Data Bases

Relational Algebra

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Operators and operands

- **Relation** $\mapsto$
  Set of *k*-tuples (k = arity of the relation).

- Relational algebra **operands** $\rightarrow$
  constant or **variable relations** with a **given arity**.

- There are **5 basic relational algebra operators**.

R?S

A	B	C
a	b	c
d	a	f
c	b	d

R

D	E	F
b	g	a
d	a	f

S

a	b	c
d	a	f
c	b	d
b	g	a

$R \cup S$ (set union)

A	B	C
a	b	c
d	a	f
c	b	d

R

D	E	F
b	g	a
d	a	f

S

a	b	c
d	a	f
c	b	d
b	g	a

R?S

A	B	C
a	b	c
d	a	f
c	b	d

R

D	E	F
b	g	a
d	a	f

S

a	b	c
c	b	d

$R - S$ (set difference)

A	B	C
a	b	c
d	a	f
c	b	d

R

D	E	F
b	g	a
d	a	f

S

a	b	c
c	b	d

R?S

A	B	C
a	b	c
d	a	f
c	b	d

R

D	E	F
b	g	a
d	a	f

S

A	B	C	D	E	F
a	b	c	b	g	a
a	b	c	d	a	f
d	a	f	b	g	a
d	a	f	d	a	f
c	b	d	b	g	a
c	b	d	d	a	f

RxS (Cartesian product)

A	B	C
a	b	c
d	a	f
c	b	d

R

D	E	F
b	g	a
d	a	f

S

A	B	C	D	E	F
a	b	c	b	g	a
a	b	c	d	a	f
d	a	f	b	g	a
d	a	f	d	a	f
c	b	d	b	g	a
c	b	d	d	a	f

RxS (Cartesian product)

- R : **relation** with arity k_1
- S : **relation** with arity k_2
- *RxS* generates a set with $(k_1 + k_2)$-tuples

?(R)

A	B	C
a	b	c
d	a	f
c	b	d

R

A	C
a	c
d	f
c	d

$\pi_{A,C}(R)$(*Projection*)

A	B	C
a	b	c
d	a	f
c	b	d

R

A	C
a	c
d	f
c	d

Projection π

- R : **relation** with arity k
- $\forall i \in [1, k]$, A_i: i-th **attribute name**, s.t. $A_j \neq A_l$ if $j \neq l$
- Let $B = \{B_1, \ldots, B_m\}$ be a set of m **attribute names**.
- **Projection** $\pi_{B_1,\ldots,B_m}(R)$:
  Set of m-tuples from R **restricted to the set** B
  (take only attributes having names in B)

?(*R*)

A	B	C
a	b	c
d	a	f
c	b	d

R

A	B	C
a	b	c
c	b	d

$\sigma_{B=b}(R)$(Selection)

A	B	C
a	b	c
d	a	f
c	b	d

R

A	B	C
a	b	c
c	b	d

Selection σ

Let F be a **formula** involving:

- **Operands**: constants or attribute names.
- **Arithmetical equality/inequalities** (<,=,>, ...).
- **Logical operators** ($\wedge$ AND, $\vee$ OR, $\neg$ NOT)

$\sigma_F(R)$ is the set of tuples $t \in R$ for which the **formula** F is evaluated as **true**.

Other operations
Set intersection ∩

Deduce the **intersection** from the **previous 5 operators**.

Other operations
Set intersection $\cap$

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

Other operations *R?S*

a	b	c	d
a	b	e	f
b	c	e	f
e	d	c	d
e	d	e	f
a	b	d	e

R

c	d
e	f

S

a	b
e	d

Division $R \div S$

a	b	c	d
a	b	e	f
b	c	e	f
e	d	c	d
e	d	e	f
a	b	d	e

R

c	d
e	f

S

a	b
e	d

Division $R \div S$

- R : **relation** with arity r
- S : **relation** with arity s
- $r > s$ and $s \neq 0$
- Let $a \cdot b$ denote the **concatenation** of tuples a and b.
- $R \div S$ is the set of $(r - s)$-tuples t s.t. for each s-tuples $u \in S$, the tuple $t \cdot u \in R$.
- **Division** as a **combination** of the **basic operators**:

$$R \div S = \pi_{1,2,\ldots,r-s}(R) - \pi_{1,2,\ldots,r-s}((\pi_{1,2,\ldots,r-s}(R) \times S) - R)$$

Other operations *R?S*

A	B	C
1	2	3
4	5	6
7	8	9

R

D	E
3	1
6	2

S

A	B	C	D	E
1	2	3	3	1
1	2	3	6	2
4	5	6	6	2

θ join $R \bowtie_{B<D} S$

A	B	C
1	2	3
4	5	6
7	8	9

R

D	E
3	1
6	2

S

A	B	C	D	E
1	2	3	3	1
1	2	3	6	2
4	5	6	6	2

θ join $R \bowtie_\theta S$

- R : **relation** with arity r
- S : **relation** with arity s
- θ is a formula
- $R \bowtie_\theta S = \sigma_\theta(RxS)$

Other operators *R?S*

A	B	C
a	b	c
d	b	c
b	b	f
c	a	d

R

B	C	D
b	c	d
b	c	e
a	d	b

S

A	B	C	D
a	b	c	d
a	b	c	e
d	b	c	d
d	b	c	e
c	a	d	b

Natural join $R \bowtie S$

A	B	C
a	b	c
d	b	c
b	b	f
c	a	d

R

B	C	D
b	c	d
b	c	e
a	d	b

S

A	B	C	D
a	b	c	d
a	b	c	e
d	b	c	d
d	b	c	e
c	a	d	b

Natural join $R \bowtie S$

- Can be applied iff **relations** R et S have **named columns**.
- Compute RxS
- Keep the tuples $\in RxS$, that have **coincident values** for each common attribute in R and S.
- For each **pair** of **common attributes**, only **keep one attribute** (**projection**).
- Write the natural join operation using the basic operations (for the previous example).

Exercise 1

Write the following requests (for the TV series model):

- Get the list of actors that played in the first episode of each season of ”Game of Thrones”.
- Get the actors that played in the first season of ”Game of Thrones”.
- Get the actors of the first episode of the ”Season 1” of ”Game of Thrones” that were payed less than 10 dollars.
- Get the actors that played both in ”Game of Thrones” and in ”The mentalist”.

Exercise 2

Write the following requests (for the Dinner model):

- Get the list of wines that can provided with a ”Cassoulet”
- Get the list of the enemies of ”Bart Simpson”
- Get the list of the enemies of the friends of ”Bart Simpson”
- Get the list of enemies of people that enjoy eating ”Cassoulet”