An Algebra for Relations

Contents

- Fundamental operations of Relational algebra
  - Select
  - Project
  - Union
  - Set different
  - Cartesian product
  - Join
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Introduction

- Relational database systems are expected to be equipped by a query language that can assist its user to query the database instances.
  - There are two kinds of query languages,
    - relational algebra and relational calculus.
- Relational algebra is a procedural query language,
  - Takes instances of relations as input and yields instances of relations as output.
  - It uses operators to perform queries.

code	name	desig	sup	joindate	basic	sex	dept
7369	SHAH	CLRK	7902	17-DEC-80	800	M	PRCH
7499	ROY	SLMN	7698	20-FEB-81	1600	M	SALE
7521	WILSON	MNGR	7698	22-FEB-81	1250	M	STOR
7566	JAIN	MNGR	7839	2-APR-81	2975	F	PRCH
7654	GUPTA	SLMN	7698	28-SEP-81	1250	M	SALE
7698	MURTHY	MNGR	7839	1-MAY-81	2850	F	SALE
7782	MENON	MNGR	7839	9-JUN-81	2450	M	ACCT
7788	KHAN	SPRV	7566	09-DEC-82	3000	M	PRCH
7839	REDDY	PRES		17-NOV-81	5000	M	ACCT
7844	SINGH	SLMN	7698	8-SEP-81	1500	F	SALE
7876	PATIL	CLRK	7788	12-JAN-83	1100	M	PRCH
7900	SHROFF	CLRK	7698	3-DEC-81	950	M	SALE
7902	NAIK	MNGR	7839	3-DEC-81	4000	M	PRCH
7934	KAUL	CLRK	7782	23-JAN-82	1300	M	ACCT

code	name	desig	sup	join	basic	sex	dept
7369	SHAH	CLRK	7902	17-DEC-80	800	M	PRCH
7499	ROY	SLMN	7698	20-FEB-81	1600	M	SALE
7521	WILSON	MNGR	7698	22-FEB-81	1250	M	STOR
7566	JAIN	MNGR	7839	2-APR-81	2975	F	PRCH
7654	GUPTA	SLMN	7698	28-SEP-81	1250	M	SALE
7698	MURTHY	MNGR	7839	1-MAY-81	2850	F	SALE
7782	MENON	MNGR	7839	9-JUN-81	2450	M	ACCT
7788	KHAN	SPRV	7566	09-DEC-82	3000	M	PRCH
7839	REDDY	PRES		17-NOV-81	5000	M	ACCT
7844	SINGH	SLMN	7698	8-SEP-81	1500	F	SALE
						M	PRCH
						M	SALE
						M	PRCH
						M	ACCT

selection

$\sigma_{\text{basic} > 1500}$ emp

code	name	desig	sup	join	basic	sex	dept
7369	SHAH	CLRK	7902	17-DEC-80	800	M	PRCH
7499	ROY	SLMN	7698	20-FEB-81	1600	M	SALE
7521	WILSON	MNGR	7698	22-FEB-81	1250	M	STOR
7566	JAIN	MNGR	7839	2-APR-81	2975	F	PRCH
7654	GUPTA	SLMN	7698	28-SEP-81	1250	M	SALE
7698	MURTHY	MNGR	7839	1-MAY-81	2850	F	SALE
7782	MENON	MNGR	7839	9-JUN-81	2450	M	ACCT
7788	KHAN	SPRV	7566	09-DEC-82	3000	M	PRCH
7839	REDDY	PRES		17-NOV-81	5000	M	ACCT
7844	SINGH	SLMN	7698	8-SEP-81	1500	F	SALE
						M	PRCH
						M	SALE
						M	PRCH
						M	ACCT

selection

$\sigma_{\text{basic} > 1500}(\text{emp})$

code	name	desig	sup	join	basic	sex	dept
7499	ROY	SLMN	7698	20-FEB-81	1600	M	SALE
7566	JAIN	MNGR	7839	2-APR-81	2975	F	PRCH
7698	MURTHY	MNGR	7839	1-MAY-81	2850	F	SALE
7782	MENON	MNGR	7839	9-JUN-81	2450	M	ACCT
7788	KHAN	SPRV	7566	09-DEC-82	3000	M	PRCH
7839	REDDY	PRES		17-NOV-81	5000	M	ACCT
7902	NAIK	MNGR	7839	3-DEC-81	4000	M	PRCH

selection

$\sigma_{\text{basic} > 1500}(\text{emp})$

code	name	desig	sup	join	basic	sex	dept
7369	SHAH	CLRK	7902	17-DEC-80	800	M	PRCH
7499	ROY	SLMN	7698	20-FEB-81	1600	M	SALE
7521	WILSON	MNGR	7698	22-FEB-81	1250	M	STOR
7566	JAIN	MNGR	7839	2-APR-81	2975	F	PRCH
7654	GUPTA	SLMN	7698	28-SEP-81	1250	M	SALE
7698	MURTHY	MNGR	7839	1-MAY-81	2850	F	SALE
7782	MENON	MNGR	7839	9-JUN-81	2450	M	ACCT
7788	KHAN	SPRV	7566	09-DEC-82	3000	M	PRCH
7839	REDDY	PRES		17-NOV-81	5000	M	ACCT
7844	SINGH	SLMN	7698	8-SEP-81	1500	F	SALE
						M	PRCH
						M	SALE
						M	PRCH
						M	ACCT

projection

π name,basic,dept **emp**

code	name	desig	sup	join	asic	sex	dept
7369	SHAH	CLRK	7902	17-DEC-80	800	M	PRCH
7499	ROY	SLMN	7698	20-FEB-81	1600	M	SALE
7521	WILSON	MNGR	7698	22-FEB-81	1250	M	STOR
7566	JAIN	MNGR	7839	2-APR-81	2975	F	PRCH
7654	GUPTA	SMN	7698	28-SEP-81	1250	M	SALE
7698	MURTHY	MNGR	7839	1-MAY-81	2850	F	SALE
7782	MENON	MNGR	7839	9-JUN-81	2450	M	ACCT
7788	KHAN	SPRV	7566	09-DEC-82	3000	M	PRCH
						M	ACCT
						F	ALE
						M	PRCH
						M	SALE
						M	PRCH
						M	ACCT

projection

π name,basic,dept **emp**

name	basic	dept
SHAH	800	PRCH
ROY	1600	SALE
WILSON	1250	STOR
JAIN	2975	PRCH
GUPTA	1250	SALE
MURTHY	2850	SALE
MENON	2450	ACCT
KHAN	3000	PRCH
		ACCT
		SALE
		PRCH
		SALE
		PRCH
		ACCT

projection

$\pi_{\text{name,basic,dept}}$ **emp**

projection

π_{dept} emp

dept
PRCH
SALE
STOR
PRCH
SALE
SALE
ACCT
PRCH
ACCT
SALE
PRCH
SALE
PRCH
ACCT

In a relation, duplicate tuples are not allowed!!!

projection

π_{dept} emp

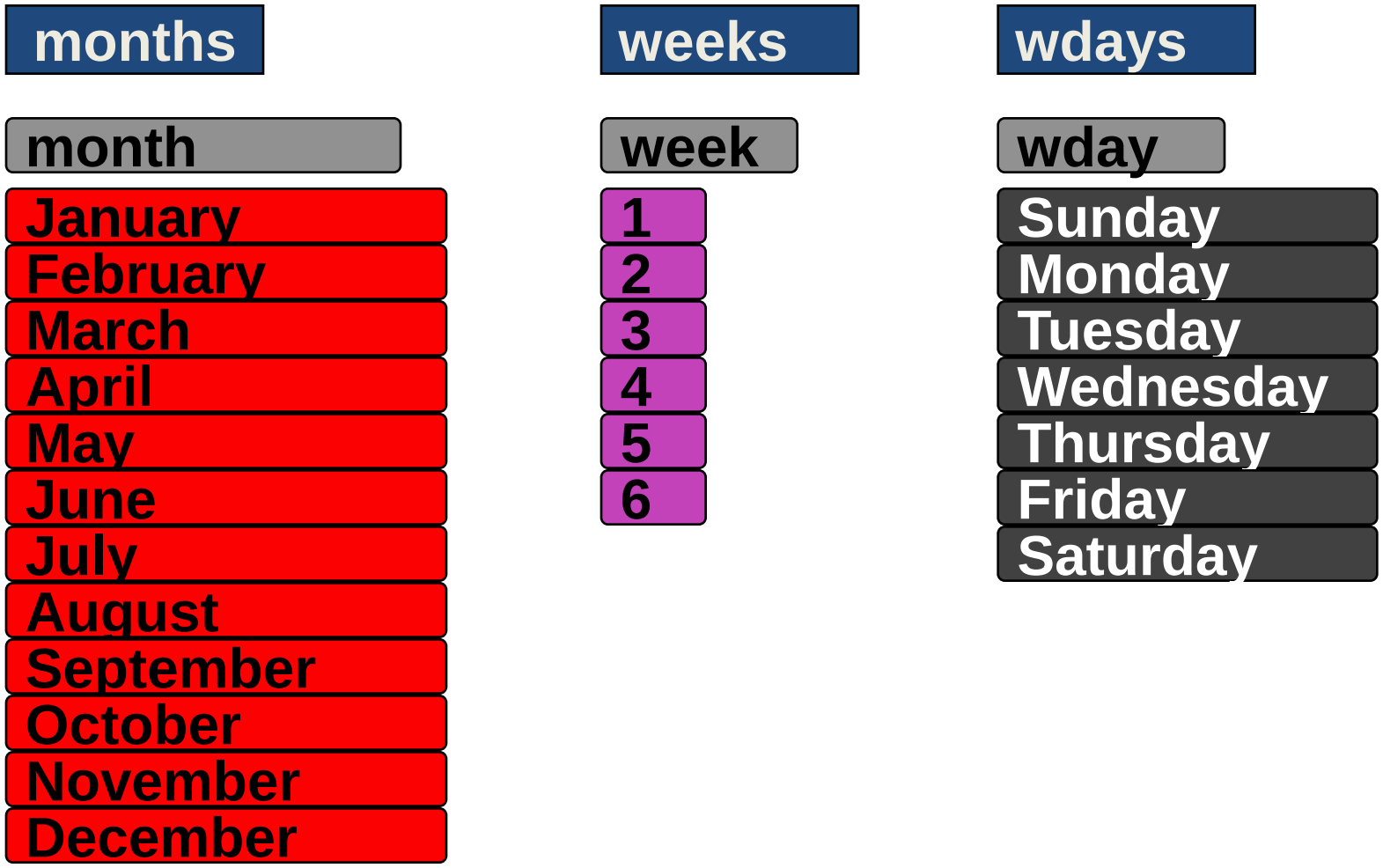
dept
PRCH
SALE
STOR
PRCH
SALE
SALE
ACCT
PRCH
ACCT
SALE
PRCH
SALE
PRCH
ACCT

dept
PRCH
SALE
STOR
ACCT

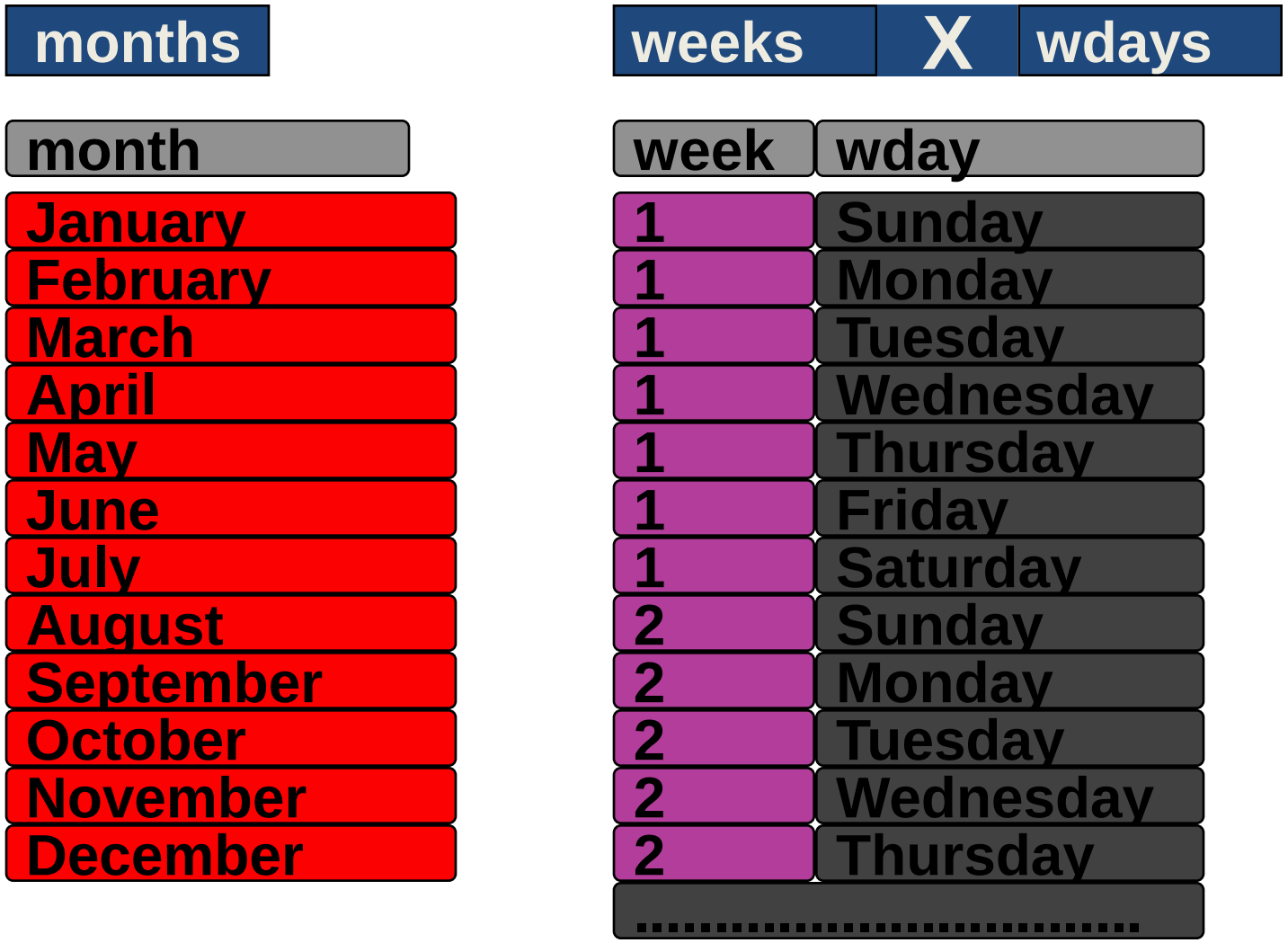
duplicate tuples removed in the last substep of projection!

projection

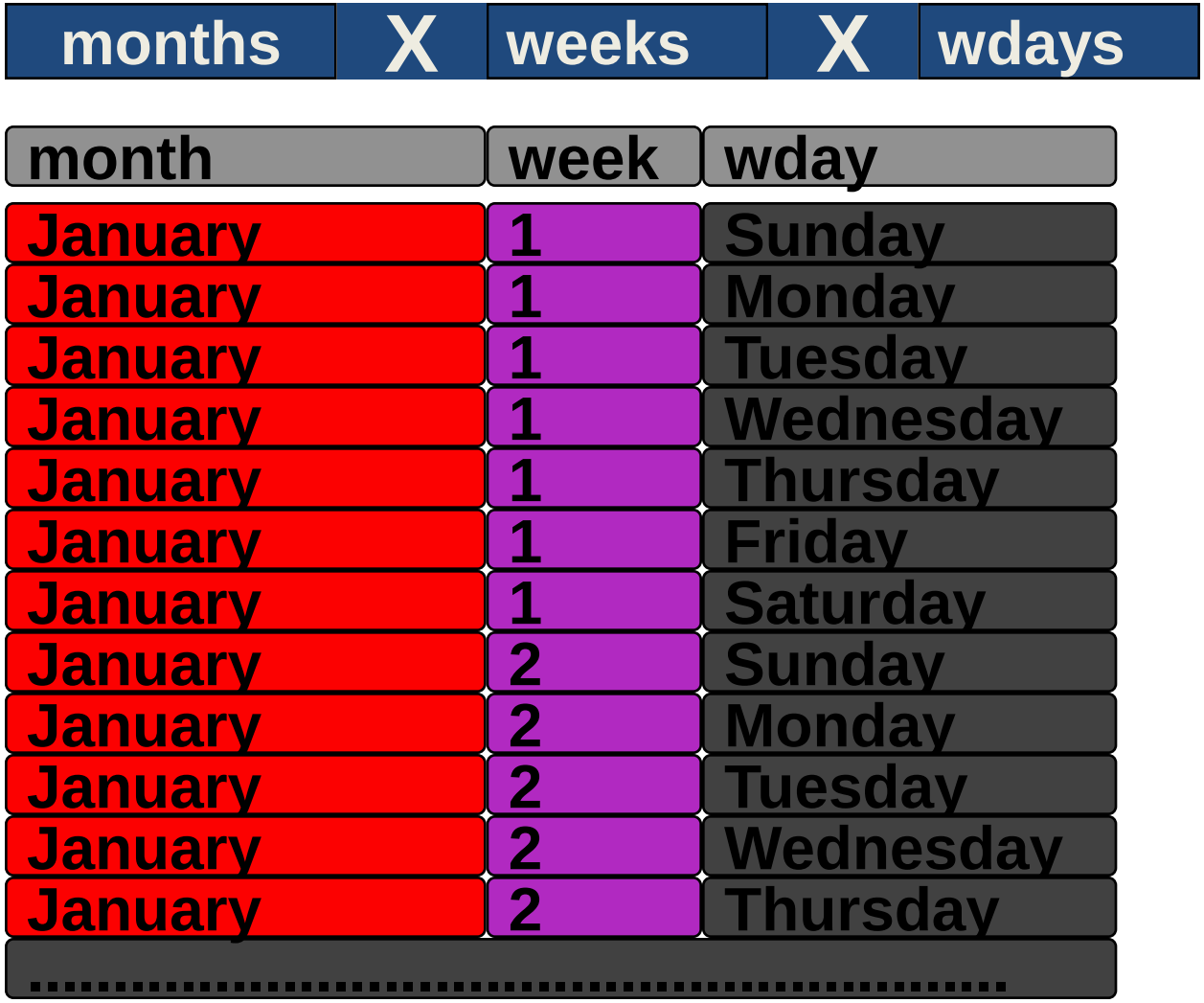
$$\pi_{\text{dept}}\ \text{emp}$$



Product Operator X



Product Operator X



Product Operator X

Theta (θ) join

- θ in Theta join is the join condition.
- Theta joins combines tuples from different relations provided they satisfy the theta condition.
- R1 ⋈θ R2
- R1 and R2 are relations with their attributes (A1, A2, .., An) and (B1, B2,.. ,Bn) such that no attribute matches that is R1 ∩ R2 = Φ Here θ is condition in form of set of conditions C.

emp

code	name	sal	dept
7369	SHAH	800	PRCH
7499	ROY	1600	SALE
7521	WILSON	1250	STOR
7566	JAIN	2975	PRCH
7654	GUPTA	1250	SALE
7698	MURTHY	2850	SALE
7782	MENON	2450	ACCT
7788	KHAN	3000	PRCH
7839	REDDY	5000	ACCT
7844	SINGH	1500	SALE
7876	PATIL	1100	PRCH
7900	SHROFF	950	SALE
7902	NAIK	4000	PRCH

deptavg

depc	name	avsal
PRCH	purch	2375
SALE	sales	1630
STOR	stores	1250
ACCT	accou	2850

emp

$\bowtie$ dept = depc and sal > avsal

deptavg

Theta Join Operator

emp

code	name	sal	dept
7369	SHAH	800	PRCH
7499	ROY	1600	SALE
7521	WILSON	1250	STOR
7566	JAIN	2975	PRCH
7654	GUPTA	1250	SALE
7698	MURTHY	2850	SALE
7782	MENON	2450	ACCT
7788	KHAN	3000	PRCH
7839	REDDY	5000	ACCT
7844	SINGH	1500	SALE
7876	PATIL	1100	PRCH
7900	SHROFF	950	SALE
7902	NAIK	4000	PRCH

deptavg

depc	name	avsal
PRCH	purch	2375
SALE	sales	1630
STOR	stores	1250
ACCT	accou	2850

emp

$\bowtie$ dept = depc and sal > avsal

deptavg

Theta Join Operator

emp

code	name	sal	dept
7369	SHAH	800	PRCH
7566	JAIN	2975	PRCH
7788	KHAN	3000	PRCH
7876	PATIL	1100	PRCH
7902	NAIK	4000	PRCH

deptavg

depc	name	avsal
PRCH	purch	2375

emp

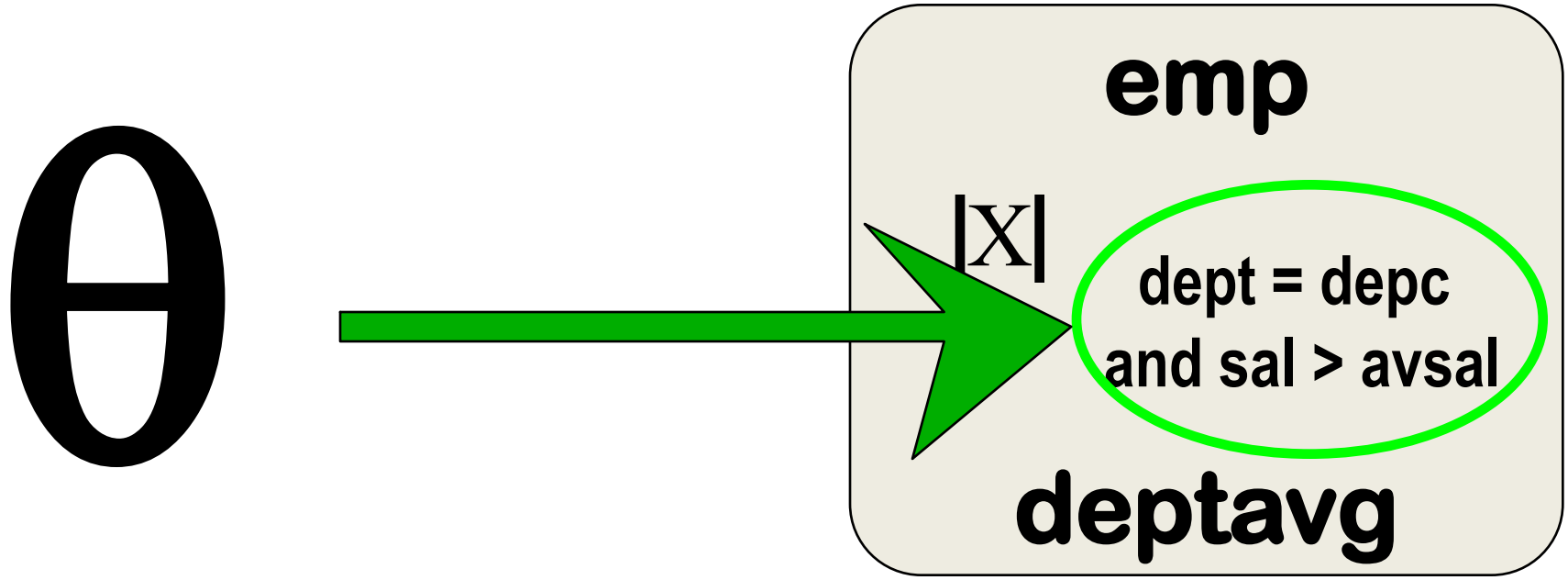
$\bowtie$ dept = depc and sal > avsal

deptavg

Theta Join Operator

result

code	name	sal	dept	depc	name	avsal
7566	JAIN	2975	PRCH	PRCH	purch	2375
7788	KHAN	3000	PRCH	PRCH	purch	2375
7902	NAIK	4000	PRCH	PRCH	purch	2375
.....						



θ in Theta join is the join condition.

Equi-Join

- When Theta join uses only equality comparison operator it is said to be Equi-Join

emp

code	name	sal	dept
7369	SHAH	800	PRCH
7499	ROY	1600	SALE
7521	WILSON	1250	STOR
7566	JAIN	2975	PRCH
7654	GUPTA	1250	SALE
7698	MURTHY	2850	SALE
7782	MENON	2450	ACCT
7788	KHAN	3000	PRCH
7839	REDDY	5000	ACCT
7844	SINGH	1500	SALE
7876	PATIL	1100	PRCH
7900	SHROFF	950	SALE
7902	NAIK	4000	PRCH

dept

depc	name
PRCH	purch
SALE	sales
STOR	stores
ACCT	accou

emp

$|X|$

dept = depc

dept

Equi-Join Operator

result

code	name	sal	dept	depc	dname
7369	SHAH	800	PRCH	PRCH	purch
7499	ROY	1600	SALE	SALE	sales
7521	WILSON	1250	STOR	STOR	stores
7566	JAIN	2975	PRCH	PRCH	purch
7654	GUPTA	1250	SALE	SALE	sales
7698	MURTHY	2850	SALE	SALE	sales
7782	MENON	2450	ACCT	ACCT	accou
7788	KHAN	3000	PRCH	PRCH	purch
7839	REDDY	5000	ACCT	ACCT	accou
7844	SINGH	1500	SALE	SALE	sales
7876	PATIL	1100	PRCH		
7900	SHROFF	950	SALE		
7902	NAIK	4000	PRCH		

Equi-Join Operator

emp

$|X|$

dept = depc

dept

Natural Join (⋈)

- Natural join does not use any comparison operator.
- It does not concatenate the way Cartesian product does.
- Natural Join can only be performed if there is at least one common attribute exists between relation.
  - Those attributes must have same name and domain.

emp

code	name	sal	dept
7369	SHAH	800	PRCH
7499	ROY	1600	SALE
7521	WILSON	1250	STOR
7566	JAIN	2975	PRCH
7654	GUPTA	1250	SALE
7698	MURTHY	2850	SALE
7782	MENON	2450	ACCT
7788	KHAN	3000	PRCH
7839	REDDY	5000	ACCT
7844	SINGH	1500	SALE
7876	PATIL	1100	PRCH
7900	SHROFF	950	SALE
7902	NAIK	4000	PRCH

dept

dept	dname
PRCH	purch
SALE	sales
STOR	stores
ACCT	accou

Natural Join Operator

Relational Algebra

emp
|x|
dept

result

code	name	sal	dept	dname
7369	SHAH	800	PRCH	purch
7499	ROY	1600	SALE	sales
7521	WILSON	1250	STOR	stores
7566	JAIN	2975	PRCH	purch
7654	GUPTA	1250	SALE	sales
7698	MURTHY	2850	SALE	sales
7782	MENON	2450	ACCT	accou
7788	KHAN	3000	PRCH	purch
7839	REDDY	5000	ACCT	accou
7844	SINGH	1500	SALE	sales
7876	PATIL	1100	PRCH	purch
7900	SHROFF	950	SALE	
7902	NAIK	4000	PRCH	

Natural Join Operator

Relational Algebra

emp

$|x|$

dept

Outer Join

- Theta Join, Equi Join and Natural Join are called inner-joins.
  - An inner-join process includes only tuples with matching attributes, rest are discarded in resulting relation.
- There are three kinds of outer joins:
  - Left outer join
  - Right outer join
  - Full outer join

emp

code	name	sal	dept
7369	SHAH	800	PRCH
7499	ROY	1600	SALE
7521	WILSON	1250	STOR
7566	JAIN	2975	POOL
7654	GUPTA	1250	SALE
7698	MURTHY	2850	SALE
7782	MENON	2450	ACCT
7788	KHAN	3000	PRCH
7839	REDDY	5000	ACCT
7844	SINGH	1500	SALE
7876	PATIL	1100	PRCH
7900	SHROFF	950	SALE
7902	NAIK	4000	PRCH

dept

dept	dname
PRCH	purch
SALE	sales
STOR	stores
ACCT	accou
INFO	info.Se

emp
|X|
dept

result

code	name	sal	dept	dname
7369	SHAH	800	PRCH	purch
7499	ROY	1600	SALE	sales
7521	WILSON	1250	STOR	stores
7654	GUPTA	1250	SALE	sales
7698	MURTHY	2850	SALE	sales
7782	MENON	2450	ACCT	accou
7788	KHAN	3000	PRCH	purch
7839	REDDY	5000	ACCT	accou
7844	SINGH	1500	SALE	sales
7876	PATIL	1100	PRCH	purch
7900	SHROFF	950	SALE	
7902	NAIK	4000	PRCH	

emp

|x|

dept

Left Outer Join

- All tuples of Left relation, R, are included in the resulting relation and if there exists tuples in R without any matching tuple in S then the S-attributes of resulting relation are made NULL.

result

code	name	sal	dept	dname
7369	SHAH	800	PRCH	purch
7499	ROY	1600	SALE	sales
7521	WILSON	1250	STOR	stores
7566	JAIN	2975	POOL	
7654	GUPTA	1250	SALE	sales
7698	MURTHY	2850	SALE	sales
7782	MENO		ACCT	accou
7788	K		CH	purch
7839				accou
7844				sales
7876			H	purch
7900				
7902			CH	

No entry for info.
services dept
in the result

Left Outer Join Operator

emp ⟕ dept

Right outer Join

- All tuples of the Right relation, S, are included in the resulting relation and if there exists tuples in S without any matching tuple in R then the R-attributes of resulting relation are made NULL.

result

code	name	sal	dept	dname
7369	SHAH	800	PRCH	purch
7499	ROY	1600	SALE	sales
7521	WILSON	1250	STOR	stores
			INFO	info.Se
7654	GUPTA	1250	SALE	sales
7698	MURTHY	2850	SALE	sales
7782	MENON	2450	ACCT	accou
7788	KHAN		PRCH	purch
7839	R		CCT	accou
7844			E	sales
7876				purch
7900				
7902	N		RCH	

No entry for Jain in the result

Right Outer Join Operator

$$emp \overset{R}{\bowtie} dept$$

Full Outer Join

- All tuples of both participating relations are included in the resulting relation and if there no matching tuples for both relations, their respective unmatched attributes are made NULL.

result

code	name	sal	dept	dname
7369	SHAH	800	PRCH	purch
7499	ROY	1600	SALE	sales
7521	WILSON	1250	STOR	stores
			INFO	info.Se
7566	JAIN	2975	POOL	
7654	GUPTA	1250	SALE	sales
7698	MURTHY	2850	SALE	sales
7782	MENC		ACCT	accou
7839	R		CCT	accou
7844			E	sales
7876				purch
7900				
7902	N		RCH	

Neither emp
nor dept info.
missed out
in the result

Full Outer Join Operator

emp ⟗ dept

Union Operation (U)

- For a union operation to be valid, the following conditions must hold:
  - r, s must have same number of attributes.
  - Attribute domains must be compatible.

ssad_trainee

code	name
7499	ROY
7654	GUPTA
7782	MENON
7788	KHAN
7839	REDDY
7844	SINGH
7876	PATIL

asd_trainee

code	name
7369	SHAH
7499	ROY
7521	WILSON
7566	JAIN
7654	GUPTA
7698	MURTHY

ssad_trainee

$\cup$

asd_trainee

Union Operator

ssad_trainee

code	name
7499	ROY
7654	GUPTA
7782	MENON
7788	KHAN
7839	REDDY
7844	SINGH
7876	PATIL

asd_trainee

code	name
7369	SHAH
7499	ROY
7521	WILSON
7566	JAIN
7788	KHAN
7698	MURTHY

ssad_trainee

$\cup$

asd_trainee

Union Operator

trainee

code	name
7499	ROY
7654	GUPTA
7782	MENON
7788	KHAN
7839	REDDY
7844	SINGH
7876	PATIL
7369	SHAH
7521	WILSON
7566	JAIN
7698	MURTHY

ssad_trainee

∪

asd_trainee

Union Operator

ssad_trainee

code	name
7499	ROY
7654	GUPTA
7782	MENON
7788	KHAN
7839	REDDY
7844	SINGH
7876	PATIL

asd_trainee

code	name
7369	SHAH
7499	ROY
7521	WILSON
7566	JAIN
7788	KHAN
7698	MURTHY

ssad_trainee

∩

asd_trainee

Intersection Operator

lucky_trainee

code	name
7499	ROY
7788	KHAN

ssad_trainee

∩

asd_trainee

Intersection Operator

ssad_trainee

code	name
7499	ROY
7654	GUPTA
7782	MENON
7788	KHAN
7839	REDDY
7844	SINGH
7876	PATIL

asd_trainee

code	name
7369	SHAH
7499	ROY
7521	WILSON
7566	JAIN
7788	KHAN
7698	MURTHY

ssad_trainee

—

asd_trainee

Difference Operator

senior_trainee	
code	name
7654	GUPTA
7782	MENON
7839	REDDY
7844	SINGH
7876	PATIL

ssad_trainee

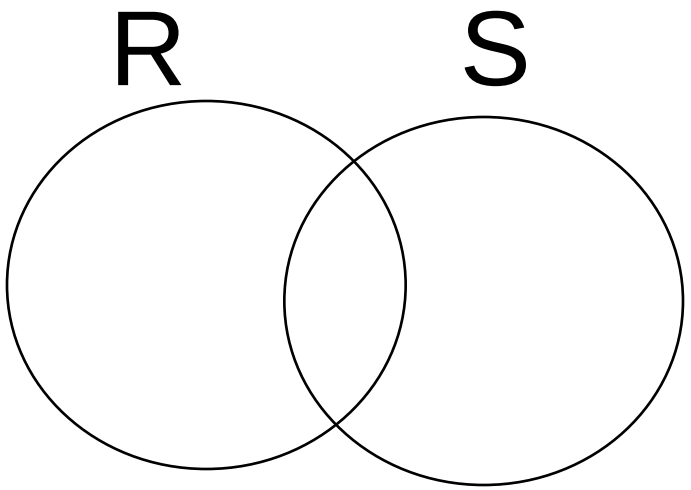
—

asd_trainee

Difference Operator

Intersection using UNION, DIFF

$$R \cap S \equiv (r \cup S) - ((R - S) \cup (S - R))$$



A Complete set:

$\sigma \quad \pi \quad \cup \quad - \quad \times$

trained

code	course
7654	SSAD
7782	SD
7782	SSAD
7782	ASD
7839	ASD
7839	SD
7839	SSAD
7839	US
7844	ASD
7844	SD
7844	US
7876	ASD
7876	SSAD

skills

course
SD
ASD
SSAD

Trained

÷

skills

Division Operator

trained	
code	course
7654	SSAD
7782	SD
7782	SSAD
7782	ASD
7839	ASD
7839	SD
7839	SSAD
7839	US
7844	ASD
7844	SD
7844	US
7876	ASD
7876	SSAD

skills
course
SD
ASD
SSAD

result
code

Trained
÷
skills

Division Operator

trained	
code	course
7654	SSAD
7782	SD
7782	SSAD
7782	ASD
7839	ASD
7839	SD
7839	SSAD
7839	US
7844	ASD
7844	SD
7844	US
7876	ASD
7876	SSAD

skills
course
SD
ASD
SSAD

result
code
7782

Trained
÷
skills

Division Operator

trained	
code	course
7654	SSAD
7782	SD
7782	SSAD
7782	ASD
7839	ASD
7839	SD
7839	SSAD
7839	US
7844	ASD
7844	SD
7844	US
7876	ASD
7876	SSAD

skills
course
SD
ASD
SSAD

result
code
7782
7839

Trained

÷

skills

Division Operator

THANK YOU!