Cross product: $\times$

Given relations R and S:

- $(r, t) \in R \times S$ iff $r \in R$ and $s \in S$

$R(a, b)$

a	b
1	x
2	y

$S(c, d)$

c	d
5	8
2	12

$T = R \times S$

a	b	c	d
1	x	5	8
1	x	2	12
2	y	5	8
2	y	2	12

What is schema of T?

Natural Join $\bowtie$

Given relations R and S

C is set of attributes of both S and R with the same name

- if C is empty.

$$R \bowtie S = R \times S$$

- otherwise

$$\Pi_{Att(R), attr(S) - C} \left(\sigma_{\bigwedge_{a_i \in C} Ra_i = Sa_i} (R \times S) \right)$$

Do not project both common attributes (only the first).

match tuples with same value in common attributes

conjunction over all common attributes

Cross Product $\times$

$R \times S$

SQL

```
SELECT * FROM R, S;
```

NATURAL JOIN

$R \bowtie S$

SQL.

```
SELECT * FROM R NATURAL JOIN S
```

Theta Join

$$R \bowtie_p S = \sigma_p (R \times S)$$

SQL:

```
SELECT * FROM
  R JOIN S ON (p);
```

NULLs (6.1)

SQL has a special value: NULL.

⇒ unknown.

Example:

- Next year champion of the Stanley Cup.
- Grades of students currently enrolled in this course.

- SQL has special considerations for expressions involving NULL
- SQL Logic 3 valued:
  - True
  - False
  - Unknown

- Any expression involving NULL results into UNKNOWN

IMPORTANT

X = NULL
X > NULL
} ⇒ UNKNOWN.

To test if attr is NULL use

X IS NULL

Ex:

NULL > 5 ⇒ UNKNOWN

X is NULL ⇒ True if X contains NULL

UNKNOWN is NOT TRUE

Ex:

UNKNOWN OR TRUE ⇒ TRUE

UNKNOWN AND FALSE ⇒ FALSE

Text Matching.

Regular expressions (Postgres)

expr ~ RegExp

Ex

a ~ '^ab'

attribute a starts with string ab

a ~ '\.txt$'

attribute a end with string .txt

FULL | NATURAL JOIN $R \overset{\circ}{\bowtie} S$

| THETA JOIN $R \overset{\circ}{\bowtie}_p S$

- Compute non-full join
- Add tuples in R not in join padded with NULL
- Add tuples in S not in join padded with NULL

$\therefore$ $R(a,b)$

a	b
3	x
1	y

$S(a,c)$

a	c
2	3.1
1	2.5
5	4

$R \overset{\circ}{\bowtie} S$

a	b	c
1	y	2.5
3	x	$\perp$
2	$\perp$	3.1
5	$\perp$	4

← Represents NULL in RA

SELECT * FROM R NATURAL FULL JOIN S

$R \overset{\circ}{\bowtie}_{R.a>S.a} S$

R.a	b	S.a	c
3	x	2	3.1
3	x	1	2.5
1	y	$\perp$	$\perp$
$\perp$	$\perp$	5	4

SELECT * FROM R FULL JOIN S
ON (R.a > S.a)

LEFT
RIGHT
} JOINS.

Similar to full join but only add tples from one side (left or right).

Natral Left Join

$\therefore$ $R(a,b)$

a	b
3	x
1	y

$S(a,c)$

a	c
2	3.1
1	2.5
5	4

$R \overset{L}{\bowtie} S$

a	b	c
1	y	2.5
3	x	$\perp$

SELECT * FROM R NATURAL LEFT JOIN S

Natral Right Join

$R \overset{R}{\bowtie} S$

a	b	c
1	y	2.5
2	$\perp$	3.1
5	$\perp$	4

SELECT * FROM R NATURAL RIGHT JOIN S

LEFT THETA JOIN

$R \overset{L}{\bowtie}_{R.a > S.a} S$

R.a	b	S.a	c
3	x	2	3.1
3	x	1	2.5
1	y	⊥	⊥

RIGHT THETA JOIN

$R \overset{R}{\bowtie}_{R.a > S.a} S$

R.a	b	S.a	c
3	x	2	3.1
3	x	1	2.5
⊥	⊥	5	4

```
SELECT * FROM R RIGHT JOIN S
ON (R.a > S.a)
```