Relational Algebra (Part II)

R & G, Chapter 4

Last Lecture

- **Relational Algebra: 5 Basic Operations**
  - *Selection* (σ): Selects a subset of *rows* from relation.
  - *Projection* (π): Retains only wanted *columns* from relation.
  - *Union* (U): Tuples in r1 and/or in r2.
  - *Set-difference* (—): Tuples in r1, but not in r2.
  - *Cross-product* (X): Cartesian product.

Today's Lecture

- Compound operations
  - Intersection ($\cap$)
  - Join ($\bowtie$)
  - Division (/)
- Renaming operation (ρ)

Intersection $\cap$

- Notation: $R \cap S$
- Output: the tuples in both R and S.
- R and S must be **<u>union-compatible</u>**.
- $\cap$ is NOT a basic operation
  - It can be expressed by using basic operations

$$R \cap S = R - (R - S)$$

Intersection

Sid	Sname	Rating	Age
22	Dustin	7	45
31	Lubber	8	55
58	Rusty	10	35

S1

Sid	Sname	Rating	Age
28	Yuppy	9	35
31	Lubber	8	55
44	Guppy	5	35
58	Rusty	10	35

S2

Sid	Sname	Rating	Age
31	Lubber	8	55
58	Rusty	10	35

$S1 \cap S2$

Q1: is ∩ a symmetric operator? (i.e., is S1 ∩ S2 = S2 ∩ S1?)

Q2: is there any duplicate in R ∩ S?

Join $\bowtie$

- "*Natural join*" (often just called "join").
  - Notation: $R \bowtie S$
  - Output of join:
    - Schema: All attributes in R & S
      - Keep only one copy of the common attributes in R & S
    - Output: All rows in R X S where they have equal values on the common attributes
  - If there are no attributes in common between two relations, the natural join will return the result of R X S.

Natural Join Example

Sid	Bid	day
22	101	10/10/96
58	103	11/12/96

R1

Sid	Sname	Rating	Age
22	Dustin	7	45
31	Lubber	8	55
58	Rusty	10	35

S1

$$R1 \bowtie S1 =$$

Sid	Sname	Rating	Age	Bid	day
22	Dustin	7	45	101	10/10/96
58	Rusty	10	35	103	11/12/96

Note: Attribute *Sid* only appears ONCE in the join result.

Natural Join Exercise

- Given the schemas R(A, B, C, D), S(A, C, E), what is the schema of R $\bowtie$ S ?

- Given R1(A, B, C) and S1(D, E)
  - What is the schema of R1 $\bowtie$ S1?
  - What is the schema of R1 X S1?

- Given R2(A, B) shown at right:
  - What is the result of R2 $\bowtie$ R2?
  - What is the result of R2 X R2?

A	B
a1	b1
a2	b2

R2

Condition Join

- Notation: $R \bowtie_c S$
  - C: the condition that the output records must satisfy
- Condition join $R \bowtie_c S$ is equivalent to $\sigma_c(R \times S)$
- *Output:*
  - *Schema:* the same as R X S.
  - Instances: Only those records in R X S that satisfies condition c

Condition Join Example

Sid	Bid	day
22	101	10/10/96
58	103	11/12/96

R1

Sid	Sname	Rating	Age
22	Dustin	7	45
31	Lubber	8	55
58	Rusty	10	35

S1

S1.sid	Sname	Rating	Age	R1.sid	Bid	day
22	Dustin	7	45	58	103	11/12/96
31	Lubber	8	55	58	103	11/12/96

$$\mathbf{R} \bowtie_{\mathbf{S1.sid<R1.sid}} \mathbf{S}$$

Note: Attribute Sid appears TWICE in the join result (as S1.sid and R1.sid).

Equi-Join

- A special case of condition join where condition contains only ***equality comparison =***
- *Result schema:* same as cross-product

A	B	C
a1	b1	c1
a1	b2	c2

R

A	B	D
a1	b1	d1
a1	b2	d2

S

R.A	R.B	C	S.A	S.B	D
a1	b1	c1	a1	b1	d1
a1	b1	c1	a1	b2	d2
a1	b2	c2	a1	b1	d1
a1	b2	c2	a1	b2	d2

$$R \bowtie_{R.A=S.A} S$$

Equi-join VS. Natural join

- *Equi-join*: the equality operator on specified attributes (not necessarily the common attributes).
- *Natural join:* an equi-join on ALL common attributes.

A	B	C
a1	b1	c1
a1	b2	c2

R

A	B	D
a1	b1	d1
a1	b2	d2

S

Is $R \bowtie S = R \bowtie_{R.A=S.A \ \wedge \ R.B=S.B} S$?

Division

- Notation: ***A*/B *or A*÷B**
- A/B is used when we wish to express queries with the keyword “ALL”:
    - Examples:
        - “Which students are registered with **ALL** the courses taught by Dr. X?”
        - “Which students have taken ALL the HUM courses?”

Output of A/B

- Attributes of B is proper subset of Attributes of A.
- Attributes of the relation returned by A/B = (All attributes of A – All Attributes of B)
    - E.g., given A (SID, PID, grade) and B (PID)
    - The schema of A/B is (SID, grade)
- The relation returned by division operator will return those tuples from relation A which are associated to every B's tuple.

X	Y
x1	y1
x1	y2
x1	y3
x1	y4
x2	y1
x2	y2

A

Y
y1
y2
y3
y4

B

X
x1

A/B

Exercise

- **Consider A (SID, Name, Age), B(SID, Address)**
  - Is A/B allowed?

  - Is $\pi_{SID,\ Name}$ (A)/ π_{SID}(B) allowed?

  - Is B/ π_{SID}(A) allowed?

Examples of Division A/B

Sno	pno
S1	P1
S1	P2
S1	P3
S1	P4
S2	P1
S2	P2
S3	P2
S4	P2
S4	P4

A

Pno
P2

$B1$

Pno
P2
P4

$B2$

Pno
P1
P2
P4

$B3$

Sno
S1
S2
S3
S4

$A/B1$

Sno
S1
S4

$A/B2$

Sno
S1

$A/B3$

Renaming Operator (ρ)

- It allows to name the results of relational-algebra expressions as a new instance
- Notation: ρ***(X, E)***
  - Assign name X to the results of expression *E*
- Rename the results of an expression, e.g.,

  $\rho(OldSailor, \ \sigma_{age>45}(Sailor))$
- Renaming operator (ρ) is NOT a compound operation

Renaming Example

Sid	Sname	Rating	Age
22	Dustin	7	48
31	Lubber	8	55
58	Rusty	10	35

Sailor

$\rho(\text{OldSailor},\ \sigma_{age>45}(\text{Sailor}))$

Sid	Sname	Rating	Age
22	Dustin	7	48
31	Lubber	8	55

OldSailor

Use the renamed OldSailor as a new relation

For example: π_{Sname} (OldSailor)