Relational Algebra and SQL
2.4 and 6.1.

Recall:

Relational Algebra (RA)
- Operations on Relations.

Projection

$\Pi_{\langle List\ Expr \rangle} R$

↑ list of expressions on the attributes of a relation.

Ex. R(a,b)

a	b
1	9
3	3

① $\Pi_a R$

a
9
1
3

② $\Pi_{a+5,\ -b} R$

a+5	-b
6	-9
8	-3

name of attributes

③ $\Pi_{b,a} R$

b	a
9	1
3	3

④ $\Pi_{-1,a} R$

"-1",	a
-1	1
-1	3

SQL:

select <list expr> from R

① SELECT a FROM R

② SELECT a+5, -b FROM R

③ SELECT b, a FROM R

④ SELECT -1, a FROM R

Name of Relation optional!!

SELECT 3;

3
3

Creates table of one tuple!!

SELECT 'abc', 5.2

=>

abc	5.2
'abc'	5.2

name of attributes.

Tuples.

The result of SELECT is always a relation

Renaming Relations and their attributes.

Sometimes we need to rename tables or their attributes.

$$\rho_{<\text{new schema}>}\ R$$

Ex: $R(a,b)$ $\quad \rho_{S(c,d)}\ R$ renames $R(a,b)$ to $S(c,d)$

dmg notation: you can rename during the projection.

If we want to rename the projected expression we can do it:

$$\Pi_{a \to c,\ b \to d}\ R \to S$$

Result schema $S(c,d)$

Ex:

① $\Pi_{a+5 \to x,\ -b \to y}\ R$

x	y
6	-9
8	-3

SQL.

Given $R(a,b)$ $S(c,d)$ R

SELECT a, b FROM R as S(c,d)

or

SELECT a as c, b as d FROM R

①

SELECT a+5 AS X, -b AS Y FROM R

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
5	2.5

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

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

← Represents NULL in RA

SELECT * FROM R NATURAL FULL JOIN S

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

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

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

Ex:

NULL > 5 ⇒ UNKNOWN

x is NULL ⇒ True if x contains NULL

UNKNOW is NOT TRUE

Ex:

UNKNOWN OR TRUE ⇒ TRUE

UNKNOWN AND TRUE ⇒ FALSE

See exercise!!

Text Matching.

Regular expressions (Postgres)

expr ~ RegExp

Ex

a ~ '^ab'

attribute a starts with string ab

a ~ '\.txt$'

attribute a end with string .txt

SELECTION

$\sigma_p R$

p is a predicate on attributes of R

Expressions:

<, >, <>, =, >=, <=

different, equal

AND, NOT and many others.

Ex:

R(a,b)

a	b
3	2
1	∅

p evaluated at each tuple.

① $\sigma_{a>1 \text{ OR } b>1} R$

a	b
3	2

SQL.

SELECT * FROM R WHERE p

* original attributes of R

Ex:

① SELECT * FROM R
WHERE a > 1 OR b > 1

We can combine Π and σ:

Ex: $\Pi_a \sigma_{a>1 \text{ OR } b>1} R$.

SELECT a FROM R
WHERE a>1 OR b>1

NOT equivalent to.

$\sigma_{a>1 \text{ OR } b>1} \Pi_a R$.

b is not part of $\Pi_a R$.

Questions

What does this return?

1) $\sigma_{\text{FALSE}} R$
2) $\sigma_{\text{TRUE}} R$

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

SQL

TABLE R { UNION / INTERSECT / EXCEPT } TABLE S

or

SELECT * FROM R { UNION / INTERSECT / EXCEPT } SELECT * FROM S

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);

Other expressions in predicates

IN

att IN (List)

Ex.

a IN (3, 2, 5)

⇒ equivalent to (a = 3 or a = 2 or a = 5)

But we can also use a query:

a in ($\Pi_c S$)

SQL:

a IN (SELECT c FROM S)

EXISTS

EXISTS (R) true if R not empty

Ex:

EXISTS ($\sigma_{a>5} R$)

Operations on 2 Relations.

Union	$\cup$
Intersection	$\cap$
Difference (except)	$-$

Union Compatible

R and S are "union compatible" iff

$$|attrs(R)| = |attrs(S)|$$

and the type of the i-th attribute of S. is type compatible with the type of the i-th attribute of R.

One type t_1 is type compatible with type t_2 if t_1 can be converted to type t_2.

$A \cup B$, $A \cap B$, $A - B$ } Defined only iff A & B are union compatible.

UNION

$t \in R \cup S \Leftrightarrow t \in R$ and $t \in S$

$t \subset R \cap S \Leftrightarrow t \in R$ or $t \in S$

$t \in R - S \Leftrightarrow t \subset R$ and $t \notin S$

Schema of result is schema of first relation.

Ex:

R (a, b)

a	b
1	a
3	x

S (c, d)

c	d
1	e
3	x
4	f

R ∪ S

a	b
1	a
3	x
1	e
4	f

R ∩ S

a	b
3	x

R − S

a	b
1	a

S − R

c	d
1	e
3	x