Introduction to Database Systems
Lecture 9

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Relational Algebra

- Relational algebra operations work on one or more relations to define another relation leaving the original intact.
- Both operands and results are relations, so output from one operation can become input to another operation.
- Allows expressions to be nested, just as in arithmetic. This property is called closure.

Relational Algebra

- There are 5 basic operations in relational algebra:
- Selection,
- Projection,
- Cartesian product,
- Union and
- Set Difference.

Five Basic Operators

- These 5 operations perform most of the data retrieval operations needed.
- Also we have Join, Intersection, and Division operations, which can be expressed in terms of 5 basic operations.

Five Basic Operators

- Unary Operators
  - Select
  - Project

Select

- The SELECT operation is used to choose a subset of the tuples from a relation that satisfies a selection condition.
- One can consider the SELECT operation to be a *filter* that keeps only those tuples that satisfy a qualifying condition.
- In general, the SELECT operation is denoted by
- σ<selection condition>(*R*)
- where the symbol σ (sigma) is used to denote the SELECT operator
- The selection condition is a Boolean expression (condition) specified on the attributes of relation *R*.

Select

- For example, to select the EMPLOYEE tuples whose department is 4, or those whose salary is greater than $30,000, we can individually specify each of these two conditions with a SELECT operation as follows:
- σDno=4(EMPLOYEE)
- σSalary>30000(EMPLOYEE)

Project

- If we think of a relation as a table, The **PROJECT** operation, selects certain *columns* from the table and discards the other columns.
- If we are interested in only certain attributes of a relation, we use the PROJECT operation to *project* the relation over these attributes only.
- The general form of the PROJECT operation is
  - π<attribute list>(*R*)
- where π (pi) is the symbol used to represent the PROJECT operation, and <attribute list> is the desired sublist of attributes from the attributes of relation *R*.

Project

- For example, to list each employee's first and last name and salary, we can use the PROJECT operation as follows:
  - πLname, Fname, Salary(EMPLOYEE)
- If the attribute list includes only nonkey attributes of *R*, duplicate tuples are likely to occur.
- The PROJECT operation *removes any duplicate tuples*, so the result of the PROJECT operation is a set of distinct tuples, and hence a valid relation.
- This is known as duplicate elimination.

Project

Results of SELECT and PROJECT operations. (a) $\sigma_{(Dno=4\ \textbf{AND}\ Salary>25000)\ OR\ (Dno=5\ \textbf{AND}\ Salary>30000)}$ (EMPLOYEE). (b) $\pi_{Lname,\ Fname,\ Salary}$(EMPLOYEE). (c) $\pi_{Sex,\ Salary}$(EMPLOYEE).

(a)

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	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	M	38000	333445555	5

(b)

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

(c)

Sex	Salary
M	30000
M	40000
F	25000
F	43000
M	38000
M	25000
M	55000

Binary Operators

- Union, Intersection
- Set Difference
- Cartesian Product

UNION

- The result of this operation, denoted by $R \cup S$, 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.
- Union is Commutative:

$$R \cup S = S \cup R$$

UNION

RESULT1

Ssn
123456789
333445555
666884444
453453453

RESULT2

Ssn
333445555
888665555

RESULT

Ssn
123456789
333445555
666884444
453453453
888665555

Result of the UNION operation RESULT ← RESULT1 ∪ RESULT2.

INTERSECTION

- The result of this operation, denoted by $R \cap S$, is a relation that includes all tuples that are in both *R* and *S*.
- Intersection is Commutative

$$R \cap S = S \cap R$$

(a) **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

Fn	Ln
Susan	Yao
Ramesh	Shah

STUDENT∩INSTRUCTOR

Set Difference(Minus)

- The result of this operation, denoted by $R - S$, is a relation that includes all tuples that are in R but not in S.
- The MINUS operation is *not commutative;* that is, in general,
- $R - S \neq S - R$

(a) STUDENT

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INSTRUCTOR

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Cartesian Product

- The CARTESIAN PRODUCT operation—also known as CROSS PRODUCT or CROSS JOIN—which is denoted by ×.
- If R has C tuples and S has D tuples, the result is C*D tuples.
- Example:
- FEMALE_EMPS ← σSex='F'(EMPLOYEE)
- EMPNAMES ← πFname, Lname, Ssn(FEMALE_EMPS)
- EMP_DEPENDENTS ← EMPNAMES × DEPENDENT
- ACTUAL_DEPENDENTS ← σSsn=Essn(EMP_DEPENDENTS)
- RESULT ← πFname, Lname, Dependent_name(ACTUAL_DEPENDENTS)

Cartesian Product

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

Cartesian Product

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	...

Cartesian Product

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

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