Database Management Systems (DBMS)

Lec 3: Relational model of data (Cont.)

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Recap

- Schema diagram and other constraints
- Relational algebra and a few operations
  - Selection: Filters tuples that satisfy a given condition
  - Projection: Selects attributes and removes duplicates, if any
  - Rename: Gives names to the intermediate result relations, and renames either the relation name or the attributes name
  - Set theoretic operations: Appilcable only if the relations satisfy ***union compatible*** condition
  - Cartesian product: All combinations of tuples

Today's plan

- The join operation
- Some exercise queries

Exercise: Bank database

- Branch(**Name,** Assets, City)
- Customer(**ID**, Customer_Name, Street, City)
- Loan (**Loan_Number**, Branch_name, Amount)
- Borrower(**BC_ID**, **BL_Number**)
- Account (**Account_Number**, AB_name, Balance)
- Depositor (**DC_ID** , **A_number**)

Queries

1. Identify all foreign keys
2. Find all loans over 10,000/-
3. Find loan number for each loan greater than 25,000/-
4. Find all customers IDs who have loan 10,000/- or account balance > 5,000/-
5. Find the IDs of all customers who have a loan at the Raichur branch
6. Find the IDs of all customers who have a loan at the Raichur branch but do not have an account at any branch of the bank

Answers

1. Branch_name in Loan, both BC_ID and BL_Number in Borrower, AB_Name in account, and both DC_ID and A_Number in Depositer

2. $\sigma_{\text{amount} > 10000}(\text{Loan})$

3. $\pi_{\text{Loan\_Number}}(\sigma_{\text{amount} > 25000}(\text{Loan}))$

4. $\pi_{\text{BC\_ID}}(\sigma_{\text{Amount} = 10000}(\text{Borrower})) \cup \pi_{\text{DC\_ID}}(\sigma_{\text{Account\_Number} = \text{A\_Number}}(\text{Account} \times \text{Depoister}))$

Answers (Cont.)

4. $\pi_{BC\_ID}\ (\sigma_{Branch\_Name\ =\ 'Raichur'\ \textbf{AND}\ BL\_Number\ =\ Loan\_Number}\ (Borrower\ x\ Loan))$

5. $TEMP \leftarrow \pi_{BC\_ID}\ (\sigma_{Branch\_Name\ =\ 'Raichur'\ \textbf{AND}\ BL\_Number\ =\ Loan\_Number}\ (Borrower\ x\ Loan))$
   $TEMP - \pi_{DC\_ID}(Depoister)$

Take home queries

1. Find the customer name for the last three queries with the same requirement

2. Find the largest account balance
   - Hint: Use Rename, Cartesian, and Set Minus operations

The join operation (⋈)

- Used to combine related tuples from two relations into single tuples
- Notation: $R \bowtie_{\text{<join condition>}} S$
- The join of two relations $R(A_1,A_2,...,A_n)$ and $S(B_1,B_2,...,B_m)$ is a new relation $Q(A_1,A_2,...,A_n,B_1,B_2,...,B_m)$
- Q contains those tuples satisfying the given join condition
- The degree of Q ?, and the cardinality?

Example

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

DEPARTMENT

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

Query: Retrieve the name of the manager of each department

$$DEPT\_MGR \leftarrow DEPARTMENT \bowtie_{Mgr\_ssn=Ssn} EMPLOYEE$$

$$RESULT \leftarrow \pi_{Dname,\ Lname,Fname}(DEPT\_MGR)$$

DEPT_MGR

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

RESULT

Dname	Lname	Fname
Research	Wong	Franklin
Administration	Wallace	Jennifer
Headquarters	Borg	James

Observation

- ⋈ is Cartesian product operation followed by a Select operation
  - $R \bowtie_{\text{<join condition>}} S = \sigma_{\text{<join condition>}}(R \times S)$
- A general join condition: <cond> **AND** <cond>**AND**….**AND**<cond>
  - **Theta join**: $A_i \theta B_i$ such that $dom(A_i) = dom(B_j)$, and θ is one of the comparison operators {=, <, ≤, >, ≥, ≠}
  - Tuples whose join attributes are NULL or for which the join condition is FALSE do not appear in the result

Example from last class

- List of names of each female employee's dependents
  - FEMALE_EMPS ← $\sigma_{Sex='F'}$(EMPLOYEE)
  - EMPNAMES ← $\pi_{Fname,\ Lname,\ Ssn}$(FEMALE_EMPS)
  - EMP_DEPENDENTS ← EMPNAMES × DEPENDENT
  - ACTUAL_DEPENDENTS ← $\sigma_{Ssn=Essn}$(EMP_DEPENDENTS)
  - RESULT ← $\pi_{Fname,Lname,Dependent\_name}$(ACTUAL_DEPENDENTS)

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
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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	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

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
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	M	1942-02-28	Spouse
123456789	Michael	M	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

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	A	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

EMP_DEPENDENTS

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

ACTUAL_DEPENDENTS

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

RESULT

Fname	Lname	Dependent_name
Jennifer	Wallace	Abner

Example from last class

- List of names of each female employee's dependents
  - FEMALE_EMPS $\leftarrow \sigma_{Sex='F'}(EMPLOYEE)$
  - EMPNAMES $\leftarrow \pi_{Fname,\ Lname,\ Ssn}(FEMALE\_EMPS)$
  - ACTUAL_DEPENDENTS $\leftarrow$ EMPNAMES $\bowtie_{Ssn=Essn}$ DEPENDENT
  - RESULT $\leftarrow \pi_{Fname,Lname,Dependent\_name}(ACTUAL\_DEPENDENTS)$

Exercise

Query 1. Retrieve the name and address of all employees who work for the 'Research' department.

$$\text{RESEARCH\_DEPT} \leftarrow \sigma_{\text{Dname='Research'}}(\text{DEPARTMENT})$$
$$\text{RESEARCH\_EMPS} \leftarrow (\text{RESEARCH\_DEPT} \bowtie_{\text{Dnumber=Dno}} \text{EMPLOYEE})$$
$$\text{RESULT} \leftarrow \pi_{\text{Fname, Lname, Address}}(\text{RESEARCH\_EMPS})$$

As a single in-line expression, this query becomes:

$$\pi_{\text{Fname, Lname, Address}} (\sigma_{\text{Dname='Research'}}(\text{DEPARTMENT} \bowtie_{\text{Dnumber=Dno}}(\text{EMPLOYEE}))$$

Thank you!