Example

Examples of Division A/B

$A/B = \{\langle x \rangle \mid \forall \langle y \rangle \in B, \langle x, y \rangle \in A\}$

cid	bname
c1	b1
c1	b2
c1	b3
c1	b4
c2	b1
c2	b2
c3	b2
c4	b2
c4	b4

A

bname
b2

B1

bname
b2
b4

B2

bname
b1
b2
b4

B3

cid
c1
c2
c3
c4

A/B

1

cid
c1
c4

A/B

2

cid
c1

A/B

3

Expressing A/B Using Basic Operators

- Can be equivalently expressed using basic operators
- **Idea:** 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 <x,y> tuple that is not in A

Can you express this operator using basic operators?

A/B: $\pi_x(A) - \pi_x((\pi_x(A) \times B) - A)$

Disqualified *x* values

Example

Examples of Division A/B

$$\pi_x(A) - \pi_x((\pi_x(A) \times B) - A)$$

cid	bname
c1	b1
c1	b2
c1	b3
c1	b4
c2	b1
c2	b2
c3	b2
c4	b2
c4	b4

A

bname
b2
b4

B

cid	bname
~~c1~~	~~b2~~
~~c1~~	~~b4~~
~~c2~~	~~b2~~
c2	b4
~~c3~~	~~b2~~
c3	b4
~~c4~~	~~b2~~
~~c4~~	~~b4~~

-A

cid
c1
c4

A/B

$$\pi_x(A) \times B$$

Example

Find names of sailors who have reserved a red OR green boat

- Identify all red or green boats, then
- find sailors who have reserved one of these boats

Sailors

sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Reserves

sid	bid	day
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Boats

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Example

Find names of sailors who have reserved a red OR green boat

- Identify all red or green boats, then
- find sailors who have reserved one of these boats:

$$\rho\ (Tempboats, (\sigma_{color='red' \vee color='green'} Boats))$$

$$\pi_{sname}(Tempboats \bowtie Reserves \bowtie Sailors)$$

Equivalent:

$$\rho(Tempboats, (\sigma_{color='red'}(Boats) \cup \sigma_{color='green'}(Boats)))$$

$$\pi_{sname}(Tempboats \bowtie Reserves \bowtie Sailors)$$

Example

Find names of sailors who have reserved a red AND green boat

?

$$\rho\ (Tempboats, (\sigma_{color='red' \wedge color='green'} Boats))$$

$$\pi_{sname}(Tempboats \bowtie Reserves \bowtie Sailors)$$

Example

Find names of sailors who have reserved a red AND green boat

- Identify
  - sailors who have reserved red boats
  - sailors who have reserved green boats
- Then find the intersection (sid is a key for Sailors):

Sailors

sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Reserves

sid	bid	day
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Boats

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Example

Find names of sailors who have reserved a red AND green boat

- Identify
  - sailors who have reserved red boats
  - sailors who have reserved green boats
- Then find the intersection (sid is a key for Sailors):

$$\rho\,(Tempred,\ \pi_{sid}((\sigma_{color='red'}Boats)\bowtie Reserves))$$

$$\rho\,(Tempgreen,\ \pi_{sid}((\sigma_{color='green'}Boats)\bowtie Reserves))$$

$$\pi_{sname}((Tempred \cap Tempgreen)\bowtie Sailors)$$

Example

Find the SIDs of sailors over age 20 who have not reserved a red boat

$$\pi_{sid}(\sigma_{age>20}Sailors) -$$

$$\pi_{sid}((\sigma_{color='red'}Boats) \bowtie Reserves)$$

Sailors

sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Reserves

sid	bid	day
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Boats

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Example

Find the names of sailors who have reserved **all** boats

- Uses division; schemas of the input relations must be carefully chosen:

$$\rho\ (Tempsids, (\pi_{sid,bid} \text{Reserves}) / (\pi_{bid} Boats))$$

$$\pi_{sname}(Tempsids \bowtie Sailors)$$

Sailors

sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Reserves

sid	bid	day
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Boats

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red