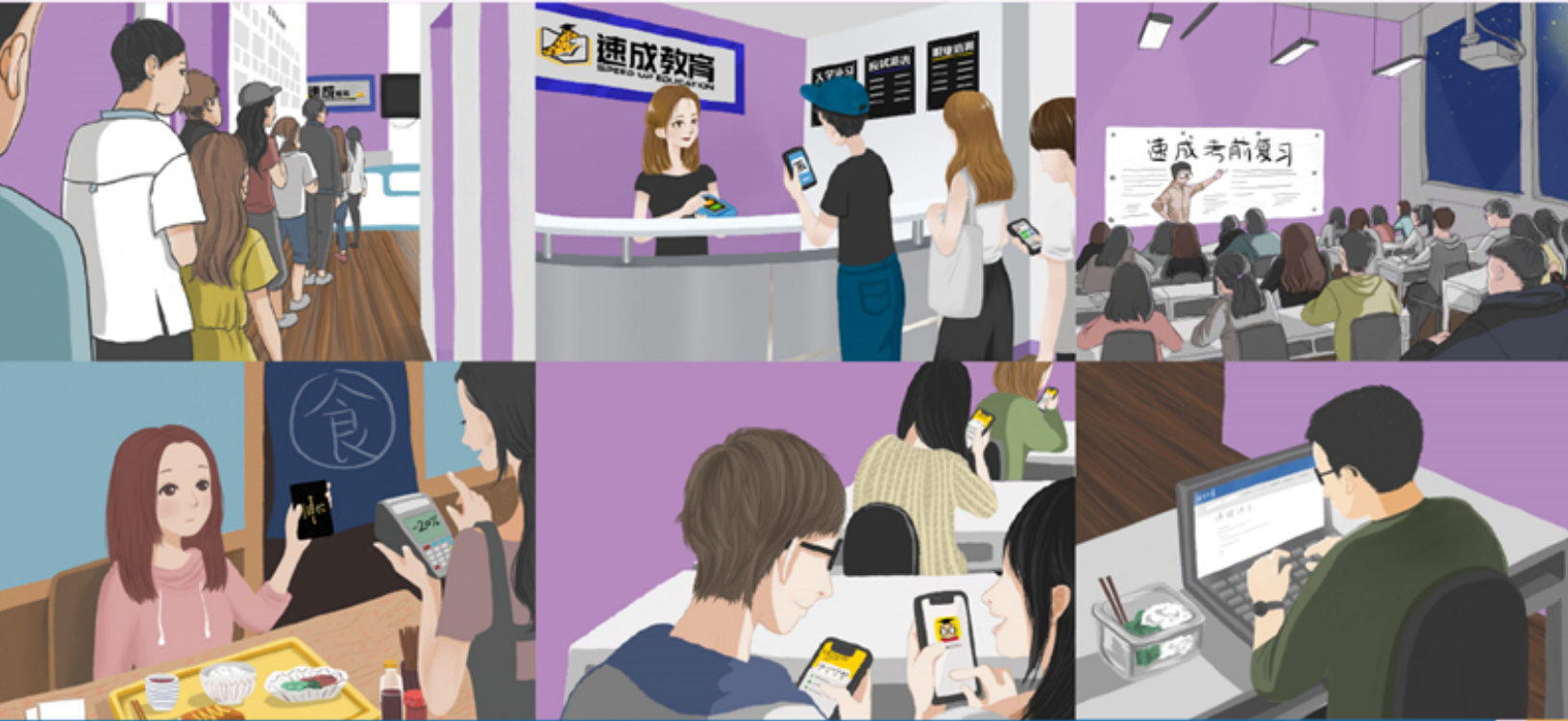




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# CSCB20

## Introduction to Database & Web Applications

导师： VC

UTSC Week 02 Relational Algebra Example I | 2024/1/21

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## Relational Algebra 練習

A Sample Database:

Employee

Number	Name	Age	Salary
101	Mary Smith	34	40
103	Mary Bianchi	23	35
104	Luigi Neri	38	61
105	Nico Bini	44	38
210	Marco Celli	49	60
231	Siro Bisi	50	60
252	Nico Bini	44	70
301	Steve Smith	34	70
375	Mary Smith	50	65

Supervision

Head	Emp
210	101
210	103
210	104
231	105
301	210
301	231
375	252

In fact, only the *database schema* is needed.

**Employees(**Number,Name,Age,Salary**)**

**Supervision(**Head,Emp**)**

Examples

1. “Find the numbers, names and ages of employees earning more than 40K”
2. “Find the registration numbers of the supervisors of the employees earning more than 40K.”
3. “Find the names and salaries of the supervisors of the employees earning more than 40K.”
4. “Find the employees earning more than their respective supervisors;  
return registration numbers, names and salaries of the employees and their supervisors.”
5. “Find registration numbers and names of supervisors, all of whose employees earn more than 40K.”
6. “Find the employees earning **maximum** salary.”
7. "Find all locations that have at **least two** employees earning more than 40K"

### Example 1:

“Find the numbers, names and ages of employees earning more than 40K”

Employees(Number,Name,Age,Salary)  
 Supervision(Head,Emp)

Number	Name	Age
104	Luigi Neri	38
210	Marco Celli	49
231	Siro Bisi	50
252	Nico Bini	44
301	Steve Smith	34
375	Mary Smith	50

$\pi$  Number, Name, Age ( $\delta_{\text{Salary} > 40}(\text{Employees})$ )

$R_1 := \delta_{\text{Salary} > 40}(\text{Employees})$

$R_2 := \pi \text{ Number, Name, Age } (R_1)$

### Example 2:

“Find the registration numbers of the supervisors of the employees earning more than 40K.”

Employees(Number,Name,Age,Salary)  
 Supervision(Head,Emp)

Head
210
301
375

$R_1 := \delta_{\text{Salary} > 40}(\text{Employees})$

$R_2 := \text{Supervision} \bowtie_{(\text{Emp} = \text{Number})} R_1$

$R_3 := \pi \text{ Head } (R_2)$

Head	Number	Name	Age	Salary
210	101	Mary Smith	34	40
210	103	Mary Bianchi	23	35
210	104	Luigi Neri	38	61
231	105	Nico Bini	44	38
301	210	Marco Celli	49	60
301	231	Siro Bisi	50	60
375	252	Nico Bini	44	70
375	301	Steve Smith	34	70
375	375	Mary Smith	50	65

Head	Emp
210	101
210	103
210	104
231	105
301	210
301	231
375	252

### Example 3:

“Find the names and salaries of the supervisors of the employees earning more than 40K.”

Employees(Number,Name,Age,Salary)  
 Supervision(Head,Emp)

NameH	SalaryH
Marco Celli	60
Steve Smith	70
Mary Smith	65

$R1 := \sigma_{\text{Salary} > 40}(\text{Employees})$

$R2 := \text{Supervision} \bowtie_{(\text{Emp} = \text{Number})} R1$

$R3 := \pi_{\text{Head}} R2$

$R4 := R3 \bowtie_{(\text{Head} = \text{Number})} \text{Employees}$

$R5 := \pi_{\text{name, salary}} R4$

Number	Name	Age	Salary
101	Mary Smith	34	40
103	Mary Bianchi	23	35
104	Luigi Neri	38	61
105	Nico Bini	44	38
210	Marco Celli	49	60
231	Siro Bisi	50	60
252	Nico Bini	44	70
301	Steve Smith	34	70
375	Mary Smith	50	65

Head	Emp
210	101
210	103
210	104
231	105
301	210
301	231
375	252

### Example 4:

“Find the employees earning more than their respective supervisors;  
 return registration numbers, names and salaries of the employees and their supervisors.”

Employees(Number,Name,Age,Salary)  
 Supervision(Head,Emp)

Number	Name	Salary	NumH	NameH	SalH
104	Luigi Neri	61	210	Marco Celli	60
252	Nico Bini	70	375	Mary Smith	65

$R1 := \pi_{\text{number, name, salary}}(\text{Employees})$

$R2 := \text{Supervision} \bowtie_{(\text{Emp} = \text{Number})} R1$

$R3 := \rho(\text{Number, name, salary} \rightarrow \text{NumH, NameH, SalH}) R1$

$R4 := R2 \bowtie_{\text{Head} = \text{NumH}} R3$

$R5 := \sigma_{\text{salary} > \text{SalH}} R4$

$R6 := \pi_{\text{Number, Name, Salary, NumH, NameH, SalH}}(R5)$

R3

NumH	NameH	SalH
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R2

Number	Name	salary	Emp	Head	NumH	NameH	SalH

R3

R4

Number	Name	Age	Salary
101	Mary Smith	34	40
103	Mary Bianchi	23	35
104	Luigi Neri	38	61
105	Nico Bini	44	38
210	Marco Celli	49	60
231	Siro Bisi	50	60
252	Nico Bini	44	70
301	Steve Smith	34	70
375	Mary Smith	50	65

Head	Emp
210	101
210	103
210	104
231	105
301	210
301	231
375	252

### Example 5:

“Find registration numbers and names of supervisors, all of whose employees earn more than 40K.”

Employees(Number, Name, Age, Salary)  
 Supervision(Head, Emp)

Number	Name
301	Steve Smith
375	Mary Smith

$R_1 := \sigma_{\text{salary} \leq 40}(\text{Employees})$

$R_2 := \pi_{\text{head}}(\text{Supervision} \bowtie_{\text{Emp} = \text{Number}} R_1)$

$R_3 := \pi_{\text{head}} \text{Supervision}$

$R_4 := R_3 - R_2$

$R_5 := \text{Employees} \bowtie_{\text{Number} = \text{Head}} R_4$

$R_6 := \pi_{\text{number}, \text{Name}} R_5$

Head  
 [ ]  
 [ ]  
 [ ]  
 [ ]

Number	Name	Age	Salary
101	Mary Smith	34	40
103	Mary Bianchi	23	35
104	Luigi Neri	38	61
105	Nico Bini	44	38
210	Marco Celli	49	60
231	Siro Bisi	50	60
252	Nico Bini	44	70
301	Steve Smith	34	70
375	Mary Smith	50	65

Head	Emp
210	101
210	103
210	104
231	105
301	210
301	231
375	252

Example 6:

**Example 6:**

"Find the employees earning **maximum** salary."

Employees(Number,Name,Age,Salary)  
 Supervision(Head,Emp)

Number	Salary
1	50
2	70
3	60
4	75
5	60

Number
252
301

R1 :=  $\sigma$  A Employees

R2 :=  $\sigma$  B Employees

R3 := R1  $\times$  R2

R4 :=  $\sigma$  A.salary > B.salary R3

R5 :=  $\pi$  B.salary R4 没有最大 (75)

R6 :=  $\pi$  salary Employees 全部

R7 := R6 - R5 只有 75

R8 :=  $\pi$  Name (Employees  $\bowtie$  R7)  
 (Salary = salary)

A.Number	A.Salary	B.Number	B.Salary
1	50	1	50
1	50	2	70
1	50	3	60
1	50	4	75
1	50	5	60
2	70	1	50
2	70	2	70
2	70	3	60
2	70	4	75
2	70	5	60
3	60	1	50
3	60	2	70
3	60	3	60
3	60	4	75
3	60	5	60
4	75	1	50
4	75	2	70
4	75	3	60
4	75	4	75
4	75	5	60
5	60	1	50
5	60	2	70
5	60	3	60
5	60	4	75
5	60	5	60



Loc

Number	Name	Age	Salary
101	Mary Smith	34	40
103	Mary Bianchi	23	35
104	Luigi Neri	38	61
105	Nico Bini	44	<del>30</del> 41
210	Marco Celli	49	60
231	Siro Bisi	50	60
252	Nico Bini	44	70
301	Steve Smith	34	70
375	Mary Smith	50	65

666
V C
50
70

Head	Emp
210	101
210	103
210	104
231	105
301	210
301	231
375	252

A.Number	A.Name	A.Loc	A.Sal	B.Number	B.Name	B.Loc	B.Sal
105	...	44	...	252	..	44	..
231		50		375		50	
231		50		666		50	
375		50		666		50	

**Example 7:**

"Find all locations that have at least two employees earning more than 40K"

Employees(Number,Name,Loc,Salary)  
 Supervision(Head,Emp)

Assume that in the schema we have 'Loc' instead of 'Age' for this example only.

$R1 := \sigma_{Salary > 40} Employees$

$R2 := \rho_A R1$

$R3 := \rho_B R1$

$R4 := R2 \bowtie (A.Loc = B.Loc \wedge A.Number \neq B.Number) R3$

$R5 := \pi_{A.Loc} R4$

Exactly 2

$R6 := \rho_C R1$

$R7 := R4 \bowtie (A.Loc = C.Loc \wedge A.Number \neq C.Number \wedge B.Number \neq C.Number) R6$

$R8 := R4 - R7$       at least 2    -    at least 3    = exactly 2

$R9 := \pi_{A.Loc} R8$

Number	Name	Age	Salary	Head	Emp
101	Mary Smith	34	40	210	101
103	Mary Bianchi	23	35	210	103
104	Luigi Neri	38	61	210	104
105	Nico Bini	44	38	231	105
210	Marco Celli	49	60	301	210
231	Siro Bisi	50	60	301	231
252	Nico Bini	44	70	375	252
301	Steve Smith	34	70		
375	Mary Smith	50	65		

## Helpful Tips

- ◆ To show “**max**” (**min**)
  - Pair tuples (self-join) and find those that are not the max
  - Then subtract from all to find the max[es]
- ◆ To show “**k or more**”:
  - Make all combos of k different tuples that meet the required condition
- ◆ To show “**exactly k**”:
  - Find “k or more”
  - Find “(k+1) or more”
  - Then subtract “(k+1) or more” from “k or more”