

RELATIONAL ALGEBRA

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Relational Algebra

Useful for representing execution plans.

Understanding Algebra is key to understanding SQL query processing.

Example Instances

R1

<u>sid</u>	<u>bid</u>	<u>day</u>
22	101	10/10/96
58	103	11/12/96

S1

<u>sid</u>	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

S2

<u>sid</u>	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Relational Algebra

Basic Operations:

Selection (σ) – Selects a subset of rows from relation.

Projection (π) – Deletes unwanted columns from relation.

Cross Product (X) – Allows us to combine two relations.

Set Difference (–) Tuples in relation 1 and but not in relation 2.

Union – Tuples in relation 1 and in relation 2.

Intersection – Tuples common in relations.

Join – Allows to combine two relations but with specific condition

Projection

Deletes attributes that are not in projection list.

S2

<u>sid</u>	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

sname	rating
yuppy	9
lubber	8
guppy	5
rusty	10

$\pi_{sname, rating}(S2)$

age
35.0
55.5

$\pi_{age}(S2)$

Selection

Select rows that satisfy condition.

S2

<u>sid</u>	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

sid	sname	rating	age
28	yuppy	9	35.0
58	rusty	10	35.0

$$\sigma_{rating > 8}(S2)$$

sname	rating
yuppy	9
rusty	10

$$\pi_{sname, rating}(\sigma_{rating > 8}(S2))$$

Union, Intersection & Set Difference

s1

<u>sid</u>	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

s2

<u>sid</u>	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0
44	guppy	5	35.0
28	yuppy	9	35.0

$S1 \cup S2$

sid	sname	rating	age
31	lubber	8	55.5
58	rusty	10	35.0

$S1 \cap S2$

sid	sname	rating	age
22	dustin	7	45.0

$S1 - S2$

Set Operations in SQL

The **UNION**, **INTERSECT** and **EXCEPT** operations correspond relational algebra operations
the relations have to be compatible (same attributes)
these operations remove duplicates by default

```
(SELECT name  
FROM Customer)  
INTERSECT (SELECT name  
FROM Supplier);
```

name
Max Frisch

customerID	name	street	postcode	city
1	Max Frisch	Bahnhofstrasse 7	8001	Zurich
2	Eddy Merckx	Pleinlaan 25	1050	Brussels
5	Claude Debussy	12 Rue Louise	75008	Paris
53	Albert Einstein	Bergstrasse 18	8037	Zurich
8	Max Frisch	ETH Zentrum	8092	Zurich

supplierID	name	postcode	city
5	Max Frisch	8037	Zurich
2	Mario Botta	6901	Lugano

Cross Product

- Each row of S_1 is paired with each row of R_1 .
- Result schema has one field per field of S_1 and R_1 , with field names 'inherited' if possible.
- Conflict: Both S_1 & R_1 have a field called sid .

(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

R_1

<u>sid</u>	<u>bid</u>	<u>day</u>
22	101	10/10/96
58	103	11/12/96

S_1

<u>sid</u>	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

Renaming operator: $\rho (C(1 \rightarrow sid1, 5 \rightarrow sid2), S_1 \times R_1)$

Joins

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

$$S1 \bowtie_{S1.sid < R1.sid} R1$$

Find the names of sailors who have reserved boat 103.

Solution 1: $\pi_{sname}((\sigma_{bid=103} Reserves) \times Sailors)$

Solution 2: $\rho(Temp1, \sigma_{bid=103} Reserves)$

$\rho(Temp2, Temp1 \times Sailors)$

$\pi_{sname}(Temp2)$

Solution 3: $\pi_{sname}(\sigma_{bid=103}(Reserves \times Sailors))$

<i>sid</i>	<i>sname</i>	<i>rating</i>	<i>age</i>
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

<i>sid</i>	<i>bid</i>	<i>day</i>
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

<i>bid</i>	<i>bname</i>	<i>color</i>
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Find the names of sailors who have reserved a red boat.

<i>sid</i>	<i>sname</i>	<i>rating</i>	<i>age</i>
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

<i>sid</i>	<i>bid</i>	<i>day</i>
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

<i>bid</i>	<i>bname</i>	<i>color</i>
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

$$\pi_{sname}((\sigma_{color='red', Boats}) \times Reserves \times Sailors)$$

The names of sailors who have reserved a red or a green boat.

<i>sid</i>	<i>sname</i>	<i>rating</i>	<i>age</i>
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

<i>sid</i>	<i>bid</i>	<i>day</i>
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

<i>bid</i>	<i>bname</i>	<i>color</i>
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

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

$\pi_{sname}(\textit{Tempboats} \times \textit{Reserves} \times \textit{Sailors})$

The names of sailors who have reserved a red and a green boat.

<i>sid</i>	<i>sname</i>	<i>rating</i>	<i>age</i>
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

<i>sid</i>	<i>bid</i>	<i>day</i>
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

<i>bid</i>	<i>bname</i>	<i>color</i>
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

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

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

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

Practice

Consider the following relations containing airline flight information:

Flights(fln: integer, from: string, to: string, distance: integer, departs: time, arrives: time)

Aircraft(aid: integer, aname: string, cruisingrange: integer)

Certified(eid: integer, aid: integer)

Employees(eid: integer, ename: string, salary: integer)

1. Find the eids of pilots certified for some Boeing aircraft.
2. Find the names of pilots certified for some Boeing aircraft.
3. Identify the flights that can be piloted by every pilot whose salary is more than \$100,000.