RDBMS and SQL

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Lecture 4, 4 September 2025

Relational algebra

- Select — Rows
- Project — Columns
- Join — cartesian product + select
  - Natural join — Implicit equality on same col names
- Set operations
  - Union, intersection, set difference
- Assignment, renaming — Self join

Table.Column

Relational algebra — Examples

`Instructor(ID,name,dept_name,salary)`

- Find all faculty members from Physics who earn more than at least one faculty member from Comp.Sci.

Witness

for each Physics faculty
for each CS faculty
Check salary & report

ID	*name*	*dept_name*	*salary*
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

Instructor

Relational algebra — Examples

`Instructor(ID,name,dept_name,salary)`

- Find all faculty members from Physics who earn more than at least one faculty member from Comp.Sci.

for each Instructor
  if dept = Physics
    for each Instructor
      if dept = CS
        ∃

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Instructor

Relational algebra — Examples

`Instructor(ID,name,dept_name,salary)`

- Find all faculty members from Physics who earn more than at least one faculty member from Comp.Sci.

Self join

$$\Pi_{L\ \text{cols}}\left[\sigma_L(\text{Instructor}) \bowtie_{\theta} \sigma_R(\text{Instructor})\right]$$

all 4 cols from left

θ: L.dept_name = Physics $\wedge$
R.dept_name = Comp Sci $\wedge$
L.salary > R.salary

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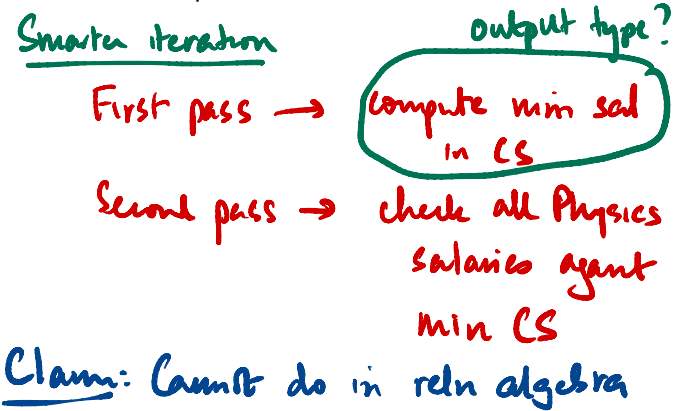
Relational algebra — Examples

`Instructor(ID,name,dept_name,salary)`

- Find all faculty members from Physics who earn more than at least one faculty member from Comp.Sci.



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98345	Kim	Elec. Eng.	80000

Instructor

Relational algebra — Examples

`Instructor(ID,name,dept_name,salary)`

- Find all faculty members from Physics who earn more than every faculty member from Comp.Sci.

Smart Iteration

1. Compute Max CS
2. Check Physics > MaxCS

Relational Algebra?

ID	*name*	*dept_name*	*salary*
10101	Srinivasan	Comp. Sci.	65000
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Instructor

Relational algebra — Examples

`Instructor(ID,name,dept_name,salary)`

- Find all faculty members from Physics who earn more than every faculty member from Comp.Sci.

Witness for exclusion from output

In Physics, earns less than someone in CS

Same as earlier self join but L.salary < R.salary

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Instructor

Relational algebra — Examples

`Instructor(ID,name,dept_name,salary)`

- Find all faculty members from Physics who earn more than every faculty member from Comp.Sci.

$$R_1 \leftarrow \Pi_{Left}\left(\rho_L(Inst.) \bowtie_{\theta_{Exclusion}} \rho_R(Inst.)\right)$$

$$R_2 \leftarrow \sigma_{dept\_name = Physics}(Inst.)$$

$$R_2 \setminus R_1$$

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Instructor

Relational algebra — Examples

`Instructor(ID,name,dept_name,salary)`

- Find the faculty member(s) with the minimum salary.

Not min ⇒ there is witness

$$NotMin = \Pi_{left}\left(\rho_L(I) \bowtie_{L.sal > R.sal} \rho_R(I)\right)$$

Instructor − NotMin

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Instructor

Relational algebra — Examples

`Instructor(ID,name,dept_name,salary)`

- Find the faculty member(s) with the minimum salary.

Min column (Relation)

Min salary (Instructor) Create new operation

Max ? L.sal < R.sal Not Max

Max col (R)

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Instructor

Relational algebra — Examples

`Instructor(ID,name,dept_name,salary)`

- Find the faculty member(s) with the minimum salary.

Min CS Set

ID	*name*	*dept_name*	*salary*
10101	Srinivasan	Comp. Sci.	65000
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15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
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Instructor

Smart Iteration

1. Find Min CS (Number)
2. Check Phy > Min CS (Hidden ×)

$\text{Instructor} \bowtie_{\theta} \pi_{\text{salary}}(\text{Min}_{\text{CS}, \text{salary}}(\text{Instructor}))$

θ:

L.dept_name = Physics ∧

L.salary > R.salary

Relational algebra — Examples

`Instructor(ID,name,dept_name,salary)`

"Grouping"

- Find the faculty member(s) with the maximum salary, department-wise.

1 row ← $\max_{CS,\,salary}$ (Instructor)

∪

1 row ← $\max_{Physic,\,salary}$ (Instructor)

∪

⋮

∪

$\max_{EE,\,salary}$ (Instructor)

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Instructor

Relational algebra — Examples

family(ID,name,gender)

~~relation(ID1,ID2,relationship)~~ only parent

- Compute the relation sister(ID1,ID2) — ID1 is a sister of ID2

Given parent(ID1, ID2)

⇓

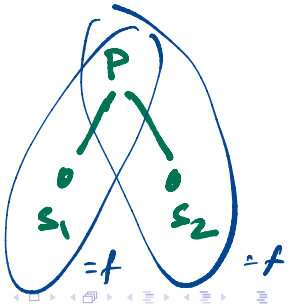
mother(ID1, ID2)?

family ⋈ $_{ID=ID_1}$ parent

∧

gender=f

$(P,S_1) \times (P,S_2) \times (S_1,f) \times (S_2,f)$

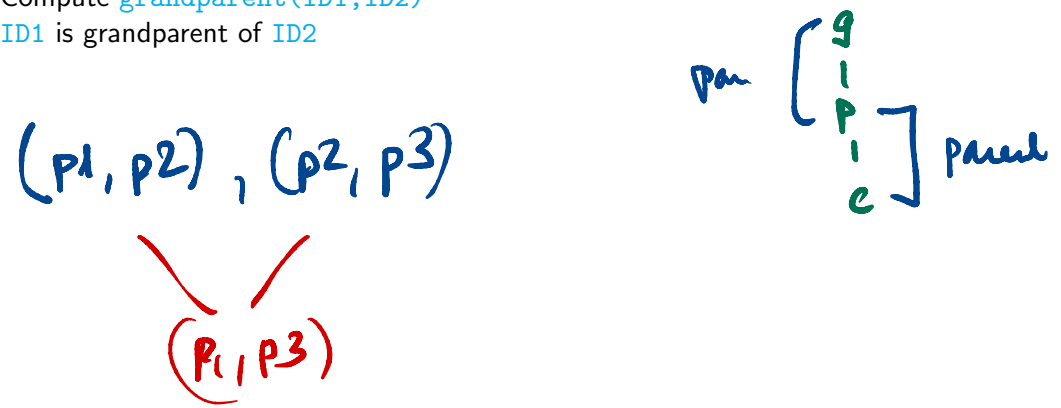


Relational algebra — Examples

`family(ID,name,gender)`

~~`relation(ID1,ID2,relationship)`~~ parent(ID1, ID2)

- Compute `grandparent(ID1,ID2)` — `ID1` is grandparent of `ID2`

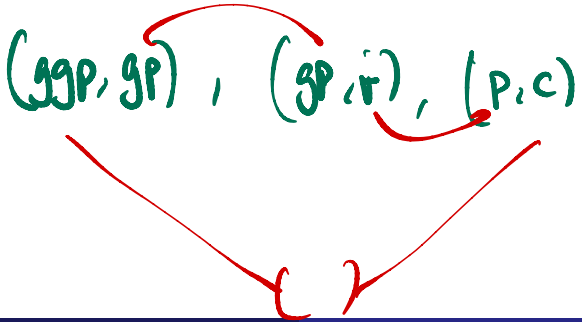


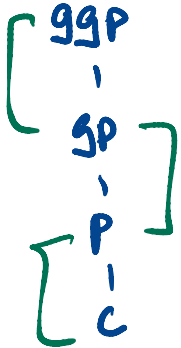
Relational algebra — Examples

`family(ID,name,gender)`

~~`relation(ID1,ID2,relationship)`~~ parent(ID1, ID2)

- Compute
  `greatgrandparent(ID1,ID2)` — `ID1` is greatgrandparent of `ID2`





Relational algebra — Examples

`family(ID,name,gender)`

~~`relation(ID1,ID2,relationship)`~~ parent (ID_1, ID_2)

- Can you compute `ancestor(ID1,ID2)` in general?

✓ parent $\cup$ grandparent $\cup$ grandgrandparent

ancestor upto 3 gens

k^{th} gen ancestor $\Rightarrow$ k-1 $\bowtie$

Relational algebra — Examples

`family(ID,name,gender)`

~~`relation(ID1,ID2,relationship)`~~ parent (ID$_1$, ID$_2$)

- Can you compute `ancestor(ID1,ID2)` in general?

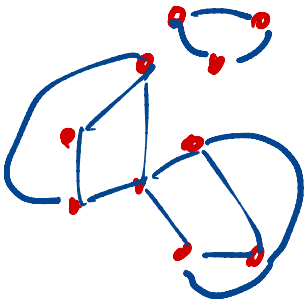
↳ Transitive Closure of Parent

Cannot be done

First Order (Predicate) logic

$\forall x \exists y \; x < y$

$\forall x \in \mathbb{R} \; \exists y \in \mathbb{R} \; x < y$



Relational algebra — Examples

`family(ID,name,gender)`
`relation(ID1,ID2,relationship)`

- Can you compute `ancestor(ID1,ID2)` in general?

$\vee$ $\exists x$
$\wedge$ $\forall x$
$\neg$

$R(x,y)$ $P(x,y,z)$

Transitive closure is not expressible in First Order logic (FOL)

Relational Algebra is complete w.r.t. FOL queries