Relational Algebra - Division
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Consider the following tables:

Boats (bid, bname, color)
Sailors (sid, sname, rating, age)
Reserves (sid, bid, day)

Division can be represented as ÷ or /
Ex. **r ÷ s** or **r / s.**

First thing we need to do when we have a division is to consider the **schema**.

r

x	y

s

y

r ÷ s

x

Reserves ÷ (π_{sid} (Sailors))

Second thing we need to consider is **Semantics.** What kind of tuples do we have? Semantics for any **x** values in **r**, if **x** is associated with all **y** in **s**, this **x** value is in **r ÷ s.**
Ex.

r

x	y
x_1	y_1
x_3	y_2
x_2	y_3

s

y
y_1
y_2
y_3

In table **r**, $\mathbf{x_i}$ can be associated with one or more than one **y**. If $\mathbf{x_i}$ is not associated with all values of **y** in **s**, then it should not be listed in the result table.
Ex.

r

S_{no}	P_{no}
s_1	p_1
s_1	p_2
s_1	p_3
s_1	p_4
s_2	p_1
s_2	p_2
s_3	p_2
s_4	p_2
s_4	p_4

s_1

P_{no}
p_2

r ÷ s_1

S_{no}
s_1
s_2
s_3
s_4

If **s** is associated with all **P_{no}** in **s** then it can be in the result table

s_2

P_{no}
p_2
p_4

$r \div s_2$

S_{no}
s_1
s_4

s_3

P_{no}
p_1
p_2
p_3
p_4

$r \div s_3$

S_{no}
s_1

1) First step is to define the schema
2) Find possible values

Simulate integer division:
C = A/B → the largest integer such that $C * B \le A$

In Relational Algebra
C = A/B → the largest relation (# of tuples) such that $C \times B \subseteq A$

Division is not part of the complete set of relational algebraic operators. Then how do we translate a division into an expression that only contains the basic operators?
$r \div s \equiv ?$
Step 1) Find those x values in r that do not satisfy the "all association" conditions
Step 2) $\pi_x(R)$ – result of step 1 (this is a set difference)

It follows the following steps to reach the solution:
Step 1) $\pi_x((\pi_x(r) \times s) - r)$ → this step helps find items in $\pi_x(r)$ that don't belong to $r \div s$
Step 2) $\pi_x(r)$ – result from step 1

Ex. Find sailors who reserve all boats
$\pi_{(sid),(bid)} R \div \pi_{(bid)}(B)$

More exercises of relational algebra:

Q1. Find sailors with rating > 5 and are younger than 35.
$\sigma_{(rating > 5) \wedge age < 35} (S)$

Q2. Find the names of (Q1)
$\pi_{(sname)}$ (Q1)
Q3. Find names of sailors who reserved boat #103

$\pi_{(sname)} (\sigma_{(bid=103)} (S \bowtie R))$

Q4. Find sailors who reserved a red boat or a green boat.

$\pi_{(sid)} (\sigma_{((color=green) \vee (color=red))} (R \bowtie B))$

You can also use union

$\pi_{(sid)} (\sigma_{(color=green)} (R \bowtie B)) \pi_{(sid)} \cup (\sigma_{(color=red)} (R \bowtie B))$

Q5. Find sailors who reserved a green boat and a red boat.

Same as Q4 but instead of union, use intersect

$\pi_{(sid)} (\sigma_{(color=green)} (R \bowtie B)) \pi_{(sid)} \cap (\sigma_{(color=red)} (R \bowtie B))$

However, we cannot do $\wedge$ instead of $\vee$ for Q5 because in a table an entry cannot be green and red at the same time, so using $\wedge$ will not return anything.