

Relational Algebra Exercises

Exercise 2

Schema:

Consider the following airline database schema:

- Flights (flightNumber, from, to, distance, departs)
- Aircraft (aircraft_ID, aircraft_Name, range)
- Certified (emp_ID, aircraft_ID)
- Employees (emp_ID, emp_name, salary)

Note that:

- Pilots are the employees certified on at least one aircraft.
- An aircraft can be used for any flight provided it has sufficient range.
- Pilots can take any flight provided that are certified on an aircraft having sufficient range.

Exercise 2 (cont.)

Flights

FlightNbr	from	to	Distance	Departs
ME309	Beirut	Cairo	500	1:00
ME307	Beirut	Dubai	1100	2:00
AF340	Paris	NY	4000	3:00
AF550	Paris	Madrid	800	4:00
DL110	LA	NY	7000	4:30

Employees

Emp_id	Emp_name	Salary
100	John	6000
200	Steve	7000
300	Mary	6500
400	Karim	5000
500	Samir	4500

Certified

Emp_id	Aircraft_id
100	1
100	3
200	1
200	4
300	4
400	3

Aircraft

Aircraft_ID	name	range
1	Boeing	8000
2	Airbus	5000
3	Saab	8000
4	Embroer	1000

Exercise 2 (cont.)

Using relational algebra, express each of the following queries:

1. Find all the names of the aircrafts in your database.
2. Find all the employees with salary more than 3000\$
3. Find the numbers of all the flights that are flying from Cairo to Beirut.
4. Find the **emp_ID(s) of pilots who are certified on Boeing (pay attention that Boeing is the name and not the ID of the aircraft)**.
5. Write the above relational algebra statement in another way
6. Assume the table resulting from the query in question (4) is renamed R. state in an English sentence what does the following expression perform. $\pi_{\text{emp_name}}(\text{Employees} \bowtie R)$
7. Find the aircraft IDs that can fly non stop from LA to NY.
8. Find names of pilots who can operate planes with a range greater than 3,000 miles.
9. Find names of pilots who can operate planes with a range greater than 3,000 miles, but are not certified on any Boeing.

Exercise 2: Solution

1. Find all the names of the aircrafts in your database.

$\Pi_{\text{name}}(\text{Aircraft})$

2. Find all the name of employees with salary more than 3000

$\Pi_{\text{emp_name}}(\sigma_{\text{Salary} > 3000}(\text{Employees}))$

Emp_name
John
Steve
Mary
Karim
Samir

3. Find the numbers of all the flights that are flying from Cairo to Beirut.

$\Pi_{\text{FlightNbr}}(\sigma_{\text{from} = \text{'Cairo'} \text{ and } \text{to} = \text{'Beirut'}}(\text{Flights}))$

Exercise 2: Solution

4. Find the emp_ID(s) of pilots who are certified on Boeing.

Method: emp_ID available in Employees and Certified
 Boeing available in Aircraft
 → We need both Certified and Aircraft (Join)

Alternative 1: $\Pi_{\text{emp_id}}(\sigma_{\text{aircraft_name}='Boeing'}(\text{Aircraft} * \text{Certified}))$

Emp_ID	Emp_i d	Aircraft_ ID	name	range
100	100	1	Boeing	8000
200	200	1	Boeing	8000

$\Pi_{\text{emp_id}}(\text{R1})$

$\text{R1} = \sigma_{\text{aircraft_name}='Boeing'}(\text{R})$

Emp_ id	Aircraft_ ID	name	range
100	1	Boeing	8000
100	3	Saab	5000
200	1	Boeing	8000
200	4	Embra er	1000
300	4	Embra er	1000
400	3	Saab	8000

$\text{R} = \text{Aircraft} * \text{Certified}$

Exercise 2: Solution

5. Find an alternative to get the emp_ID(s) of pilots who are certified on Boeing. (Write the above relational algebra statement in another way)

As second alternative, we can get the Boeing aircraft first then natural join with certified to find out those that are certified on Boeing.

Alternative 2: $\pi_{\text{emp_id}}((\sigma_{\text{aircraft_name}='Boeing'}(\text{Aircraft})) \bowtie \text{Certified})$

Aircraft_ID	name	range
1	Boeing	8000

Emp_id	Aircraft_id
100	1
100	3
200	1
200	4
300	4
400	3

Exercise 2: Solution

6. Assume the table resulting from the query in question (4) is renamed R. state in an English sentence what does the following expression perform.

$\pi_{\text{emp_name}}(\text{Employees} \bowtie R)$.

Solution:

R is the ID of employees certified on Boeing. If we join we Employees then project the name we get the name of the Employee certified on some Boeing.

Find the names of the pilots who are certified on Boeing.

Emp_name
John
Steve

Exercise 2: Solution

7. Find the aircraft IDs that can fly non stop from LA to NY.

$\sigma_{\text{from}='LA' \text{ AND } \text{to}='NY'}(\text{Flights})$

Solution:

- Get the flight from LA to NY
- The only link with the aircraft is the distance and range. Not same attribute names so we have to use Cartesian.

Aircraft x ($\sigma_{\text{from}='LA' \text{ AND } \text{to}='NY'}(\text{Flights})$)

Aircraft_ID	name	range	FlightNr	from	to	Distance	Departs
1	Boeing	8000	DL110	LA	NY	7000	4:30
2	Airbus	5000	DL110	LA	NY	7000	4:30
3	Saab	8000	DL110	LA	NY	7000	4:30
4	Embraer	1000	DL110	LA	NY	7000	4:30

- Now we keep only those with range >= distance

$\Pi_{\text{Aircraft_ID}}\{\sigma_{\text{range} \geq \text{Distance}}(\text{Aircraft x } \sigma_{\text{from}='LA' \text{ AND } \text{to}='NY'}(\text{Flights}))\}$

Exercise 2: Solution

7. Find the aircraft IDs that can fly non stop from LA to NY.

$\Pi_{\text{Aircraft_ID}}\{\sigma_{\text{range} \geq \text{Distance}} (\text{Aircraft} \times \sigma_{\text{from}='LA' \text{ AND } \text{to}='NY'}(\text{Flights}))\}$

$\sigma_{\text{range} \geq \text{Distance}} (\text{Aircraft} \times \sigma_{\text{from}='LA' \text{ AND } \text{to}='NY'}(\text{Flights}))$

Aircraft_ID	name	range	FlightNbr	from	to	Distance	Departs
1	Boeing	8000	DL110	LA	NY	7000	4:30
3	Saab	8000	DL110	LA	NY	7000	4:30

Then we project the Aircraft_ID

$\Pi_{\text{Aircraft_ID}}\{\sigma_{\text{range} \geq \text{Distance}} (\text{Aircraft} \times \sigma_{\text{from}='LA' \text{ AND } \text{to}='NY'}(\text{Flights}))\}$

Aircraft_ID
1
3

Exercise 2: Solution

7'. Find the theta-join alternative of expression in question (7).

Strategy:

- Find the flights from LA to NY
- Join with Aircraft for only those with range $\geq$ the distance
- Project the Aircraft_ID

$$\Pi_{\text{Aircraft_ID}} \{ \text{Aircraft} \bowtie_{\text{range} \geq \text{Distance}} (\sigma_{\text{from}='LA' \text{ AND } \text{to}='NY'}(\text{Flights})) \}$$

Exercise 2: Solution

8. Find names of pilots who can operate planes with a range greater than 3,000 miles.

Strategy:

- Get the Employee ID of pilots certified on aircraft with range > 3000
- Natural join with Employee table to get the names
- Project the names

$$\Pi_{\text{emp_name}}\{ \text{Employees} \bowtie \{ \Pi_{\text{emp_ID}}(\sigma_{\text{range}>3000}(\text{Aircraft} \bowtie \text{certified})) \} \}$$
$$\Pi_{\text{emp_name}}\{\text{Employees} \bowtie (\sigma_{\text{range}>3000}(\text{Aircraft}) \bowtie \text{certified})\}$$
$$\Pi_{\text{emp_name}}\{\sigma_{\text{range}>3000}(\text{Employees} * \text{Aircraft} * \text{certified})\}$$

Exercise 2: Solution

9. Find names of pilots who can operate planes with a range greater than 3,000 miles, but are not certified on any Boeing.

$\Pi_{\text{emp_name}}\{\sigma_{\text{range}>3000}(\text{Employees} * \text{Aircraft} * \text{certified})\}$

$-\Pi_{\text{emp_name}}(\text{Employees} \bowtie \Pi_{\text{emp_id}}(\sigma_{\text{aircraft_name}='Boeing'}(\text{Aircraft} * \text{Certified})))$

Strategy:

- Get the Employee ID of pilots certified on aircraft with range > 3000
- Get the Employee ID of Pilots certified on Boeing
- Do a set difference
- Natural join with Employee table to get the names
- Project the names

$\Pi_{\text{emp_name}}\{ \text{Employees} \bowtie \{ \Pi_{\text{emp_ID}}(\sigma_{\text{range}>3000}(\text{Aircraft} \bowtie \text{certified}))$

$-\Pi_{\text{emp_ID}}(\sigma_{\text{aircraft_name}='Boeing'}(\text{Aircraft} \bowtie \text{Certified})) \} \}$

Exercise 2: Solution

In details

$\Pi_{\text{emp_name}} \{ \text{Employees} \bowtie \{ \Pi_{\text{emp_ID}} (\sigma_{\text{range} > 3000} (\text{Aircraft} \bowtie \text{certified}))$
 $\quad \quad \quad - \Pi_{\text{emp_ID}} (\sigma_{\text{aircraft_name} = \text{'Boeing'}} (\text{Aircraft} \bowtie \text{Certified})) \} \}$

Certified

Emp_ID	Aircraft_id
100	1
100	3
200	1
200	4
300	4
400	3

Aircraft

Aircraft_ID	name	range
1	Boeing	8000
2	Airbus	5000
3	Saab	8000
4	Embraer	1000

certified $\bowtie$ Aircraft

Emp_ID	Aircraft_ID	name	range
100	1	Boeing	8000
200	1	Boeing	8000
100	3	Saab	8000
400	3	Saab	8000
200	4	Embraer	1000
300	4	Embraer	1000

Exercise 2: Solution

$\Pi_{\text{emp_name}}\{ \text{Employees} \bowtie \{ \Pi_{\text{emp_ID}}(\sigma_{\text{range}>3000}(\text{Aircraft} \bowtie \text{certified}))$
 $\quad - \Pi_{\text{emp_ID}}(\sigma_{\text{aircraft_name}='Boeing'}(\text{Aircraft} \bowtie \text{Certified})) \} \}$

Emp_ID	Aircraft_ID	name	range
100	1	Boeing	8000
200	1	Boeing	8000
100	3	Saab	8000
400	3	Saab	8000

$\Pi_{\text{emp_name}}\{ \text{Employees} \bowtie \{ \Pi_{\text{emp_ID}}(\sigma_{\text{range}>3000}(\text{Aircraft} \bowtie \text{certified}))$
 $\quad - \Pi_{\text{emp_ID}}(\sigma_{\text{aircraft_name}='Boeing'}(\text{Aircraft} \bowtie \text{Certified})) \} \}$

Emp_ID
100
200
400

Exercise 2: Solution

$\Pi_{\text{emp_name}}\{ \text{Employees} \bowtie \{ \Pi_{\text{emp_ID}}(\sigma_{\text{range}>3000}(\text{Aircraft} \bowtie \text{certified}))$
 $- \Pi_{\text{emp_ID}}(\sigma_{\text{aircraft_name}='Boeing'}(\text{Aircraft} \bowtie \text{Certified})) \} \}$

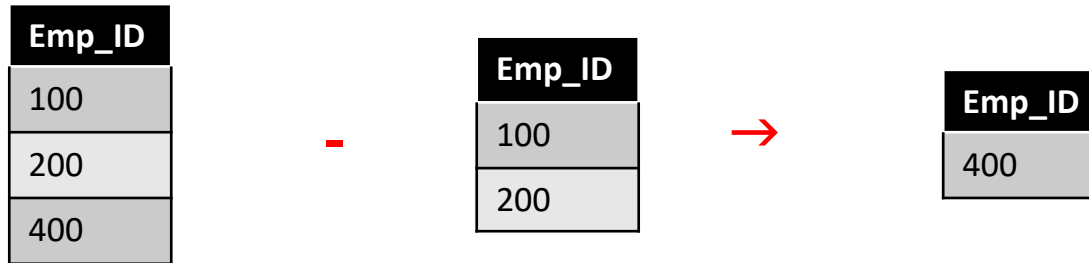
Emp_ID	Aircraft_ID	name	range
100	1	Boeing	8000
200	1	Boeing	8000

$\Pi_{\text{emp_name}}\{ \text{Employees} \bowtie \{ \Pi_{\text{emp_ID}}(\sigma_{\text{range}>3000}(\text{Aircraft} \bowtie \text{certified}))$
 $- \Pi_{\text{emp_ID}}(\sigma_{\text{aircraft_name}='Boeing'}(\text{Aircraft} \bowtie \text{Certified})) \} \}$

Emp_ID
100
200

Exercise 2: Solution

$\Pi_{\text{emp_name}}\{ \text{Employees} \bowtie \{ \Pi_{\text{emp_ID}}(\sigma_{\text{range}>3000}(\text{Aircraft} \bowtie \text{certified}))$
 $\quad - \Pi_{\text{emp_ID}}(\sigma_{\text{aircraft_name}='Boeing'}(\text{Aircraft} \bowtie \text{Certified})) \} \}$



$\Pi_{\text{emp_name}}\{ \text{Employees} \bowtie \{ \Pi_{\text{emp_ID}}(\sigma_{\text{range}>3000}(\text{Aircraft} \bowtie \text{certified}))$
 $\quad - \Pi_{\text{emp_ID}}(\sigma_{\text{aircraft_name}='Boeing'}(\text{Aircraft} \bowtie \text{Certified})) \} \}$

Emp_ID	Emp_name	Salary
400	Karim	5000

Exercise 3

Schema: Consider the following Pizzeria database schema:

Person (name, age, gender)

Frequents (name, pizzeria)

Eats (name, pizza)

Serves (pizzeria, pizza, price)

Pizzeria: a place to serve pizza.

Frequents: pizzerias frequented by persons

Person: each person is identified by his name (the key)

Eats: what kind of pizza each person eats. A person might love to eat more than one kind of pizza

Exercise 3-Example

Person

name	age	gender
Amy	19	F
Sara	17	F
Reem	20	F
kamil	19	M
Sam	16	M
John	22	M

Serves

Pizzeria	pizza	price
pizza Hut	cheese	9
pizza Hut	mushroom	12
Napoli	peperoni	11
Napoli	mushroom	8
Una Pizza	cheese	12
Una Pizza	peperoni	14

Frequents

name	pizzeria
Amy	Pizza Hut
Amy	Napoli
Reem	Napoli
Reem	Pizza Hut
Sara	Pizza Hut
John	Napoli
Kamil	Una Pizza
Kamil	Napoli
Sam	Una Pizza

Eats

name	Pizza
Amy	Cheese
Amy	Peperoni
Reem	Peperoni
Reem	Mushroom
Sara	Cheese
John	Cheese
Kamil	Peperoni
Kamil	Mushroom
Sam	Mushroom

Exercise 3

Using relational algebra, express each of the following queries:

- a. Find the names of all the persons in your database.
- b. Find all the Pizzas in your database.
- c. Find all the pizzas offered by Dominos.
- d. Find the names and the ages of the persons who eat Pizza
- e. Find all the pizzas eaten by female persons
- f. Find all pizzerias frequented by at least one person under the age of 18.
- g. Find the names of all females who eat either mushroom or pepperoni pizza (or both).
- h. Find the names of all females who eat both mushroom and pepperoni pizza.
- i. Find all pizzerias that serve at least one pizza that Amy eats for less than \$10.00.
- j. Find all pizzerias that are frequented by only females or only males.
- k. For each person, find all pizzas the person eats that are not served by any pizzeria the person frequents. Return all such person (name) / pizza pairs.

Exercise 3

a. Find the names of all the persons in your database. $\Pi_{name}(Person)$

b. Find all the Pizzas in your database.

$$\Pi_{pizza}(Serves)$$

c. Find all the pizzas offered by Dominos.

$$\Pi_{pizza}(\sigma_{pizzeria='Dominos'}(Serves))$$

name	age	gender	pizza
karim	17	M	cheese
karim	17	M	mushroom
Sara	20	F	mushroom
Sara	20	F	pepperoni
Maher	20	M	cheese
Amy	21	F	mushroom

d. Find the names and the ages of the persons who eat Pizza $Person \bowtie Eats$

$$\Pi_{name,age}(Person \bowtie Eats)$$

e. Find all the pizzas eaten by female persons $\Pi_{pizza}(\sigma_{gender='F'}(Person \bowtie Eats))$

f. Find all pizzerias frequented by at least one person under the age of 18.

$$\Pi_{pizzeria}(\sigma_{age < 18}(Person \bowtie Frequents))$$

$$\Pi_{pizzeria}((\sigma_{age < 18}(Person)) \bowtie Frequents)$$

Exercise 3: Solution

- g. Find the names of all females who eat either mushroom or pepperoni (or both).

name	age	gender	pizza
Sara	20	F	mushroom
Sara	20	F	pepperoni
Amy	21	F	mushroom

$$\Pi_{name} (\sigma_{gender='female' \text{ AND } (pizza='mushroom' \text{ OR } 'pizza='pepperoni')} (Person \bowtie Eats))$$

- h. Find the names of all females who eat both mushroom and pepperoni pizza.

$$\Pi_{name} (\sigma_{gender='female' \text{ AND } (pizza='mushroom')} (Person \bowtie Eats)) \cap$$

$$\Pi_{name} (\sigma_{gender='female' \text{ AND } (pizza='pepperoni')} (Person \bowtie Eats))$$

Person

Eats

name	age	gender
Karim	17	M
Sara	20	F
Maher	20	M
Amy	21	F

name	pizza
karim	cheese
karim	mushroom
Sara	mushroom
Sara	pepperoni
Maher	cheese
Amy	mushroom

name	age	gender	pizza
karim	17	M	cheese
karim	17	M	mushroom
Sara	20	F	mushroom
Sara	20	F	pepperoni
Maher	20	M	cheese
Amy	21	F	mushroom

Person ⋈ Eats

Exercise 3: Solution

i. Find all pizzerias that serve at least one pizza that Amy eats for less than \$10.00.

$$\Pi_{\text{pizzeria}} (\sigma_{\text{name}='Amy'}(Eats) \bowtie \sigma_{\text{price}<10}(Serves))$$

pizzeria

Pizza Hut

$$\sigma_{\text{price}<10}(Serves)$$

$$\sigma_{\text{name}='Amy'}(Eats)$$

name	pizza
Amy	cheese
Amy	peperoni

pizzeria	pizza	price
Napoli	Mushroom	8
Pizza Hut	cheese	9

name	pizza	pizzeria	price
Amy	cheese	Pizza Hut	9

$$\sigma_{\text{name}='Amy'}(Eats) \bowtie \sigma_{\text{price}<10}(Serves)$$

Exercise 3: Solution

j. Find all pizzerias that are frequented by only females or only males.

2

$\sigma_{gender='M'}(Person \bowtie Frequents)$

name	age	gender	pizzeria
karim	17	M	dominos
karim	17	M	pizza hut
Maher	20	M	dominos
Maher	20	M	pizza hut

3

$\sigma_{gender='F'}(Person \bowtie Frequents)$

name	age	gender	pizzeria
Sara	20	F	pizza hut
Amy	21	F	pizza hut

1

$Person \bowtie Frequents$

name	age	gender	pizzeria
karim	17	M	dominos
karim	17	M	pizza hut
Sara	20	F	pizza hut
Mahe	20	M	domino

$(\Pi_{pizzeria}(\sigma_{gender='M'}(Person \bowtie Frequents))) -$
 $\Pi_{pizzeria}(\sigma_{gender='F'}(Person \bowtie Frequents))) \cup$
 $(\Pi_{pizzeria}(\sigma_{gender='F'}(Person \bowtie Frequents))) -$
 $\Pi_{pizzeria}(\sigma_{gender='M'}(Person \bowtie Frequents)))$

Exercise 3: Solution

- k. For each person, find all pizzas the person eats that are not served by any pizzeria the person frequents. Return all such person (name, pizza) pairs.

Eats

name	pizza
karim	cheese
karim	mushroom
Sara	mushroom
Sara	pepperoni
Maher	cheese
Amy	mushroom

name	pizzeria	pizza	price
karim	dominos	cheese	8
karim	dominos	pepperoni	9
karim	pizza hut	Mushroom	9.5
karim	pizza hut	Cheese	7
karim	pizza hut	Pepperoni	8
Sara	pizza hut	Mushroom	9.5
Sara	pizza hut	Cheese	7
Sara	pizza hut	Pepperoni	8
Maher	dominos	cheese	8
Maher	dominos	pepperoni	9
Maher	pizza hut	Mushroom	9.5
Maher	pizza hut	Cheese	7
Maher	pizza hut	Pepperoni	8
Amy	pizza hut	Mushroom	9.5
Amy	pizza hut	Cheese	7
Amy	pizza hut	Pepperoni	8

Freqents $\bowtie$ *Serves*

$$Eats - \Pi_{name, pizza} (Freqents \bowtie Serves)$$