# DBMS Languages

## Data Manipulation Language (DML)

Two classes of languages

## Procedural (Low Level)

- User specifies what data is required and how to get those data
- Example: **Relational Algebra.** 
  - In RA, we specify the order in which the operations have to be performed.

# Nonprocedural (High Level)

- User specifies what data is required without specifying how to get those data
- Example: SQL

## SQL can be

used in a standalone way (query language)

embedded in a programming language (host language)

# Relational Algebra

# Relational Algebra

Operations in RDBMS

Retrieval Update

Relational Algebra is a set of operations for specifying <u>retrieval requests</u> (or <u>queries</u>) in relational model

Relational algebra expression is a sequence of relational algebra operations

# Company Database

#### **EMPLOYEE** Minit Ssn Fname Lname **B**date Address Sex Salary Super\_ssn Dno **DEPARTMENT** Dnumber Dname Mgr\_ssn Mgr\_start\_date **DEPT\_LOCATIONS** Dnumber Dlocation **PROJECT** Pnumber Pname Plocation Dnum WORKS ON Essn Pno Hours DEPENDENT Essn Dependent\_name Sex **Bdate** Relationship

# Select Operation(unary operation)

This operation selects a subset of tuples from a relation that satisfy a selection condition.

Select is denoted by:  $\sigma_{\text{selection condition}}(R)$ 

EMPLOYE	EMPLOYEE									
Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno	
John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	30000	333445555	5	
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5	
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4	
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4	
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5	
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5	
Ahmad	٧	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	М	25000	987654321	4	
James	Е	Borg	888665555	1937-11-10	450 Stone, Houston, TX	М	55000	NULL	1	

# **Examples: Select Operation**

• Select the employees whose department number is 4:

$$\sigma_{DNO=4}$$
 (EMPLOYEE)

Select the employees whose salary is greater than \$35,000

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	30000	333445555	5
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	К	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5
loyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	М	25000	987654321	4
James	Е	Borg	888665555	1937-11-10	450 Stone, Houston, TX	М	55000	NULL	1

## Print Pnumbers of projects offered by department 5

# Print the SSN of employees who work more than 10 hours on a project

#### WORKS\_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0
999887777	30	30.0
999887777	10	10.0
987987987	10	35.0
987987987	30	5.0
987654321	30	20.0
987654321	20	15.0
888665555	20	NULL

#### PROJECT

Pname	Pnumber	Plocation	Dnum	
ProductX	1	Bellaire	5	
ProductY	2	Sugarland	5	
ProductZ	3	Houston	5	
Computerization	10	Stafford	4	
Reorganization	20	Houston	1	
Newbenefits	30	Stafford	4	

#### DEPENDENT

Essn		Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	М	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	М	1942-02-28	Spouse
123456789	Michael	М	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

# **Select Operation**

 $\sigma_{\text{(DNO = 4 AND Salary > 25000) OR (DNO = 5 AND Salary > 30000)}}$  (EMPLOYEE)

EMPLOYE	E								
Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	30000	333445555	5
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	٧	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	М	25000	987654321	4
James	Е	Borg	888665555	1937-11-10	450 Stone, Houston, TX	М	55000	NULL	1

## **OUTPUT**

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5

# Select Operation

- **Selection condition** is a Boolean expression specified on the attributes of relation **R** 
  - It can include boolean operators **AND**, **OR**, **NOT** applied on relational operators < , > , <= , >= , != , =

### • Select σ is commutative:

$$\sigma_{\text{<}condition1>}(\sigma_{\text{<}condition2>}(R)) = \sigma_{\text{<}condition2>}(\sigma_{\text{<}condition1>}(R))$$

Cascade of Select operations

$$\sigma_{<\text{cond1>}}(\sigma_{<\text{cond2>}} (\sigma_{<\text{cond3>}}(R)) = \sigma_{<\text{cond1>}AND < \text{cond2>}AND < \text{cond3>}}(R)))$$

# $\sigma_{\text{(DNO = 4 AND Salary > 25000) OR (DNO = 5 AND Salary > 30000)}}$ (EMPLOYEE)

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5

# Project Operation (unary operation)

- It selects a subset of columns from the relation.
- $\circ$  denoted by  $\pi_{\text{<attribute list>}}R$

# **Example:**

 $\pi_{\text{LNAME, FNAME, SALARY}}$  (EMPLOYEE)

It removes <u>duplicate</u> <u>tuples</u>

The result of project is set of tuples

### **OUTPUT**

Fname	Minit	Lname	Ssn
John	В	Smith	123456789
Franklin	Т	Wong	333445555
Alicia	J	Zelaya	999887777
Jennifer	S	Wallace	987654321
Ramesh	K	Narayan	666884444
Joyce	Α	English	453453453
Ahmad	V	Jabbar	987987987
James	Е	Borg	888665555

Lname	Fname	Salary
Smith	John	30000
Wong	Franklin	40000
Zelaya	Alicia	25000
Wallace	Jennifer	43000
Narayan	Ramesh	38000
English	Joyce	25000
Jabbar	Ahmad	25000
Borg	James	55000

Sex	Salary	Super_ssn	Dno
М	30000	333445555	5
М	40000	888665555	5
F	25000	987654321	4
F	43000	888665555	4
м	38000	333445555	5
F	25000	333445555	5
М	25000	987654321	4
М	55000	NULL	1

## **Project Operation**

## Example 1

 $\square$   $\pi$  SALARY ( $\pi$  LNAME, FNAME, SALARY EMPLOYEE)

#### OUTPUT

Lname	Fname	Salary
Smith	John	30000
Wong	Franklin	40000
Zelaya	Alicia	25000
Wallace	Jennifer	43000
Narayan	Ramesh	38000
English	Joyce	25000
Jabbar	Ahmad	25000
Borg	James	55000

Salary 30000

40000

25000 43000

38000

55000

## Example 2

Minit

В

S

K

A

V

E

**EMPLOYEE** 

Fname

John

Franklin

Jennifer

Ramesh

Joyce

Ahmad

James

Alicia

 $^{
floor}$  LNAME, FNAME, SAL

Lname

Smith

Wong

Zelaya

Wallace

Narayan

English

Jabbar

Borg

 $_{
m RY}$  EMPLOYEE

Address

638 Voss, Houston, TX 3321 Castle, Spring, TX

291 Berry, Bellaire, TX

975 Fire Oak, Humble, TX

5631 Rice, Houston, TX

980 Dallas, Houston, TX

450 Stone, Houston, TX

731 Fondren, Houston, TX

Project operation is *not* commutative

Bdate

1965-01-09

1955-12-08

1968-01-19

1941-06-20

1962-09-15

1972-07-31

1969-03-29

1937-11-10

Ssn

123456789

333445555

999887777

987654321

666884444

453453453

987987987

888665555

PLOYEE)	Salary
ŕ	30000

40000 25000

25000

A	2	$\wedge$	Λ	$\sim$
4	o	U	u	U
	-			

ex	Sa	38	3000	ssn	Dno
И	30	50	5000	555	5
M	40	00	0000	555	5
F	250	000	98765	4321	4
F	430	000	88866	55555	4
M	380	000	33344	5555	5
F	250	000	33344	5555	5
И	250	000	98765	4321	4

NULL

55000

NOW WHAT

# **Project Operation**

- Project operation is not commutative
- $\pi_{< \text{list1}>}$  ( $\pi_{< \text{list2}>}$  (R)) =  $\pi_{< \text{list1}>}$  (R) as long as <list2> contains the attributes in <list1>

No of Tuples in the result of projection  $\pi_{< list>}(R)$  is less or equal to the number of tuples in R

If the list of attributes includes a *key* of R, then the no of is *equal* to the no of tuples in R

# Print the name and number of projects offered by department 5

#### WORKS\_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0
999887777	30	30.0
999887777	10	10.0
987987987	10	35.0
987987987	30	5.0
987654321	30	20.0
987654321	20	15.0
888665555	20	NULL

#### PROJECT

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

#### DEPENDENT

Essn		Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	М	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	М	1942-02-28	Spouse
123456789	Michael	М	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

# Relational Algebra Expressions

Retrieve the first name, last name, and salary of all employees who work in department number 5

# Single relational algebra expression:

 $\square \pi_{\text{FNAME, LNAME, SALARY}} (\sigma_{\text{DNO}=5}(\text{EMPLOYEE}))$ 

# Using intermediate relation:

- D5  $\leftarrow$   $\sigma_{DNO=5}(EMPLOYEE)$
- RESULT  $\leftarrow \pi_{\text{FNAME, LNAME, SALARY}}$  (D5)

# Example of applying multiple operations and **RENAME**

# $\pi_{\text{FNAME, LNAME, SALARY}}(\sigma_{\text{DNO}=5}(\text{EMPLOYEE}))$

Fname	Lname	Salary
John	Smith	30000
Franklin	Wong	40000
Ramesh	Narayan	38000
Joyce	English	25000

$$D5 \leftarrow \sigma_{DNO=5}(EMPLOYEE)$$

**R** (First\_name,Last\_name,Salary)  $\leftarrow \pi_{\text{Fname,Lname,Salary}} D5$ 

### D5

Fname	Minit	Lname	Ssn	Bdate	Address		Sex	Salary	Super_ss	n Dno
John	В	Smith	123456789	1965-01-09	731 Fondren, Houston					
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston,TX	R				
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble	-	t na	me L	ast_name	Salary
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston,	John	_		Smith	30000
						Fran	nklin	V	Vong	40000
						Ran	nesh	N	larayan	38000
						Joyc	се	E	inglish	25000

# Union (Binary Operation)

- The result of  $R \cup S$ , is a relation that includes all tuples that are either in R or in S or in both R and S
- Duplicate tuples are eliminated

# Type compatible (Union compatible)

- The two relations R and S must be **Type compatible** 
  - R and S must have same number of attributes
  - Each pair of corresponding attributes must have same or compatible domains

Fname	Lname	Salary
John	Smith	30000
Franklin	Wong	40000
Ramesh	Narayan	38000
Joyce	English	25000



Fname	Lname	Salary
John	Smith	30000
Franklin	Wong	40000

# UNION Example

To retrieve the SSN of all employees who either

- work in department 5 or
- directly supervise an employee in department 5

 $D5\_EMPS \leftarrow \sigma_{DNO=5} (EMPLOYEE)$ RESULT1  $\leftarrow \pi_{SSN}(D5\_EMPS)$ RESULT2(SSN)  $\leftarrow \pi_{\text{SUPERSSN}}(\text{D5\_EMPS})$  $RESULT \leftarrow RESULT1 \cup RESULT2$ 

### **RESULT1 RESULT2** Ssn 123456789 333445555 666884444 453453453

### Ssn 333445555 888665555

#### **EMPLOYEE**

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Sala	RESULT	Dno	
John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	3000		5	
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	4000	Ssn 123456789	5	
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	2500	333445555	4	
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	4300	666884444	4	
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	3800	453453453	5	
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	2500	888665555	5	
Ahmad	٧	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	М	25000	987654321	4	
James	Е	Borg	888665555	1937-11-10	450 Stone, Houston, TX	М	55000	NULL	1	

# INTERSECTION And SET DIFFERENCE (Binary Operations)

- INTERSECTION operation: the result of  $R\cap S$ , is a relation that includes all tuples that are in both R and S
- SET DIFFERENCE operation: the result of R-S, is a relation that includes all tuples that are in R but not in S
- Two relations R and S must be "type compatible"

# RELATIONAL ALGEBRA OPERATIONS FROM SET THEORY

- Both  $\cup$  and  $\cap$  are *commutative* operations
  - $R \cup S = S \cup R$ , and  $R \cap S = S \cap R$
- Both  $\cup$  and  $\cap$  can be treated as n-ary operations
  - $R \cup (S \cup T) = (R \cup S) \cup T$
  - $(R \cap S) \cap T = R \cap (S \cap T)$
- Minus operation is not commutative
  - $R S \neq S R$

# Example

#### STUDENT

Fn	Ln
Susan	Yao
Ramesh	Shah
Johnny	Kohler
Barbara	Jones
Amy	Ford
Jimmy	Wang
Ernest	Gilbert

#### INSTRUCTOR

Fname	Lname			
John	Smith			
Ricardo	Browne			
Susan	Yao			
Francis	Johnson			
Ramesh	Shah			

## Compatible relation

Fn	Ln
Susan	Yao
Ramesh	Shah

 $Student \cap Instructor$ 

Fn	Ln			
Johnny	Kohler			
Barbara	Jones			
Amy	Ford			
Jimmy	Wang			
Ernest	Gilbert			

Student – Instructor

Fn	Ln			
Susan	Yao			
Ramesh	Shah			
Johnny	Kohler			
Barbara	Jones			
Amy	Ford			
Jimmy	Wang			
Ernest	Gilbert			
John	Smith			
Ricardo	Browne			
Francis	Johnson			

Student  $\cup$  Instructor

Fname	Lname
John	Smith
Ricardo	Browne
Francis	Johnson

Instructor – Student

# Example: Retrieve a list of female employee's dependents

#### **EMPLOYEE**

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno	
John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	30000	333445555	5	
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5	
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4	
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4	
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5	
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5	
Ahmad	٧	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	М	25000	987654321	4	
James	Е	Borg	888665555	1937-11-10	450 Stone, Houston, TX	М	55000	NULL	1	

#### DEPENDENT

Essn		Sex	Bdate	Relationship	
333445555	Alice	F	1986-04-05	Daughter	
333445555	Theodore	М	1983-10-25	Son	
333445555	Joy	F	1958-05-03	Spouse	
987654321	Abner	М	1942-02-28	Spouse	
123456789	Michael	М	1988-01-04	Son	
123456789	Alice	F	1988-12-30	Daughter	
123456789	Elizabeth	F	1967-05-05	Spouse	

# CARTESIAN PRODUCT

• The result of Cartesian product of two relations

$$R(A1, A2, ..., An) \times S(B1, B2, ..., Bm)$$

is given as:

- Let  $|R| = n_R$  and  $|S| = n_S$ , then  $|R \times S| = n_R * n_S$
- R and S may NOT be "type compatible"

Cross Product is a meaningful operation only if it is followed by other operations

## Example: Retrieve a list of female employee's dependents

#### **EMPLOYEE**

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno	
John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	30000	333445555	5	
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5	
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4	
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4	
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5	
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5	
Ahmad	٧	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	М	25000	987654321	4	
James	Е	Borg	888665555	1937-11-10	450 Stone, Houston, TX	М	55000	NULL	1	

$$F \leftarrow \sigma_{SEX=F'}(EMPLOYEE)$$

## Example: Retrieve a list of female employee's dependents

#### **EMPLOYEE**

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	30000	333445555	5
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	٧	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	М	25000	987654321	4
James	Е	$F \leftarrow$	σ <sub>SEX='I</sub>	EMP	LOYEE)				1

# EmpNames $\leftarrow \pi_{\text{FNAME, LNAME, SSN}}(F)$

FEMALE	EMPS
--------	------

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
Alicia	J	Zelaya	999887777	1968-07-19	3321Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291Berry, Bellaire, TX	F	43000	888665555	4
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5

#### **EMPNAMES**

Fname	Lname	Ssn
Alicia	Zelaya	999887777
Jennifer	Wallace	987654321
Joyce	English	453453453

## Problem: Retrieve a list of female employee's dependents

#### **EMPNAMES**

Fname	Lname	Ssn
Alicia	Zelaya	999887777
Jennifer	Wallace	987654321
Joyce	English	453453453

#### DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	М	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	М	1942-02-28	Spouse
123456789	Michael	М	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

#### **EMP\_DEPENDENTS**

Fname	Lname	Ssn	Essn	Dependent_name	Sex	Bdate	
Alicia	Zelaya	999887777	333445555	Alice	F	1986-04-05	-000
Alicia	Zelaya	999887777	333445555	Theodore	М	1983-10-25	
Alicia	Zelaya	999887777	333445555	Joy	F	1958-05-03	
# #F0.15.11	-	000000000	000001001				

### $Emp\_DP \leftarrow EmpNames \times DEPENDENT$

#### Alicia Zelaya 999887777 987654321 Alicia Zelaya 999887777 123456789 999887777 123456789 Alicia Zelaya Alice 1988-12-30 F Zelaya 999887777 123456789 Elizabeth 1967-05-05 Alicia Wallace Alice F Jennifer 987654321 333445555 1986-04-05 Wallace 987654321 333445555 Theodore M 1983-10-25 Jennifer 333445555 F Wallace 987654321 Joy 1958-05-03 Jennifer 987654321 Jennifer Wallace 987654321 Abner M 1942-02-28 987654321 123456789 Jennifer Wallace Michael M 1988-01-04 987654321 123456789 Alice F 1988-12-30 Jennifer Wallace Elizabeth F Wallace 987654321 123456789 1967-05-05 Jennifer English 453453453 333445555 Alice F 1986-04-05 Joyce 453453453 333445555 Theodore M 1983-10-25 Joyce English F English 453453453 333445555 Joy 1958-05-03 Joyce English 453453453 987654321 Abner M Joyce 1942-02-28 453453453 123456789 Michael M 1988-01-04 English Joyce F Joyce English 453453453 123456789 Alice 1988-12-30 Elizabeth F English 453453453 123456789 1967-05-05 Joyce

## **Problem:** Retrieve a list of female employee's dependents

#### **EMPNAMES**

Fname	Lname	Ssn
Alicia	Zelaya	999887777
Jennifer	Wallace	987654321
Joyce	English	453453453

#### DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	М	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	М	1942-02-28	Spouse
123456789	Michael	М	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

#### **EMP DEPENDENTS**

Zelaya

Zelaya

Zelaya

English English

English

English

Alicia

Alicia Alicia

Joyce

Joyce

Joyce

Joyce

Fname	Lname	Ssn	Essn	Dependent_name	Sex	Bdate	
Alicia	Zelaya	999887777	333445555	Alice	F	1986-04-05	
Alicia	Zelaya	999887777	333445555	Theodore	М	1983-10-25	
Alicia	Zelaya	999887777	333445555	Joy	F	1958-05-03	
Alicia	Zelaya	999887777	987654321	_			

### **Emp\_DP** ← **EmpNames** x **DEPENDENT**

Actual\_DP  $\leftarrow \sigma_{SSN=ESSN}(Emp_DP)$ 

#### Wallace 987654321 333445555 Jennifer Jennifer Wallace 987654321 333445555 Jennifer | Wallace | 987654321 333445555

999887777

999887777

999887777

4 16	144.00	F-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1					
Jenniter	Wallace	987654321	987654321	Abner	M	1942-02-28	
Jennifer	Wallace	987654321	123456789	Michael	М	1988-01-04	
Jennifer	Wallace	987654321	123456789	Alice	F	1988-12-30	640
Jennifer	Wallace	900054004	100450500	Ellerhath	r	1007.05.05	

#### ACTUAL DEPENDENTS

123456789

123456789

123456789

Fname	Lname	Ssn	Essn	Dependent_name	Sex	Bdate	
Jennifer	Wallace	987654321	987654321	Abner	М	1942-02-28	

/		-			-		
Joyce	English	453453453	123456789	Michael	IVI	1988-01-04	1.63
Joyce	English	453453453	123456789	Alice	F	1988-12-30	.,,,
Joyce	English	453453453	123456789	Elizabeth	F	1967-05-05	245

## **Problem:** Retrieve a list of each female employee's dependents

#### FEMALE EMPS

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
Alicia	J	Zelaya	999887777	1968-07-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291Berry, Bellaire, TX	F	43000	888665555	4
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5

#### **EMPNAMES**

Fname	Lname	Ssn
Alicia	Zelaya	999887777
Jennifer	Wallace	98765432

EMP	_DE	PEN	DEN	ITS

Jennifer

Fname	Lname	Ssn	Essn	
Alicia	Zelaya	999887777	333445555	Ī
Alicia	Zelaya	999887777	333445555	Ī
Alicia	Zelaya	999887777	333445555	ľ
Alicia	Zelaya	999887777	987654321	Ī
Alicia	Zelaya	999887777	123456789	ľ
Alicia	Zelaya	999887777	123456789	Ī
Alicia	Zelaya	999887777	123456789	Γ
Jennifer	Wallace	987654321	333445555	
Jennifer	Wallace	987654321	333445555	
Jennifer	Wallace	9876543		

Wallace 9876543 Wallace 9876543

Wallace 9876543 Jennifer | Wallace | 98765435

#### DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	М	1983-10-25	Son

 $\begin{array}{l} F \leftarrow \sigma_{\text{SEX='F'}}(EMPLOYEE) \\ EmpNames \leftarrow \pi_{\text{FNAME, LNAME, SSN}}(F) \\ Emp\_DP \leftarrow EmpNames \times DEPENDENT \end{array}$ Actual\_DP  $\leftarrow \sigma_{\text{SSN}=\text{ESSN}}(\text{Emp}_DP)$ 

Result  $\leftarrow \pi_{\text{FNAME, LNAME, DEPENDENT\_NAME}}(Actual\_DP)$ 

M | 1983-10-25 | ... Theodore

#### **ACTUAL DEPENDENTS**

Fname	Lname	Ssn	Essn	Dependent_name	Sex	Bdate	
Jennifer	Wallace	987654321	987654321	Abner	М	1942-02-28	

Joyce	English	453453455	555445555	Alloe	1	1000
Joyce	English	453453453	333445555	Theodore	М	1983-
Joyce	English	453453453	333445555	Joy	F	1958-
Joyce	English	453453453	987654321	Abner	М	1942-
Joyce	English	453453453	123456789	Michael	М	1988-
Joyce	English	453453453	123456789	Alice	F	1988-
Joyce	English	453453453	123456789	Elizabeth	F	1967-0

#### RESULT

Fname	Lname	Dependent_name
Jennifer	Wallace	Abner

# JOIN(Binary Operation)

- JOIN denoted by ⋈ combines related tuples from various relations
- JOIN combines CARTESIAN PRODECT and SELECT into a single operation
- General form of a join operation on two relations R(A1, A2, ..., An) and S(B1, B2, ..., Bm) is:

$$R \bowtie_{< join \ condition>} S$$

## **Problem:** Retrieve a list of each female employee's dependents

#### FEMALE EMPS

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
Alicia	J	Zelaya	999887777	1968-07-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291Berry, Bellaire, TX	F	43000	888665555	4
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5

#### **EMPNAMES**

Fname	Lname	Ssn
Alicia	Zelaya	999887777
Jennifer	Wallace	987654321

#### DEPENDENT

Sex

Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	М	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
		М	1942-02-28	Spouse

Lname

EMP\_DEPENDENTS

Alicia	Zelaya	999887777
Alicia	Zelaya	999887777
Jennifer	Wallace	987654321

Wallace 98765432

Jennifer

 $F \leftarrow \sigma_{SEX=F'}(EMPLOYEE)$ 

Dependent name

EmpNames  $\leftarrow \pi_{\text{FNAME, LNAME, SSN}}(F)$ 

Bdate

## **Emp\_DP** ← **EmpNames** ⋈ <sub>SSN=ESSN</sub> **DEPENDENT**

Result  $\leftarrow \pi_{\text{FNAME, LNAME, DEPENDENT\_NAME}}(DP)$ 

Jennifer	Wallace	987654321				
Joyce	English	453453453	333445555	Alice	F	1986-
Joyce	English	453453453	333445555	Theodore	М	1983-
Joyce	English	453453453	333445555	Joy	F	1958-
Joyce	English	453453453	987654321	Abner	M	1942-
Joyce	English	453453453	123456789	Michael	М	1988-
Joyce	English	453453453	123456789	Alice	F	1988-
Joyce	English	453453453	123456789	Elizabeth	F	1967-

Essn

#### RESULT

Fr	name	Lname	Dependent_name
Je	nnifer	Wallace	Abner

1988-01-04

Son

# **Example: JOIN operation**

## Retrieve the name of the manager of each department

Fname	Minit	Lname	Ssn	Bdate	A	ddress	Sex	Salary	Super_ssn	Dno
John	В	Smith	123456789	1965-01-09	1965-01-09 731 Fondren, Houston, TX		М	30000	333445555	5
Franklin	Т	Wong	333445555	1955-12-08	08 638 Voss, Houston, TX		М	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	068-01-19 3321 Castle, Spring, TX		F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	41-06-20 291 Berry, Bellaire, TX		F	43000	888665555	4
Ramesh	K	Narayan	666884444	DEPARTM	ENT					
Joyce	Α	English	453453453	Dnam	20	Dnumber	Mgr_ssn		Mgr_start_date	
Ahmad	V	Jabbar	987987987	Ditail	10	Dilation	mgi	_880	1988-05-22	
James	E	Borg	888665555	Research	n	5	3334	45555		
2000		20.9		Administ	ration	4	9876	54321	1995-01-	01
		·		Headqua			2000	65555	1981-06-	10

## $\mathsf{DEPT\_MGR} \leftarrow \mathsf{DEPARTMENT} \quad \bowtie_{\mathsf{MGRSSN=SSN}} \mathsf{EMPLOYEE}$

DEPT_WIGH						-		- 10
Dname	Dnumber	Mgr_ssn	* * *	Fname	Minit	Lname	Ssn	
Research	5	333445555		Franklin	Т	Wong	333445555	
Administration	4	987654321	****	Jennifer	S	Wallace	987654321	
Headquarters	1	888665555		James	Е	Borg	888665555	• • •

# Complete Set of Relational Operations

- The set of operations including
  - SELECT σ,
  - PROJECT  $\pi$ ,
  - UNION  $\cup$ ,
  - DIFFERENCE ,
  - RENAME ρ, and
  - CARTESIAN PRODUCT X

is called a *complete set* because any relational algebra expression can be expressed using these.

• R 
$$\bowtie_{< \text{join condition}>} S = \sigma_{< \text{join condition}>} (R X S)$$

# Some properties of JOIN

- Consider the following JOIN operation:
  - R(A1, A2, ..., An)  $\searrow$  S(B1, B2, ..., Bm) R.Ai=S.Bj
  - Result is a relation Q with degree n + m attributes:
    Q(A1, A2, . . ., An, B1, B2, . . ., Bm), in that order.
  - If R has  $n_R$  tuples, and S has  $n_S$  tuples, then no of tuples in join result  $< n_R * n_S$ .

# Equi-Join

- EQUIJOIN is a join condition that involves only equality operator = .
- Example:
  - Retrieve a list of each female employee's dependents

```
\begin{aligned} & FEmp \leftarrow \sigma_{SEX='F'}(EMPLOYEE) \\ & E\_DP \leftarrow FEmp \bowtie_{SSN=ESSN} & DEPENDENT \\ & Result \leftarrow \pi_{FNAME,\ LNAME,\ SSN,DEPENDENT\_NAME} \\ & (E\_DP) \end{aligned}
```

# This is EQUI -JOIN operation

## Retrieve the name of the manager of each department

Fname	Minit	Lname	Ssn	Bdate	A	ddress	Sex	Salary	Super_ssn	Dno
John	В	Smith	123456789	1965-01-09	731 Fon	dren, Houston, TX	М	30000	333445555	5
Franklin	Т	Wong	333445555	1955-12-08	638 Vos	s, Houston, TX	М	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Ca	astle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Ber	ry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	DEPARTM	ENT					
Joyce	Α	English	453453453	Dnam	20	Dnumber	Mo	r_ssn	Mgr_start	data
Ahmad	V	Jabbar	987987987	Ditail	ю	* Manufacture Common Co			55.0	
James	Е	Borg	888665555	Research	1	5	3334	45555	1988-05	-22
2411100	_	Doig	00000000	Administ	ration	4	9876	54321	1995-01	-01
				Headqua	rtore	4	2000	65555	1981-06	10

# DEPT\_MGR ← DEPARTMENT ⋈<sub>MGRSSN=SSN</sub> EMPLOYEE

ı	Research	5	333443333		гтанкіін	1	vvong	<del>333443333</del>	36
	Administration	4	987654321	****	Jennifer	S	Wallace	987654321	0 * * * * * * * * * * * * * * * * * * *
ı	Headquarters	1	888665555	•	James	Е	Borg	888665555	• • •

## For each employee, print his project numbers

#### WORKS\_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	EMD	OVEE

333445555	EMPLOYE	E								
999887777	Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
999887777	John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	30000	333445555	5
999007777	— Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5
987987987	Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
987987987	Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
987654321	Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5
907004021	Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
987654321	Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	М	25000	987654321	4
888665555	James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	М	55000	NULL	1

## · For each employee, list the name of his projects

#### WORKS\_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
222445555		

#### **PROJECT**

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

333443333	EMPLOYE	:E								
999887777	Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
999887777	John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	30000	333445555	5
999007777	— Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5
987987987	Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
987987987	Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
987654321	Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5
907004021	Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
987654321	Ahmad	٧	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	М	25000	987654321	4
888665555	James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	М	55000	NULL	1

# • For each employee, retrieve the employee's name and the name of his project

#### WORKS\_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
000445555		l-

#### **PROJECT**

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

EMPLOYE	E								
Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	30000	333445555	5
— Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	К	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5
— Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	М	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	М	55000	NULL	1
	Fname John Franklin Alicia Jennifer Ramesh Joyce Ahmad	John B Franklin T Alicia J Jennifer S Ramesh K Joyce A Ahmad V	Fname Minit Lname John B Smith Franklin T Wong Alicia J Zelaya Jennifer S Wallace Ramesh K Narayan Joyce A English Ahmad V Jabbar	Fname         Minit         Lname         Ssn           John         B         Smith         123456789           Franklin         T         Wong         333445555           Alicia         J         Zelaya         999887777           Jennifer         S         Wallace         987654321           Ramesh         K         Narayan         666884444           Joyce         A         English         453453453           Ahmad         V         Jabbar         987987987	Fname         Minit         Lname         Ssn         Bdate           John         B         Smith         123456789         1965-01-09           Franklin         T         Wong         333445555         1955-12-08           Alicia         J         Zelaya         999887777         1968-01-19           Jennifer         S         Wallace         987654321         1941-06-20           Ramesh         K         Narayan         666884444         1962-09-15           Joyce         A         English         453453453         1972-07-31           Ahmad         V         Jabbar         987987987         1969-03-29	Fname         Minit         Lname         Ssn         Bdate         Address           John         B         Smith         123456789         1965-01-09         731 Fondren, Houston, TX           Franklin         T         Wong         333445555         1955-12-08         638 Voss, Houston, TX           Alicia         J         Zelaya         999887777         1968-01-19         3321 Castle, Spring, TX           Jennifer         S         Wallace         987654321         1941-06-20         291 Berry, Bellaire, TX           Ramesh         K         Narayan         666884444         1962-09-15         975 Fire Oak, Humble, TX           Joyce         A         English         453453453         1972-07-31         5631 Rice, Houston, TX           Ahmad         V         Jabbar         987987987         1969-03-29         980 Dallas, Houston, TX	Fname         Minit         Lname         Ssn         Bdate         Address         Sex           John         B         Smith         123456789         1965-01-09         731 Fondren, Houston, TX         M           Franklin         T         Wong         333445555         1955-12-08         638 Voss, Houston, TX         M           Alicia         J         Zelaya         999887777         1968-01-19         3321 Castle, Spring, TX         F           Jennifer         S         Wallace         987654321         1941-06-20         291 Berry, Bellaire, TX         F           Ramesh         K         Narayan         666884444         1962-09-15         975 Fire Oak, Humble, TX         M           Joyce         A         English         453453453         1972-07-31         5631 Rice, Houston, TX         F           Ahmad         V         Jabbar         987987987         1969-03-29         980 Dallas, Houston, TX         M	Fname         Minit         Lname         Ssn         Bdate         Address         Sex         Salary           John         B         Smith         123456789         1965-01-09         731 Fondren, Houston, TX         M         30000           Franklin         T         Wong         333445555         1955-12-08         638 Voss, Houston, TX         M         40000           Alicia         J         Zelaya         999887777         1968-01-19         3321 Castle, Spring, TX         F         25000           Jennifer         S         Wallace         987654321         1941-06-20         291 Berry, Bellaire, TX         F         43000           Ramesh         K         Narayan         666884444         1962-09-15         975 Fire Oak, Humble, TX         M         38000           Joyce         A         English         453453453         1972-07-31         5631 Rice, Houston, TX         F         25000           Ahmad         V         Jabbar         987987987         1969-03-29         980 Dallas, Houston, TX         M         25000	Fname         Minit         Lname         Ssn         Bdate         Address         Sex         Salary         Super_ssn           John         B         Smith         123456789         1965-01-09         731 Fondren, Houston, TX         M         30000         333445555           Franklin         T         Wong         333445555         1955-12-08         638 Voss, Houston, TX         M         40000         888665555           Alicia         J         Zelaya         999887777         1968-01-19         3321 Castle, Spring, TX         F         25000         987654321           Jennifer         S         Wallace         987654321         1941-06-20         291 Berry, Bellaire, TX         F         43000         888665555           Ramesh         K         Narayan         666884444         1962-09-15         975 Fire Oak, Humble, TX         M         38000         333445555           Joyce         A         English         453453453         1972-07-31         5631 Rice, Houston, TX         F         25000         987654321           Ahmad         V         Jabbar         987987987         1969-03-29         980 Dallas, Houston, TX         M         25000         987654321

# NATURAL JOIN Operation

- Example: Print location of each department

  DEPT\_LOCS ← DEPARTMENT \* DEPT\_LOCATIONS
- Only attribute with the same name is **DNUMBER**

An implicit join condition is created based on this attribute: DEPARTMENT.DNUMBER=DEPT\_LOCATIONS.DNUMBER

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

#### DEPT\_LOCATIONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

# NATURAL JOIN Operation

• Example: Print location of each department

DEPT\_LOCS ← DEPARTMENT \* DEPT\_LOCATIONS

	Dname	Dnumber	Mgr_ssn	Mgr_start_date	Location
	Headquarters	1	888665555	1981-06-19	Houston
	Administration	4	987654321	1995-01-01	Stafford
	Research	5	333445555	1988-05-22	Bellaire
l	Research	5	333445555	1988-05-22	Sugarland
4	Research	5	333445555	1988-05-22	Houston

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

DEF	T_L	oc,	ATIC	ONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

# Issue with Equijoin Operation

- You have to specify the **join condition**.
  - Even if two cols in the joining tables have same name.

#### DEPT\_MGR

Dname	Dnumber	Mgr_ssn		Fname	Minit	Lname	Ssn	
Research	5	333445555		Franklin	Т	Wong	333445555	
Administration	4	987654321	****	Jennifer	S	Wallace	987654321	• • •
Headquarters	1	888665555		James	E	Borg	888665555	•••

- Superfluous column
- Result of EQUIJOIN always have one or more pairs of attributes that have identical values in every tuple.

# NATURAL JOIN Operation

## NATURAL JOIN operation (denoted by \*) is used when

- the two join attributes, or
- each pair of corresponding join attributes

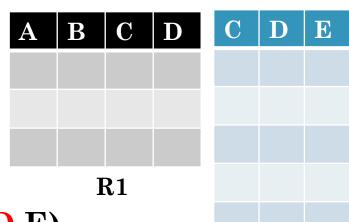
### must have the same name in both relations

• If this is not the case, a renaming operation is applied first.

• NATURAL JOIN also get rid of the superfluous attribute in an EQUIJOIN condition.

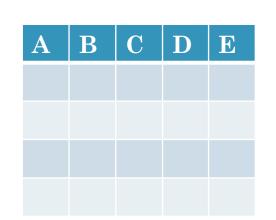
# Example: Natural Join

- Consider two Relations
  - R1(A,B,C,D) & R2(C,D,E)



- Natural Join R\*S
  - RES  $\leftarrow$  R1(A,B,C,D) \* R2(C,D,E)
  - The implicit join condition
    - R1.C=R2.C AND R1.D=R2.D

RES(A,B,C,D,E)



**R.2** 

# Theta-join

theta

- *Theta* is a boolean expression on the attributes of R and S; for example:
  - R.Ai<S.Bj AND (R.Ak=S.Bl OR R.Ap<S.Bq)
- Theta can have any comparison operators  $\{=,\neq,<,\leq,>,\geq,\}$

# Theta-join Example

For each Male employee, list his colleagues who earn more than him. Retrieve only the first name and salary.

```
\begin{split} & M(Name, Sal) \leftarrow \pi_{\ FNAME, \ SALARY} \ (\ \sigma_{\ SEX=M'} \ EMPLOYEE \ ) \\ & ECOL(CName, \ CSal) \leftarrow \pi_{\ FNAME, \ SALARY} \ EMPLOYEE \\ & R1 \leftarrow M \bowtie_{M.Sal < ECol.CSal} ECol \end{split}
```

EMPLOYE	E								
Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	30000	333445555	5
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	М	55000	NULL	1

# Theta-join Example

For each Male employee list his colleagues who earn more than him. Retrieve only the first name and salary.

M(Name, Sal)  $\leftarrow \pi_{\text{FNAME, SALARY}}$  ( $\sigma_{\text{SEX='M'}}$  EMPLOYEE) ECOL(CName, CSal)  $\leftarrow \pi_{\text{FNAME, SALARY}}$  EMPLOYEE

 $R1 \leftarrow M \bowtie_{M.Sal < ECol.CSal} ECol$ 

Name	Sal	CName	CSal
John	30000	Franklin	40000
John	30000	Jennifer	43000
John	30000	Ramesh	38000
John	30000	James	55000
Franklin	40000	Jennifer	43000
Franklin	40000	James	55000
Ramesh	38000	Franklin	40000
Ramesh	38000	Jennifer	43000
Ramesh	38000	James	55000

# Theta-join

• For each Male employee, print the names of his peers with the same salary

```
\begin{array}{l} \textcolor{red}{\rho_{E2}\text{(EMPLOYEE)}} \\ E2 \leftarrow \pi_{FNAME, \ SALARY} \ (\ \sigma_{SEX=M} \ EMPLOYEE) \\ Res \leftarrow \pi_{E1.FNAME, \ E2.FNAME} \ (\ E1 \bowtie_{E1.SSN \ != \ E2.SSN \ and \ E1.Salary=E2.Salary} E2) \end{array}
```

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	В	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	М	30000	333445555	5
Franklin	Т	Wong	333445555	1955-12-08	638 Voss, Houston, TX	М	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
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Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	М	38000	333445555	5
Joyce	Α	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	٧	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	М	25000	987654321	4
James	Е	Borg	888665555	1937-11-10	450 Stone, Houston, TX	М	55000	NULL	1