM Sailors S;
```

? Why is this wrong?

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Attempt 2

```
  SELECT S.sid, S.age, MAX(S.age)
    FROM Sailors S
GROUP BY S.id, S.age;
```

? Why is this wrong?

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Solution 1: Subquery in FROM

```
SELECT S.sid, S.age, M.mxage
  FROM Sailors S,(SELECT MAX(S2.age) as mxage
                  FROM Sailors S2) M;
```

- We can put a query in the FROM clause instead of a table
- The query in the FROM clause must be renamed with a range variable (M in this case).

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Solution 2: Subquery in SELECT

```
SELECT S.sid, S.age, (SELECT MAX(S2.age)
                      FROM Sailors S2)
  FROM Sailors S;
```

- A query in the SELECT clause must return at most one value for each row returned by the outer query.

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Another Example of a Sub-query in SELECT

```
SELECT S.sid, S.age, (SELECT MAX(S2.age)
                      FROM Sailors S2
                     WHERE S2.age<S.age)
  FROM Sailors S;
```

- What does this query return?
- Note the use of S (defined in the outer query) within the inner query.

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Another Example of a Sub-query in FROM??

```
SELECT S.sid, S.age, M.mxage
  FROM Sailors S, (SELECT MAX(S2.age) as mxage
                   FROM Sailors S2
                  WHERE S2.age<S.age);
```

? Why is this wrong?

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Solution 3: Create a Table

- A View is a query that looks like a table and can be used as a table.

```
CREATE TABLE MaxAge as
SELECT MAX(S.age) as mxage
  FROM Sailors S;
```

MUST Rename!

```
SELECT S.sid, S.age, M.mxage
  FROM Sailors S, MaxAge M;
```

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Views

- A view is a "virtual table" defined using a query
- You can use a view as if it were a table, even though it doesn't contain data
- The view is computed every time that it is referenced

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Advantages and Disadvantages

- Advantages:
  - no memory used for table
  - update of table does not require updating views
  - gives query processor more choices for optimizing
- Disadvantages:
  - must be recomputed every time used
  - if tables that view uses are dropped, view data is lost

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Solution 4: Views

- A View is a query that looks like a table and can be used as a table.

```
CREATE OR REPLACE VIEW MaxAge as
SELECT MAX(S.age) as mxage
  FROM Sailors S;
```

MUST Rename!

```
SELECT S.sid, S.age, M.mxage
  FROM Sailors S, MaxAge M;
```

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Views For Restricting Access

- Suppose that we have a table:

  Grades(Login, Exercise, Grade)

- We would like a user to only be able to see his own grades. We create the following view and grant privileges to query the view (not the underlying table)

```
CREATE OR REPLACE VIEW UserGrades as
SELECT *
  FROM Grades
 WHERE Login = User;
```

Pseudo-column which is equal to the user name.

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