Database Management System (DBMS)

L-3:

Relational Algebra

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Lecture Content

- Relational Algebra
- Relational Database Operations
- Set Theoretic Operations
- Additional Relational Operations

Relational Algebra

"The relational algebra is a theoretical language with operations that work on one or more relations to define another relation without changing the original relation/s."

Three Types of operations:

- Relational Database Operations

select, project, join

- Set Theoretic Operations

Union, Intersect, Set Difference, Cartesian Product

- Additional Relational Operations

Aggregate, Grouping, and Outer Join

Selection

"Selection operation works on a single relation R and defines a relation that contains only those tuples of R that satisfy the specified condition."

$$\sigma_{condition}(R)$$

Selection cont.

For example, We have a relation called ***Student****.*

Student

LName	*FName*	*StudId*	*Major*
Smith	Susan	131313	Comp
Bond	James	007007	Math
Smith	Susan	555555	Comp
Cecil	John	010101	Math

σ_{StudId} **(Student)**

Student1

LName	*FName*	*StudId*	*Major*
Bond	James	007007	Math

Projection

"Projection operation works on a single relation R and defines a relation that contains a vertical subset of R, extracting the values of specified attributes and eliminate duplicates."

$$\pi_{A1, \ldots\ldots\ldots\ldots\ldots, An} (R)$$

Projection cont.

For example, We have a relation called ***Student****.*

Student

LName	*FName*	*StudId*	*Major*
Smith	Susan	131313	Comp
Bond	James	007007	Math
Smith	Susan	555555	Comp
Cecil	John	010101	Math

$\pi_{Lname, FName}(Student)$

Student1

Lname	*FName*
Smith	Susan
Bond	James
Cecil	John

Union

"The union of two relations R and S defines a relation that contains all the tuples of R, or S, or both R and S, duplicate tuples being eliminated. R and S must be union compatible."

R U S

Union cont.

For Example,

"List all cities where there is either a branch office or property for rent"

Branch

branchNo	city
B005	London
B007	Aberdeen
B003	Glasgow
B004	Bristol
B002	London

PropertyForRent

propertyNo	city
PA14	Aberdeen
PL94	London
PG4	Glasgow
PG36	Glasgow
PG21	Glasgow
PG16	Glasgow

How do we list them?

Union cont.

Branch

branchNo	city
B005	London
B007	Aberdeen
B003	Glasgow
B004	Bristol
B002	London

PropertyForRent

propertyNo	city
PA14	Aberdeen
PL94	London
PG4	Glasgow
PG36	Glasgow
PG21	Glasgow
PG16	Glasgow

*First **project** them to make union compatible then **union** operation.*

$$\pi_{city}(Branch) \cup \pi_{city}(PropertyForRent)$$

city
London
Aberdeen
Glasgow
Bristol

Intersection

"The intersection operation defines a relation consisting of the set of all tuples that are in both R and S. R and S must be union compatible."

$R \cap S$

Intersection cont.

For Example,

"List all cities where there is both a branch office and at least one property for rent"

Branch

branchNo	city
B005	London
B007	Aberdeen
B003	Glasgow
B004	Bristol
B002	London

PropertyForRent

propertyNo	city
PA14	Aberdeen
PL94	London
PG4	Glasgow
PG36	Glasgow
PG21	Glasgow
PG16	Glasgow

How do we list them?

Intersection cont.

Branch

branchNo	city
B005	London
B007	Aberdeen
B003	Glasgow
B004	Bristol
B002	London

PropertyForRent

propertyNo	city
PA14	Aberdeen
PL94	London
PG4	Glasgow
PG36	Glasgow
PG21	Glasgow
PG16	Glasgow

*First **project** them to make union compatible then **intersect** operation.*

$$\pi_{city}(Branch) \cap \pi_{city}(PropertyForRent)$$

city
Aberdeen
London
Glasgow

Cartesian Product

"The Cartesian Product operation defines a relation that is the concatenation of every tuple of relation R with every tuple of relation S."

R x S

Cartesian Product

For Example,

R

A	B
1	2
3	3
4	4

X

S

B	C
2	7
4	9
ω	0

=

R x S

A	B	B	C
1	2	2	7
1	2	4	9
1	2	ω	0
3	3	2	7
3	3	4	9
3	3	ω	0
4	4	2	7
4	4	4	9
4	4	ω	0

Join

"Join operation joins two relations by merging those tuples from two relations that satisfy some given condition."

There are various forms of join operations -

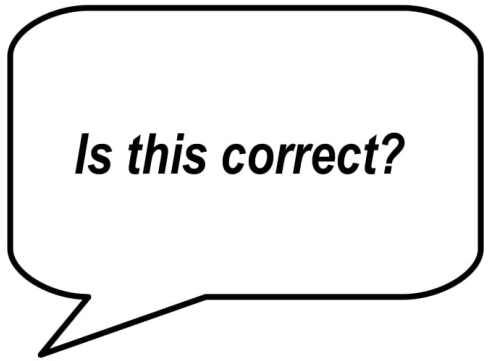
- ➔ Theta join
- ➔ Equi join
- ➔ Natural join
- ➔ Outer join
- ➔ Semi join

Theta Join (θ-join)

"Theta join operation defines a relation that contains tuples satisfying the condition F from the Cartesian Product of R and S. The condition is in the form $R.a_i$ θ $S.b_i$, where θ may be one of the comparison operations (<, ≤, >, ≥, =, ≠)."

$$R \bowtie_F S$$

Theta Join (θ-join)



$$R \bowtie_F S = \sigma_F (R \times S)$$

So we can say, a join operation is nothing but a "Selection operation with some condition on a Cartesian Product".

Equi join

R

A	B
1	2
3	3
4	4

X

S

B	C
2	7
4	9
ω	0

=

R x S

A	B	B	C
1	2	2	7
1	2	4	9
1	2	ω	0
3	3	2	7
3	3	4	9
3	3	ω	0
4	4	2	7
4	4	4	9
4	4	ω	0

Equi join Example,

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

A	B	B	C
1	2	2	7
4	4	4	9

Natural Join

"The natural join is an Equijoin of the two relations R and S over all common attributes. One occurrence of each common attribute is eliminated from the result."

$R \bowtie S$

Natural join

R

A	B
1	2
3	3
4	4

X

S

B	C
2	7
4	9
ω	0

=

R x S

A	B	B	C
1	2	2	7
1	2	4	9
1	2	ω	0
3	3	2	7
3	3	4	9
3	3	ω	0
4	4	2	7
4	4	4	9
4	4	ω	0

Natural join Example,

R ⋈ S

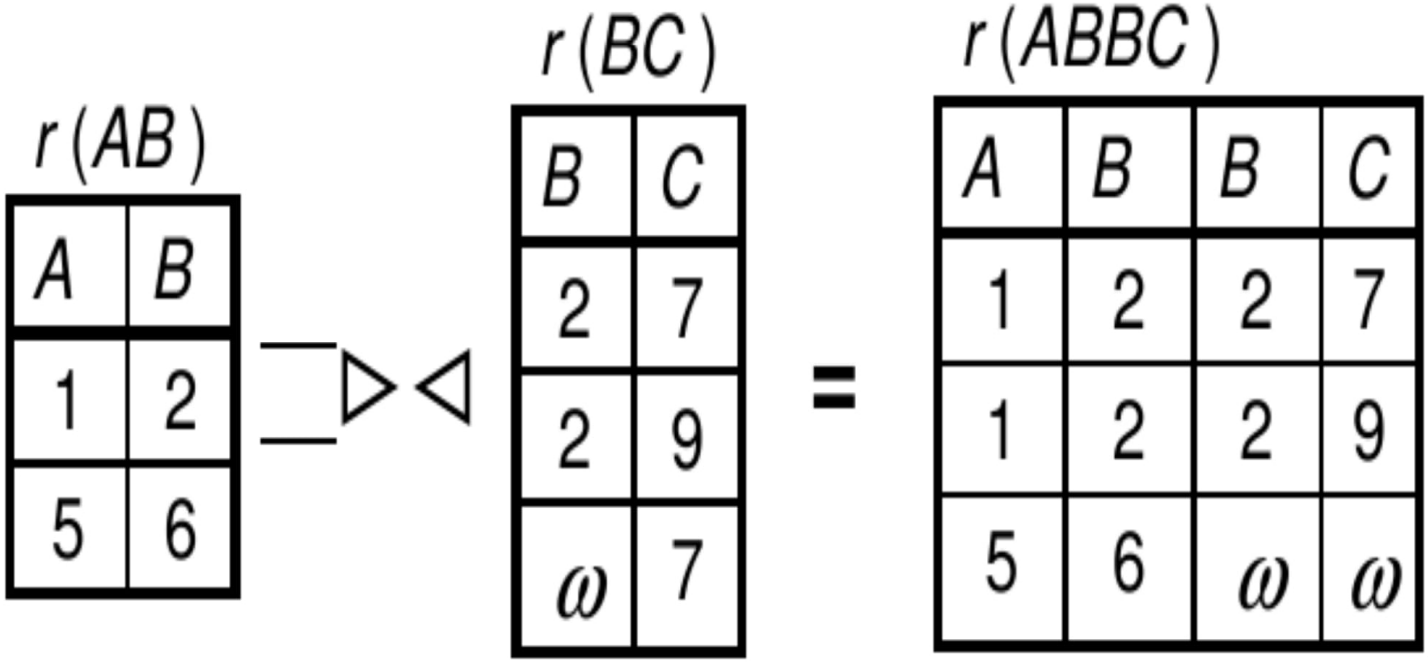
A	B	C
1	2	7
4	4	9

Outer Join

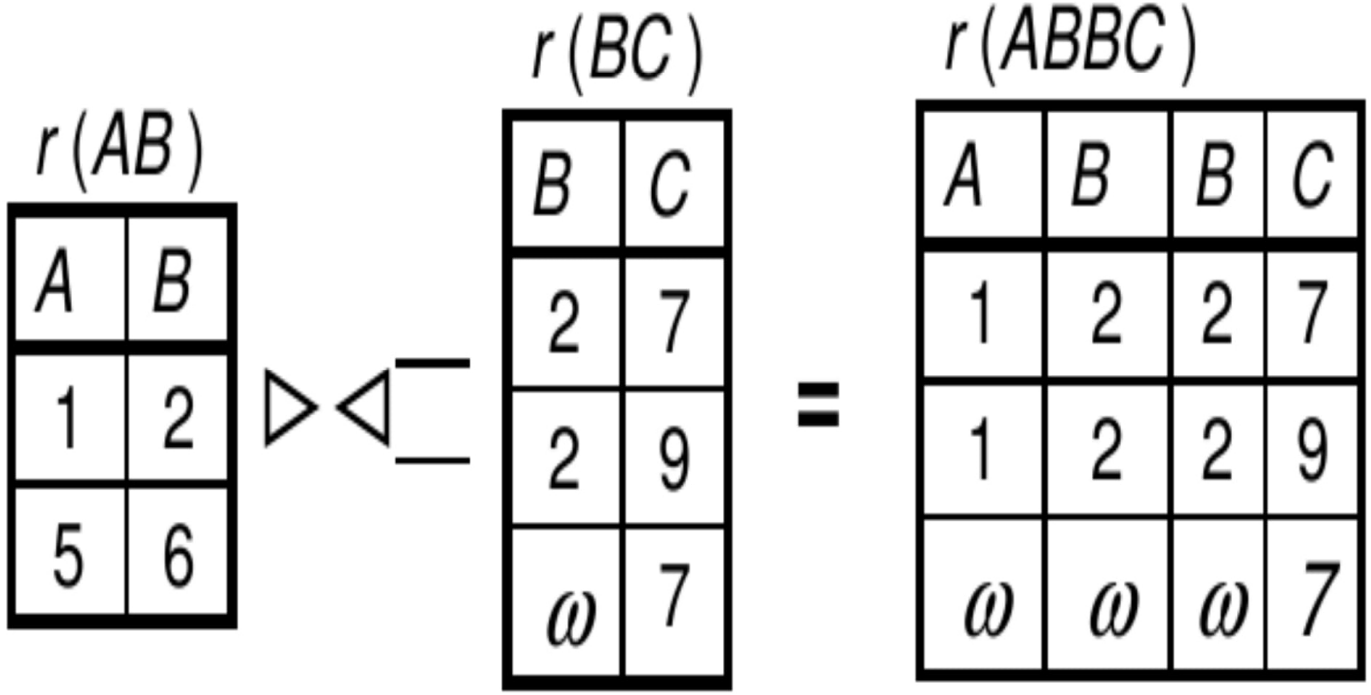
"The (left) outer join is a join in which tuples from R that do not have matching values in the common attributes of S are also included in the result relation. Missing values in the second relation are set to null."

$R \ltimes S$

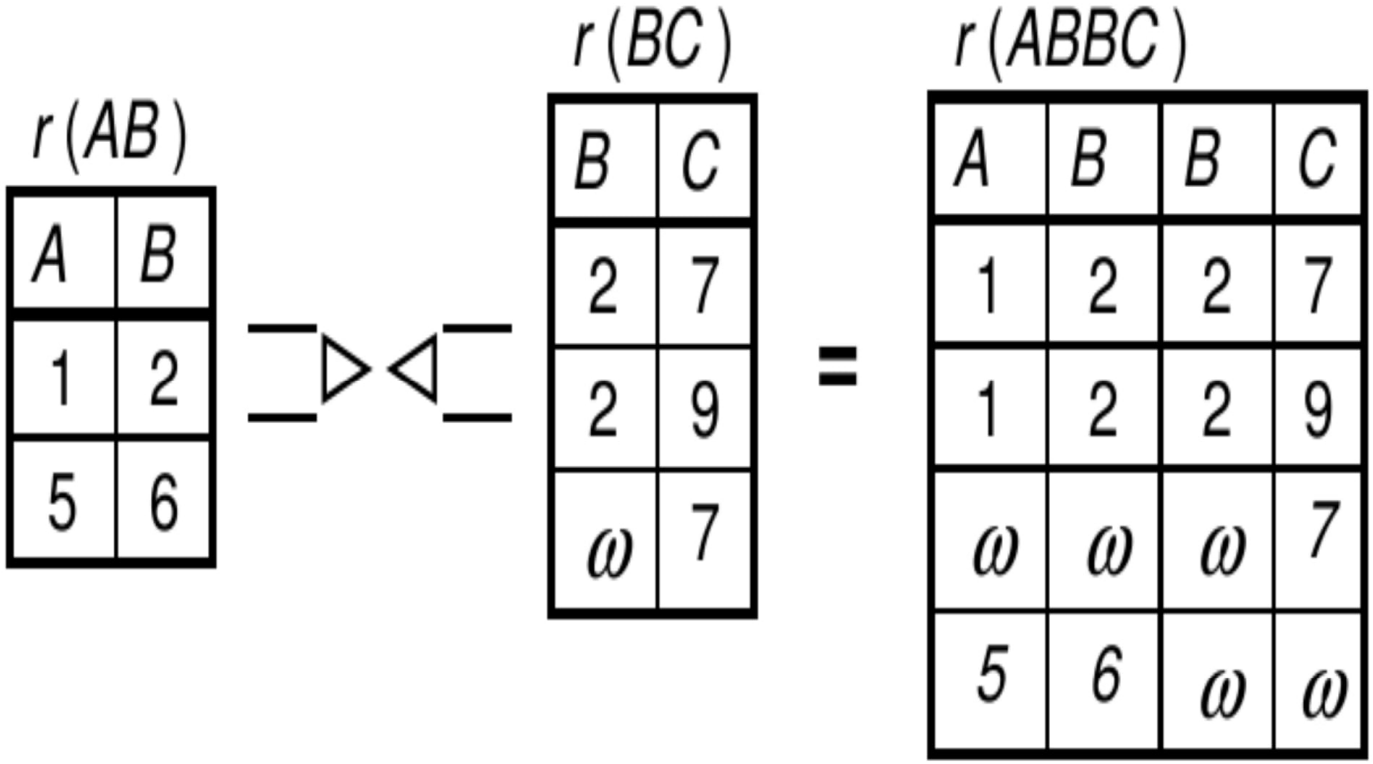
Left Outer Join cont.



Right Outer Join cont.



Full Outer Join cont.



$r(AB)$

A	B
1	2
5	6

$r(BC)$

B	C
2	7
2	9
ω	7

=

$r(ABBC)$

A	B	B	C
1	2	2	7
1	2	2	9
ω	ω	ω	7
5	6	ω	ω

Semi Join

"The semi join operation defines a relation that contains the tuples of R that participates in the join of R with S."

$R \ltimes S$

Semi join cont.

R

A	B
1	2
3	3
4	4

X

S

B	C
2	7
4	9
ω	0

=

R x S

A	B	B	C
1	2	2	7
1	2	4	9
1	2	ω	0
3	3	2	7
3	3	4	9
3	3	ω	0
4	4	2	7
4	4	4	9
4	4	ω	0

Semi join Example,

$R \ltimes_{R.B = S.B} S$

A	B
1	2
4	4

Division Join

"The division operation defines a relation over the attributes C that consists of the set of tuples from R that match the combination of every tuples in S."

$R \div S$

Division cont.

Semi join Example,

R ÷ S

R

ClientNo	PropertyNo
CR56	PA14
CR76	PG4
CR56	PG4
CR62	PA14
CR56	PG36

S

PropertyNo
PG4
PG36

ClientNo
CR56

Summary

- Relational Algebra
- Relational Database Operations: **select**, **project**, **join**
- Set Theoretic Operation

  - union, **intersect**, **set difference**,**Cartesian product**
- Join Operations

  - theta join, equijoin, natural join, left outer join

  right outer join, full outer join, semi join, division