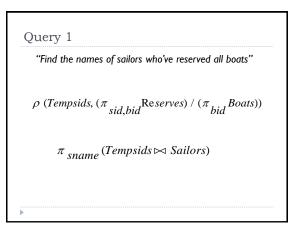


In general, x and y can be any sets of fields (not singletons)

sid	<u>bid</u>	<u>bid</u>	<u>bid</u>	<u>bid</u>
s1	b1	b2	b2	b1
s1	b2	<u>B1</u>	b4	b2
s1	b3	DI	В2	b4
s1	b4		DΖ	В3
s2	b1	sid		DS
s2	b2	s1		
s3	b2	s2	sid	_
s4	b2	s3	s1	sid
s4	b4	s4	s4	s1
	\overline{A}	A/B1	A/B2	A/B



Query 2

"Find sailors who've reserved all red boats" $\rho(Temp,(\pi_{sid,bid}^{Reserves)/(\pi_{bid}^{G}(\sigma_{color='red}^{Boats})))}$ $\pi_{sname}(Temp\bowtie Sailors)$

For A/B, compute all x values that are not disqualified by some y value in B
 x value is disqualified if by attaching y value from B, we obtain an xy tuple that is not in A
 Disqualified x values: π_X((π_X(A)×B)−A)
 A/B: π_X(A) − all disqualified tuples
 π_X(A)−π_X((π_X(A)×B)−A)

Expressing A/B Using Basic Operators

Division in SQL

- Not supported as primitive operator
- ▶ Need to use nested queries to express division
 - One of the most subtle queries in SQL
 - ▶ Need to pay close attention to writing SQL division queries!
- There are two ways of writing division queries
 - Using the set EXCEPT operator (2-level nesting)
 - ▶ Without the **EXCEPT** operator (3-level nesting)

•

```
Division: Solution 1

"Find sailors who've reserved all boats."

With EXCEPT:
SELECT S.sname
FROM Sailors S
WHERE NOT EXISTS

(
(SELECT B.bid FROM Boats B)
EXCEPT
(SELECT R.bid FROM Reserves R
WHERE R.sid=S.sid)
)
```

```
Division: Solution 2

"Find sailors who've reserved all boats."

Without EXCEPT:

SELECT S.sname
FROM Sailors S Sailors S such that ...
WHERE NOT EXISTS (SELECT B.bid
here is no boat B ...
FROM Boats B
WHERE NOT EXISTS (SELECT *

without a Reserves tuple showing S reserved B
WHERE R.bid=B.bid
AND R.sid=S.sid))
```

```
"Find sailors who've reserved all red boats."

"Find sailors who've reserved all red boats."

With EXCEPT:
SELECT S.sname
FROM Sailors S
WHERE NOT EXISTS

(
(SELECT B.bid FROM Boats B
WHERE B.color = 'red')
EXCEPT
(SELECT R.bid FROM Reserves R
WHERE R.sid=S.sid)
)
```

```
"Find sailors who've reserved all red boats."

"Find sailors who've reserved all red boats."

Without EXCEPT:

SELECT S.sname
FROM Sailors S
WHERE NOT EXISTS (SELECT B.bid
FROM Boats B
WHERE B.color='red' AND
NOT EXISTS (SELECT *
FROM Reserves R
WHERE R.bid=B.bid
AND R.sid=S.sid))
```

```
Another Example

Movies (movie id, title, year, studio)
Actors (actor id, name, nationality)
StarsIn(actor id, movie id, character)

"Find names of actors who star in ALL movies produced by Universal in year 1990."

SELECT A.name FROM Actors A
WHERE NOT EXISTS(

SELECT M.movie_id FROM Movies M
WHERE M.year=1990 AND M.studio='Universal'

EXCEPT

SELECT S.movie_id FROM Stars_In S
WHERE S.actor_id=A.actor_id
)
```