Database Management Systems

Module 07: Introduction to Relational Model/2

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Module Recap

- Basic notions of modeling introduced
  - Attributes and their Types
  - Schema and Instance
  - Keys and their Categorization
- Languages for Relation Model introduced

Module Objectives

- To understand relational algebra
- To familiarize with the operators of relational algebra

Module Outline

- Operations
  - Select
  - Project
  - Union
  - Difference
  - Intersection
  - Cartesian Product
  - Natural Join
- Aggregate Operations

Relational Operators

Basic Properties of Relations

- **A relation is set**. Hence,
- **Ordering of rows / tuples is inconsequential**

A	B
a1	b1
a1	b2
a2	b1
a2	b2

is same as:

A	B
a1	b1
a2	b1
a2	b2
a1	b2

- **All rows / tuples must be distinct**

A	B
a1	b1
a1	b2
a1	b2
a1	b1

is not valid

A	B
a1	b1
a1	b2

is

Select Operation – selection of rows (tuples)

- Relation r

A	B	C	D
α	α	1	7
α	β	5	7
β	β	12	3
β	β	23	10

- $\sigma_{A=B \wedge D>5}(r)$

A	B	C	D
α	α	1	7
β	β	23	10

Project Operation – selection of columns (Attributes)

- Relation r

A	B	C
α	10	1
α	20	1
β	30	1
β	40	2

- $\pi_{A,C}(r)$

A	C
α	1
α	1
β	1
β	2

=

A	C
α	1
β	1
β	2

Union of two relations

- Relation r, s

A	B
α	1
α	2
β	1

r

A	B
α	2
β	3

s

- $r \cup s$

A	B
α	1
α	2
β	1
β	3

Set difference of two relations

- Relation r, s

A	B
α	1
α	2
β	1

r

A	B
α	2
β	3

s

- $r - s$

A	B
α	1
β	1

Set intersection of two relations

- Relation r, s

A	B
α	1
α	2
β	1

r

A	B
α	2
β	3

s

- $r \cap s$

A	B
α	2

Note: $r \cap s = r - (r - s)$

Joining two relations – Cartesian-product

- Relation r, s

A	B
α	1
β	2

r

C	D	E
α	10	a
β	10	a
β	20	b
γ	10	b

s

- $r \times s$

A	B	C	D	E
α	1	α	10	a
α	1	β	10	a
α	1	β	20	b
α	1	γ	10	b
β	2	α	10	a
β	2	β	10	a
β	2	β	20	b
β	2	γ	10	b

Cartesian-product – naming issue

- Relation r, s

A	B
α	1
β	2

r

B	D	E
α	10	a
β	10	a
β	20	b
γ	10	b

s

- $r \times s$

A	$r.B$	$s.B$	D	E
α	1	α	10	a
α	1	β	10	a
α	1	β	20	b
α	1	γ	10	b
β	2	α	10	a
β	2	β	10	a
β	2	β	20	b
β	2	γ	10	b

Renaming a Table

- Allows us to refer to a relation, (say E) by more than one name.

$$\rho_X(E)$$

returns the expression E under the name X

- Relations r

A	B
α	1
β	2

r

- $r \times \rho_s(r)$

$r.A$	$r.B$	$s.A$	$s.B$
α	1	α	1
α	1	β	2
β	2	α	1
β	2	β	2

Composition of Operations

- Can build expressions using multiple operations
- Example: $\sigma_{A=C}(r \times s)$
- $r \times s$

A	B	C	D	E
α	1	α	10	a
α	1	β	10	a
α	1	β	20	b
α	1	γ	10	b
β	2	α	10	a
β	2	β	10	a
β	2	β	20	b
β	2	γ	10	b

- $\sigma_{A=C}(r \times s)$

A	B	C	D	E
α	1	α	10	a
β	2	β	10	a
β	2	β	20	b

Joining two relations – Natural Join

- Let r and s be relations on schemas R and S respectively. Then, the "natural join" of relations R and S is a relation on schema $R \cup S$ obtained as follows:
  - Consider each pair of tuples t_r from r and t_s from s.
  - If t_r and t_s have the same value on each of the attributes in $R \cap S$, add a tuple t to the result, where
    - t has the same value as t_r on r
    - t has the same value as t_s on s

Natural Join Example

- Relations r, s :

A	B	C	D
α	1	α	a
β	2	γ	a
γ	4	β	b
α	1	γ	a
δ	2	β	b

r

B	D	E
1	a	α
3	a	β
1	a	γ
2	b	δ
3	b	ε

s

- Natural Join
  - $r \bowtie s$

A	B	C	D	E
α	1	α	a	α
α	1	α	a	γ
α	1	γ	a	α
α	1	γ	a	γ
δ	2	β	b	δ

$$\pi_{A,r.B,C,r.D,E}\left(\sigma_{r.B=s.B \ \wedge \ r.D=s.D}(r \times s)\right)$$

Aggregation Operators

Aggregate Operators

- Can we compute:
  - SUM
  - AVG
  - MAX
  - MIN

Notes about Relational Languages

- Each query input is a table (or set of tables)
- Each query output is a table
- All data in the output table appears in one of the input tables
- Relational Algebra is not Turing complete

Summary of Relational Algebra Operators

Symbol (Name)	Example of Use
σ (Selection)	$\sigma_{\text{salary} >= 85000\ (instructor)}$
	Return rows of the input relation that satisfy the predicate.
Π (Projection)	$\Pi_{ID,\ salary\ (instructor)}$
	Output specified attributes from all rows of the input relation. Remove duplicate tuples from the output.
X (Cartesian Product)	*instructor* X *department*
	Output all possible combinations of rows in *instructor* and *department*.
∪ (Union)	$\Pi_{name\ (instructor)} \cup \Pi_{name\ (student)}$
	Output the union of tuples from the *two* input relations.
- (Set Difference)	$\Pi_{name\ (instructor)} - \Pi_{name\ (student)}$
	Output the set difference of tuples from the two input relations.
⋈ (Natural Join)	*instructor* ⋈ *department*
	Output pairs of rows from the two input relations that have the same value on all attributes that have the same name.

Module Summary

- Introduced relational algebra
- Familiarized with the operators of relational algebra

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