

In-Class Exercises #5

- What is the result?

1. $AB \bowtie_{A=a_1} CD1$
2. $AB \bowtie_{A=a_1} CD2$
3. AB^*CD1
4. AB^*CD2
5. AB^*CD3
6. AB^*CD4
7. AB^*CD5

AB	A	B
	a1	b1
	a2	b2

CD1	C	D	X
	c1	d1	x1
	d2	d2	x2

CD4	AA1	BB1	X
	a1	b1	x1
	a2	b2	x2

CD2	A	D	X
	a2	d2	x1
	a1	d1	x2

CD5	A	B	X
	a1	d1	x1
	a2	d2	x2

CD3	A	B	X
	a1	b1	x1
	a2	b2	x2



In-Class Exercises #5

- What is the result?

1. $AB \bowtie_{A=a_1} CD1$

AB	A	B	CD1	C	D	X
	a1	b1		c1	d1	x1
	a2	b2		d2	d2	x2

$R1 \leftarrow AB \times CD1$

R1	A	B	C	D	X
	a1	b1	c1	d1	x1
	a1	b1	d2	d2	x2
	a2	b2	c1	d1	x1
	a2	b2	d2	d2	x2

Result $\leftarrow \sigma_{A=a_1}(R1)$

R1	A	B	C	D	X
	a1	b1	c1	d1	x1
	a1	b1	d2	d2	x2



In-Class Exercises #5

- What is the result?

2. $AB \bowtie_{A=a_1} CD2$

AB	A	B
	a1	b1
	a2	b2

CD2	A	D	X
	a2	d2	x1
	a1	d1	x2

$R1 \leftarrow AB \times CD2$

R1	A	B	A	D	X
	a1	b1	a2	d2	x1
	a1	b1	a1	d1	x2
	a2	b2	a2	d2	x1
	a2	b2	a1	d1	x2

Result $\leftarrow \sigma_{A=a_1}(R1)$

Invalid query due to joining two tables with identical attribute names.



In-Class Exercises #5

- What is the result?

5. $AB * CD3$

AB	A	B
	a1	b1
	a2	b2

CD3	A	B	X
	a1	b1	x1
	a2	b2	x2

$R1 \leftarrow AB \bowtie CD3$

R1	A	B	A	B	X
	a1	b1	a1	b1	x1
	a1	b1	a2	b2	x2
	a2	b2	a1	b1	x1
	a2	b2	a2	b2	x2

$R2 \leftarrow \sigma_{\text{Equality of common}}(R1)$

R2	A	B	A	B	X
	a1	b1	a1	b1	x1
	a2	b2	a2	b2	x2

Result \leftarrow Remove one copy of common from R2

Result	A	B	X
	a1	b1	x1
	a2	b2	x2



Exercise: What is Wrong?

1. $\rho_{\text{Salary} > \text{avg}(\text{Salary})}$ (Employee)
2. $\pi_{\text{FNAME}, \text{LNAME}} (\sigma_{\text{DNO} = \text{DNUMBER}} (\text{Employee}, \text{Department}))$
3. $\pi_{\text{FNAME}, \text{LNAME}} (\rho_{\text{max}(\text{Salary})} (\text{Employee}))$
4. Works_ON / Project.PNUMBER
5. $\pi_{\text{FNAME}, \text{LNAME}, \text{Project.HOURS}} (\sigma_{\text{SSN} = \text{Project.ESSN}} (\text{Employee}))$
6. $\sigma_{\text{Salary} = \text{min}(\text{Salary})}$ (Employee)



Review of Lecture 4-1

- Aggregation function

$$G_1, G_2, \dots, G_n \quad g \quad F_1(A_1), F_2(A_2), \dots, F_n(A_n) \quad (E)$$

- Grouping attribute(s)
- Schema of output
- Outer join
 - 3 forms (Left, Right, Full)



Lecture 4-2: Today's Plan

- Query tree
- Query optimization
- Relational calculus
- RA exercises



Query Tree

- Representation for computation
 - cf. arithmetic trees for arithmetic computations
 - Leaf nodes are base relations
 - Internal nodes are relational algebra operations
 - Algebraic Query Optimization consists of rewriting the query or modifying the query tree into an equivalent tree. (see Chapter 15)

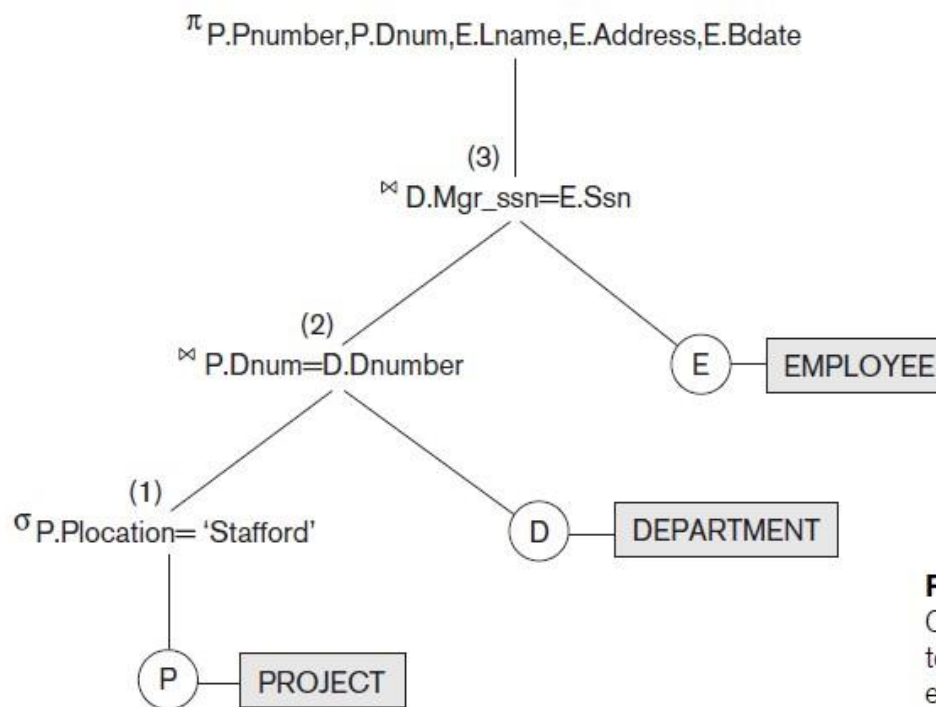


Figure 6.9

Query tree corresponding to the relational algebra expression for Q2.



Query Optimization: Example

- Employee table has 8 tuples and Department table has 3 tuples.
- Write a query to list the names of employees who work for the research department
 - Which one runs faster?

$R1 \leftarrow \text{Employee X Department}$

$R2 \leftarrow \sigma_{DNO = DNUMBER} (R1)$

$R3 \leftarrow \sigma_{DNAME = \text{"Resarch"}} (R2)$

$\text{Result} \leftarrow \pi_{Fname, Lname} (R3)$

$R1 \leftarrow \sigma_{DNAME = \text{"Resarch"}} (\text{Department})$

$R2 \leftarrow \text{Employee X } R1$

$R3 \leftarrow \sigma_{DNO = DNUMBER} (R2)$

$\text{Result} \leftarrow \pi_{Fname, Lname} (R3)$



Relational Calculus

- A relational calculus expression creates a new relation, which is specified in terms of variables:
 - range over rows (in tuple calculus)
 - Part of the model for SQL $\{t \mid \text{EMPLOYEE}(t) \text{ and } t.\text{FNAME} = \text{"John"}\}$
 - or over columns (in domain calculus)
 - QBE (Query By Example) $\{f,n \mid (\exists p) \text{EMPLOYEE}(f,m,n,s,b,a,x,p,u,d) \text{ and } p > 25000\}$
- Nonprocedural language.
 - No order of operations to specify how to retrieve the query
- Note that: RA, Tuple RC and Domain RC are equivalent
 - Any one can always be converted to the other two



How many rows and columns in the results?

1. `(lname, fname || max(Salary) as Salary (Employee))`
2. `(dno || max(Salary) as Salary (Employee))`

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	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	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1



Can you help?

1. A couple of days after starting in the new position, Jane realized that she accidentally created two employee tables E1 and E2 and data has been randomly stored in either table. She is not sure whether the two tables have the same content. Can you help?

Will this work $(E1 - E2)$?

2. If the two tables are not same, what would you do to ensure no information is lost?



Can you help? - Solution

1. A couple of days after starting in the new position, Jane realized that she accidentally created two employee tables E1 and E2 and data has been randomly stored in either table. She is not sure whether the two tables have the same content. Can you help?

$(E1 - E2) \cup (E2 - E1)$. If this query returns an empty table, then the two are the same.
Otherwise, not the same

2. If the two tables are not same, what would you do to ensure no information is lost?

$E1 \cup E2$



Can you help? – Problem Statement

- Kate (SSN=111000) is suspected of embezzling money from the company and she likely has an accomplice.
- Can you help the company narrow down the pool of suspects?
 - Maybe someone from the accounting department and worked with her in some project(s)



Can you help? – Query Question

- Find employees from the accounting department who worked with Kate (SSN=111000) in some project(s).



Image Source: <https://www.learnaboutnature.com/how-can-i-help/>



Can you help? – Thoughts

- Find employees from the accounting department who worked with Kate (SSN=111000) in some project(s).

EMPLOYEE	FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	PNO
John	B		Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T		Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J		Zelaya	999887777	1968-07-19	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	M	38000	333445555	5
Joyce	A		English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V		Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E		Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	null	1

DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
	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

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	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP
	333445555	Alice	F	1986-04-05	DAUGHTER



Can you help? – Step 1

- Find employees from the accounting department who worked with Kate (SSN=111000) in some project(s).
 - Find all employees from accounting

$A \leftarrow \text{Employee} \bowtie \text{Department}$
 $AE(\text{ESSN}) \leftarrow \pi_{\text{SSN}}(A)$

EMPLOYEE	FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5	
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5	
Alicia	J	Zelaya	999887777	1968-07-19	3321 Castle, Spring, TX	F	25000	987654321	4	
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Boffaire, TX	F	43000	888665555	4	
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5	
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5	
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4	
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	null	1	

DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
	Research	5	333445555	1988-05-22
	Administration	4	987654321	1995-01-01
	Headquarters	1	888665555	1961-06-19

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



Can you help? – Step 2

- Find employees from the accounting department who worked with Kate (SSN=111000) in some project(s).
 - Projects accounting employees work on

AEP ←



EMPLOYEE	FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
John	B		Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T		Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J		Zelaya	999887777	1968-07-19	3321 Castle, Spring, TX	F	25000	987654321	4
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Ramesh	K		Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A		English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V		Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E		Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	null	1

AE	ESSN
	.
	.
	.

DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
	Research	5	333445555	1988-05-22
	Administration	4	987654321	1995-01-01
	Headquarters	1	888665555	1981-06-19

WORKS_ON	ESSN	PNQ	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



Can you help? – Step 3

- Find employees from the accounting department who worked with Kate (SSN=111000) in some project(s).
 - Projects Kate works on.

$K \leftarrow \text{[Redacted]} (\text{ESSN}=111000) \text{ (Works_ON)}$
 $KP \leftarrow \pi_{\text{PNO}} (K)$

EMPLOYEE	FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5	
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5	
Alicia	J	Zelaya	999887777	1968-07-19	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	M	38000	333445555	5	
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5	
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4	
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	null	1	

DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
	Research	5	333445555	1988-05-22
	Administration	4	987654321	1995-01-01
	Headquarters	1	888665555	1961-06-19

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



Can you help? – Step 4

- Find employees from the accounting department who worked with Kate (SSN=111000) in some project(s).
 - Match the two project lists

M ← **KP**  **AEP**

Result ← $\pi_{\text{ESSN}}(\mathbf{M})$

EMPLOYEE	FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5	
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5	
Alicia	J	Zelaya	999887777	1968-07-19	3321 Castle, Spring, TX	F	25000	987654321	4	
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bofaire, TX	F	43000	888665555	4	
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5	
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5	
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4	
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	null	1	

KP	PNO
	.
	.
	.

DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
	Research	5	333445555	1988-05-22
	Administration	4	987654321	1995-01-01
	Headquarters	1	888665555	1961-06-19

AEP	ESSN	PNO	HOURS
	.	.	.
	.	.	.
	.	.	.

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



In Class Exercise #9

1. List the names of employees who have the highest salary
2. List the names of employees who have above average salary
3. List the names of employees who have higher salary than John
4. List the names of employees who have the lowest salary in research department



In Class Exercise #9 - Solution

1. $\pi_{\text{FName, LName}} \left(\left(\rho_{\text{max(Salary) as Salary}} (\text{Employee}) \right) * \text{Employee} \right)$
2. $\pi_{\text{FName, LName}} \left(\left(\rho_{\text{avg(Salary) as A}} (\text{Employee}) \right) \bowtie_{\text{Salary>A}} \text{Employee} \right)$
3. $\pi_{\text{FName, LName}} \left(\text{Employee} \bowtie_{\text{Salary>JS}} \left(\pi_{\text{Salary as JS}} \left(\sigma_{\text{FName='John'}} (\text{Employee}) \right) \right) \right)$
4. $R1 \leftarrow \sigma_{\text{DName='Research'}} (\text{Department})$
 $R2 \leftarrow (\text{Employee}) \bowtie_{\text{DNO=DNumber}} (R1)$
 $R3 \leftarrow \rho_{\text{min(Salary) as mins}} (R2)$
 $\text{Result} \leftarrow \pi_{\text{FName, LName}} \left((R3) \bowtie_{\text{Salary=mins}} (R2) \right)$



TABLE 6.1 OPERATIONS OF RELATIONAL ALGEBRA

Operation	Purpose	Notation
SELECT	Selects all tuples that satisfy the selection condition from a relation R .	$\sigma_{\langle \text{SELECTION CONDITION} \rangle}(R)$
PROJECT	Produces a new relation with only some of the attributes of R , and removes duplicate tuples.	$\pi_{\langle \text{ATTRIBUTE LIST} \rangle}(R)$
THETA JOIN	Produces all combinations of tuples from R_1 and R_2 that satisfy the join condition.	$R_1 \bowtie_{\langle \text{JOIN CONDITION} \rangle} R_2$
Aggregation	Produces summary statistics on a table	$G_1, G_2, \dots, G_n \mathcal{G}_{F_1(A_1), F_2(A_2), \dots, F_n(A_n)}(E)$
NATURAL JOIN	Same as EQUIJOIN except that the join attributes of R_2 are not included in the resulting relation; if the join attributes have the same names, they do not have to be specified at all.	$R_1 * R_2$
UNION	Produces a relation that includes all the tuples in R_1 or R_2 or both R_1 and R_2 ; R_1 and R_2 must be union compatible.	$R_1 \cup R_2$
INTERSECTION	Produces a relation that includes all the tuples in both R_1 and R_2 ; R_1 and R_2 must be union compatible.	$R_1 \cap R_2$
DIFFERENCE	Produces a relation that includes all the tuples in R_1 that are not in R_2 ; R_1 and R_2 must be union compatible.	$R_1 - R_2$
CARTESIAN PRODUCT	Produces a relation that has the attributes of R_1 and R_2 and includes as tuples all possible combinations of tuples from R_1 and R_2 .	$R_1 \times R_2$
DIVISION	Produces a relation $R(X)$ that includes all tuples $t[X]$ in $R_1(Z)$ that appear in R_1 in combination with every tuple from $R_2(Y)$, where $Z = X \cup Y$.	$R_1(Z) \div R_2(Y)$



Benefits of Relational Algebra

- The relational model has rigorously defined query languages that are simple and powerful.
- Relational algebra is more operational; useful as internal representation for query evaluation plans.
- Several ways of expressing a given query; a query optimizer should choose the most efficient version.



In Class Exercise #10

- a. (Easy) List names of employees who work on more than one project.
- b. (Tough) Find all the pairs of employees, where the first one has a higher salary than the second one.
- c. (Tricky) Find out the supervisor of John's Supervisor.
- d. Find out the names of employees who work for any of the projects controlled by the Research department.
- e. Find out the names of employees who work for all of the projects controlled by the Research department.



In Class Exercise #10 - Solution

a. $R1 \leftarrow \text{ESSN } \rho_{\text{count(PNO) as np}} (\text{WORK_ON})$

$R2 \leftarrow \sigma_{\text{np} > 1} (R1)$

$\text{Result} \leftarrow \pi_{\text{FName, LName}} ((\text{Employee}) \bowtie_{\text{SSN=ESSN}} (R2))$

b. $R1 (\text{F, L, S}) \leftarrow \pi_{\text{FName, LName, Salary}} (\text{Employee})$

$\text{Result} \leftarrow \pi_{\text{FName, LName, F, L}} ((\text{Employee}) \bowtie_{\text{Salary} > \text{S}} (R1))$

c. $R1 (\text{SJ}) \leftarrow \pi_{\text{SUPERSSN}} (\sigma_{\text{FNAME}='John'} (\text{Employee}))$

$R2(\text{SSJ}) \leftarrow \pi_{\text{SUPERSSN}} ((\text{Employee}) \bowtie_{\text{SSN=SJ}} (R1))$

$\text{Result} \leftarrow \pi_{\text{FName, LName}} ((\text{Employee}) \bowtie_{\text{SSN=SSJ}} (R2))$

d. $R1 \leftarrow \pi_{\text{DNUMBER}} (\sigma_{\text{DNAME}='Research'} (\text{Department}))$

$R2(\text{PNO}) \leftarrow \pi_{\text{PNUMBER}} ((\text{Project}) \bowtie_{\text{DNUM=DNUMBER}} (R1))$

$R3 \leftarrow \pi_{\text{ESSN}} ((\text{WORK_ON}) * (R2))$

$\text{Result} \leftarrow \pi_{\text{FNAME, LNAME}} ((\text{Employee}) \bowtie_{\text{SSN=ESSN}} (R3))$



In Class Exercise #10 - Thoughts

- e.) Find out the names of employees who work for all of the projects controlled by research department.

EMPLOYEE	FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
John	B		Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T		Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J		Zelaya	999887777	1968-07-19	3321 Castle, Spring, TX	F	25000	987654321	4
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Ahmad	V		Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E		Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	null	1

DEPT_LOCATIONS	DNUMBER	DLOCATION
	1	Houston
	4	Stafford
	5	Bellaire
	5	Sugarland
	5	Houston

DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
	Research	5	333445555	1988-05-22
	Administration	4	987654321	1995-01-01
	Headquarters	1	888665555	1981-06-19

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	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP
	333445555	Alice	F	1986-04-05	DAUGHTER
	333445555	Theodore	M	1983-10-25	SON



In Class Exercise #10 – Step 1

- e.) Find out the names of employees who work for all of the projects controlled by research department.
 - Find projects controlled by Research

R ← Project Department

RP(PNO) ← π_{PNUMBER} (R)

DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
	Research	5	333445555	1988-05-22
	Administration	4	987654321	1995-01-01
	Headquarters	1	888665555	1981-06-19

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



In Class Exercise #10 – Step 2

- e.) Find out the names of employees who work for all of the projects controlled by research department.
 - Find projects controlled by Research

$$WK \leftarrow \pi_{PNO, ESSN} (Works_ON)$$

$$ERP \leftarrow WK \text{ } \square \text{ } RP$$

DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
Research		5	333445555	1988-05-22
Administration		4	987654321	1995-01-01
Headquarters		1	888665555	1981-06-19

RP	PNO
	1
	2
	3

WORKS_ON	ESSN	PNO	HOURS
	123456789	1	2.5
	123456789	2	7.5
	666884444	3	4.0
	453453453	1	2.0
	453453453	2	2.0
	333445555	2	1.0
	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



In Class Exercise #10 – Step 3

- e.) Find out the names of employees who work for all of the projects controlled by research department.
 - Get the employee names.

$R1 \leftarrow ERP$  **Employee**

Result $\leftarrow \pi_{FNAME, LNAME} (R1)$

EMPLOYEE	FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5	
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5	
Alicia	J	Zelaya	999887777	1968-07-19	3321 Castle, Spring, TX	F	25000	987654321	4	
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellairs, TX	F	43000	888665555	4	
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5	
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5	
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4	
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	null	1	

ERP	ESSN
	.
	.
	.



Summary of Lecture 4-2

- Query tree
- Query optimization
- Relational calculus
- RA exercises

