

Relational Query Languages: Relational Algebra

Davood Raffei

Copyright 2019-2022

Relational query languages

- 1) Relational Algebra
- 2) Relational Calculus
- 3) SQL

Tables:

teach(sin, cid)

courses(cid, title)

emp(sin, name, phone, age, salary)

E.g. Find names and phones of employees who make more than 50k.

3) SQL

```
select e.name, e.phone
from emp e
where e.salary > 50000;
```

2) Relational Calculus

$\{ \langle e.name, e.phone \rangle \mid emp(e) \text{ and } e.salary > 50000 \}$

1) Relational Algebra

$\Pi_{name, phone} \sigma_{salary > 50000}^{emp}$

Relational calculus: declarative

SQL: based on rel. calculus and declarative (sometimes with procedural components)

Relational Algebra:

- a procedural or operational query language
- It is an algebra: much similar to elementary algebra and linear algebra

$(x + 2 - 6) * 3 + 5$

domain: numbers

OP: +, -, *

- domain: relations

- operators:

basic: selection, projection, renaming, Cartesian product, union, set diff

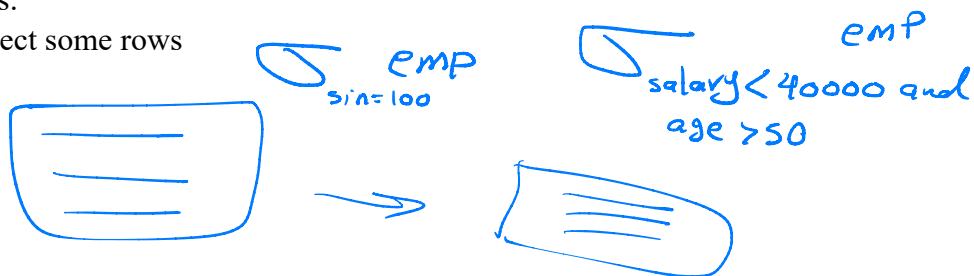
derived: join, division, set intersection

- Some features

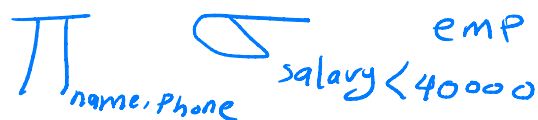
- good to describe eval. steps (an algorithm)
- Can optimize the steps
- (subset of) SQL & rel. calculus
→ rel. algebra

Operations:

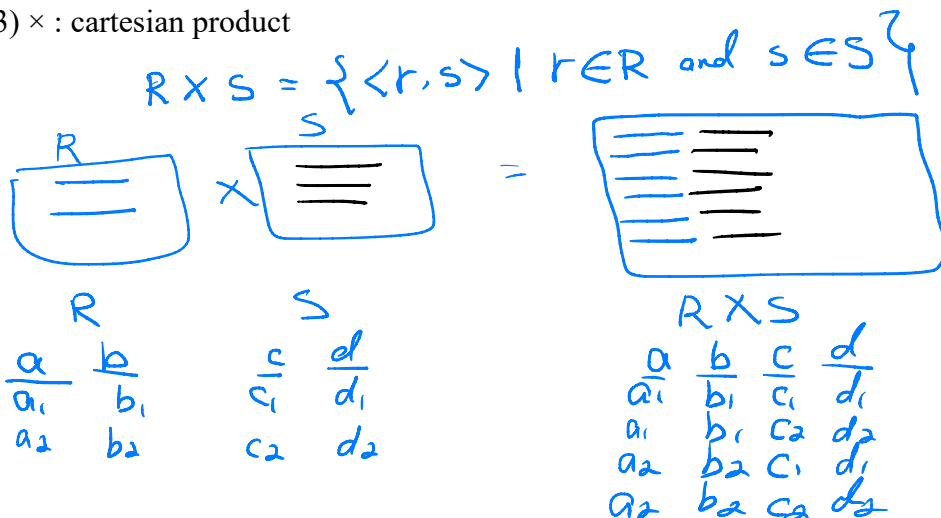
1) σ : select some rows



2) π : project some columns

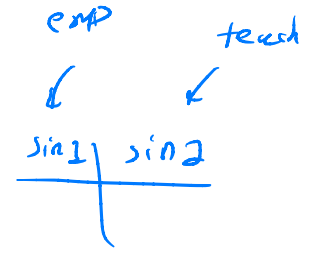


3) \times : cartesian product



4) ρ : rename result columns (and table)

$$\rho_{(sin1)} \pi_{sin}(emp) \times \rho_{(sin2)} \pi_{sin}(teach)$$

$$\rho_{(sin1, sin2)} (\pi_{sin}(emp) \times \pi_{sin}(teach))$$


5) \cup : Set union

$$\sigma_{salary < 40000} emp \cup \sigma_{age > 60} emp$$

"union compatible" \rightarrow - same # of columns
- corresponding columns have the same names & domains

$$\pi_{sin} emp \cup \pi_{sin} teach ?$$

6) $-$: Set difference

$$\sigma_{salary < 40000} emp - \sigma_{age > 60} emp \equiv \sigma_{salary < 40000 \text{ and } age \leq 60} emp$$

$$\pi_{sin} emp - \pi_{sin} teach$$



derived op e.g. find every one who is not teaching 291.

7) \cap : set intersection is a derived operator (how?)

the sets must be union compatible

8) \bowtie : join

$\pi_{sin, name, phone, age, salary, cid}$

$emp \bowtie teach$

$\frac{sin}{100} \quad \frac{name}{sch-}$

$\frac{sin}{100} \quad \frac{cid}{291}$

natural join

9) $/$: division

$R(a, b, c, d)$

$S(c, d)$

$\{a, b, c, d\} - \{c, d\}$

R/S is a table with columns (a, b) and it includes all $\langle a, b \rangle$ tuples in R that appear with all $\langle c, d \rangle$ values from S .

$\frac{teach}{sin, cid} / \frac{\pi_{cid} courses}{cid}$

sin of every teacher who teaches all courses

Another set of tables:

courses(cid, title)

students(sid, name)

taken(sid, cid, sem, year, grade)

Queries:

Q1. Find the names of students who have taken a course in 2021.

Q2. Find the sid and names of students who have not taken a course in 2021.

Q3. Find the sid of students who have taken at least two different courses in 2021.

Q4. Find students who have taken all courses.