Relational Model

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Additional Operations

- Set intersection
- Natural join
- Division

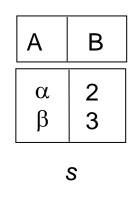
Set-Intersection Operation

- Notation: $r \cap s$
- Defined as:
- $r \cap s = \{ t \mid t \in r \text{ and } t \in s \}$
- Assume:
 - \bullet r, s have the same arity
 - attributes of r and s are compatible
- Note: $r \cap s = r (r s)$

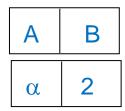
Set-Intersection Operation - Example

• Relation r, s:

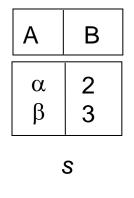
Α	В
α	1
α	2
β	1







A B
α 1
α 2
β 3



 $r \cap s$

Α	В	
α	2	
β	3	

Natural-Join Operation

- Notation: $r \bowtie s$
- Let r and s be relations on schemas R and S respectively.
- The result is a relation on schema $R \cup S$ which is obtained by considering each pair of tuples t_r from r and t_s from s.
- If t_r and t_s have the same value on each of the attributes in $R \cap S$, a tuple t is added to the result, where
 - t has the same value as t_r on r
 - t has the same value as t_s on s
- Example:

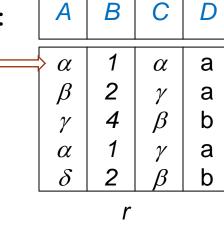
$$R = (A, B, C, D)$$
$$S = (E, B, D)$$

Result schema = (A, B, C, D, E)

• $r \bowtie s$ is defined as:

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\mathbf{O}_{r.B = s.B \ r.D = s.D} (r \ x \ s))$$

• Relations r, s:



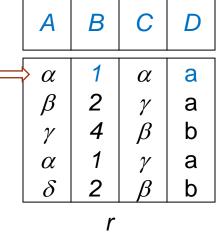
В	D	E	
1 3 1 2 3	a a a b b	$\begin{array}{c} \alpha & \\ \beta & \\ \gamma & \\ \delta & \\ \in \end{array}$	
	S		

 $r \bowtie s$

A	В	С	D	E
α	1	α	а	α
α	1	α	а	γ
α	1	γ	а	α
α	1	γ	а	γ
δ	2	β	b	δ

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



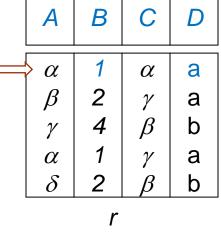
В	D	E	
1	а	$\alpha \leftarrow$	
1 3 1	a a a b b	$\alpha \leftarrow \beta$ γ δ ϵ	
1	а	γ	
2 3	b	δ	
3	b	\in	
	S		

 $r \bowtie s$

A	В	C	D	E
α	1	α	а	α
α	1	α	а	γ
α	1	γ	а	α
α	1	γ	а	γ
δ	2	β	b	δ

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



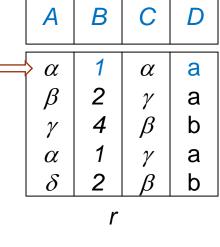
В	D	E	
1	а	α	
1 3 1	a	$\beta \Leftarrow$	
1	a a a b b	$\begin{array}{c} \alpha \\ \beta \\ \downarrow \\ \gamma \\ \delta \\ \in \end{array}$	
2	b	δ	
3	b	ϵ	
	S		

 $r \bowtie s$

A	В	C	D	E
α	1	α	а	α
α	1	α	а	γ
α	1	γ	а	α
α	1	γ	а	γ
δ	2	β	b	δ

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\sigma_{r.B = s.B \ r.D = s.D} (r \ x \ s))$$

• Relations r, s:



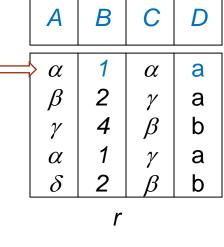
В	D	E
1	а	α
3 1 2 3	a a a b	$\begin{array}{ccc} \alpha & & \\ \beta & & \\ \gamma & & \\ \delta & \\ \epsilon & & \end{array}$
1	a	$\gamma \longleftarrow$
2	b	δ
3	b	€
	S	_

 $r \bowtie s$

A	В	С	D	E
α	1	α	а	α
$\mid \alpha \mid$	1	α	а	γ
$\mid \alpha \mid$	1	γ	а	α
$\mid \alpha \mid$	1	γ	а	γ
δ	2	β	b	δ

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\sigma_{r.B = s.B \ r.D = s.D} (r \ x \ s))$$

• Relations r, s:



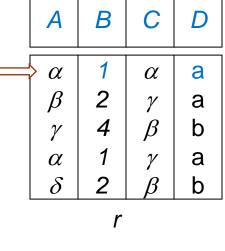
В	D	E	
1 3 1 2 3	a a a b b	$\begin{array}{c} \alpha \\ \beta \\ \gamma \\ \delta \\ \in \end{array}$	
	S		

 $r \bowtie s$

Α	В	С	D	E	
α	1	α	а	α	<u>_</u>
α	1	α	а	$\gamma \leqslant$	
α	1	γ	а	α	
α	1	γ	а	γ	
δ	2	β	b	δ	

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\mathbf{O}_{r.B = s.B \ r.D = s.D} (r \times s))$$

• Relations r, s:



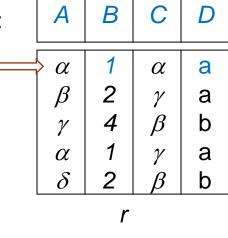
В	D	E
1 3 1 2 3	a a b b	$\begin{array}{c c} \alpha \\ \beta \\ \gamma \\ \delta \end{array}$

 $r \bowtie s$

Α	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	$\gamma \Leftarrow$
α	1	γ	а	α
α	1	γ	а	γ
δ	2	β	b	δ

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\mathbf{O}_{r.B = s.B \ r.D = s.D} (r \times s))$$

• Relations r, s:



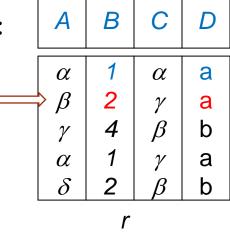
В	D	E
1 3 1 2 3	a a a b b	$\begin{array}{c c} \alpha \\ \beta \\ \gamma \\ \delta \\ \in \end{array}$
<u>, </u>	S	<u>. </u>

 $r \bowtie s$

A	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	$\gamma \Leftarrow$
α	1	γ	а	α
α	1	γ	а	γ
δ	2	β	b	δ

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\mathbf{O}_{r.B = s.B \ r.D = s.D} (r \times s))$$

• Relations r, s:



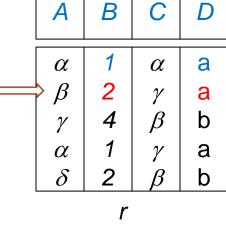
В	D	E	
1	а	$\alpha \longleftarrow$	
1 3 1	a a a b b	$\begin{array}{ccc} \alpha & & \\ \beta & & \\ \gamma & & \\ \delta & \\ \in & & \end{array}$	
1	а	γ	
2 3	b	δ	
3	b	ϵ	
	S		

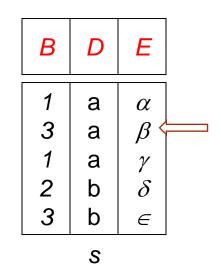
 $r \bowtie s$

A	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	γ <u></u>
α	1	γ	а	$\mid \alpha \mid$
α	1	γ	а	γ
δ	2	β	b	δ

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\sigma_{r.B = s.B \ r.D = s.D} (r \ x \ s))$$

• Relations r, s:



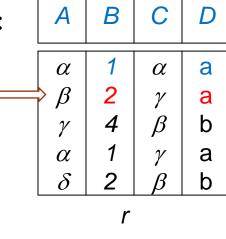


 $r \bowtie s$

Α	В	С	D	E	
α	1	α	а	α «	
α	1	α	а	γ <	
α	1	γ	а	α	
α	1	γ	а	γ	
δ	2	β	b	δ	

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



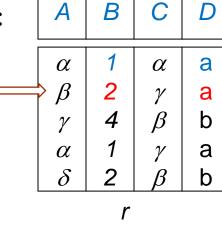
В	D	E
1	а	α
3	а	β
1 3 1 2 3	a a a b b	$\begin{array}{c c} \alpha \\ \beta \\ \gamma \\ \delta \\ \in \end{array}$
2	b	δ
3	b	ϵ
	S	

 $r \bowtie s$

A	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	$\gamma \Leftarrow$
α	1	γ	а	α
α	1	γ	а	γ
δ	2	β	b	δ

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\sigma_{r.B = s.B \ r.D = s.D} (r \ x \ s))$$

• Relations r, s:



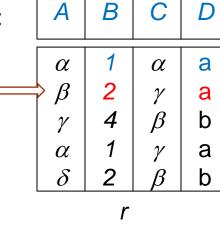
В	D	E
1	а	α
1 3 1 2 3	a a a b b	$\begin{array}{c c} \alpha \\ \beta \\ \gamma \\ \delta \end{array}$
1	а	γ
2	b	$\delta \longleftarrow$
3	b	ϵ
	S	<u> </u>

 $r \bowtie s$

A	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	$\gamma \longleftarrow$
α	1	γ	а	α
α	1	γ	а	$ \gamma $
δ	2	β	b	δ

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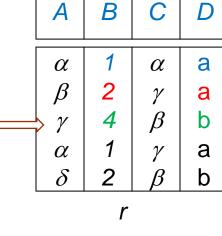
В	D	E
1 3 1 2 3	a a a b b	$\begin{bmatrix} \alpha \\ \beta \\ \gamma \\ \delta \\ \epsilon \end{bmatrix}$
1	a	γ
3	b b	$\left \begin{array}{c}\delta\\ \epsilon\end{array}\right $
	S	

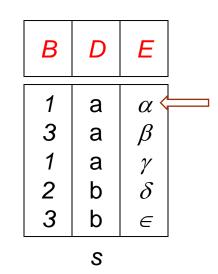
 $r \bowtie s$

Α	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	$\gamma \Leftarrow$
α	1	γ	а	α
α	1	γ	а	γ
δ	2	β	b	δ

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\mathbf{O}_{r.B = s.B \ r.D = s.D} (r \times s))$$

• Relations r, s:



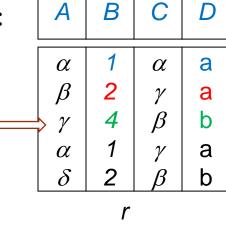


 $r \bowtie s$

A	В	С	D	E
α	1	α	а	$\alpha \leftarrow$
α	1	α	а	$\gamma \Leftarrow$
α	1	γ	а	α
α	1	γ	а	γ
δ	2	β	b	δ

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• Relations r, s:



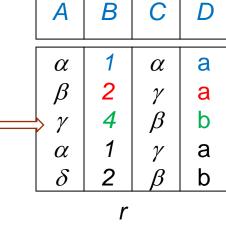
	В	D	E	
	1 3 1 2 3	a a a b b	$\begin{array}{c} \alpha \\ \beta \\ \gamma \\ \delta \\ \in \end{array}$	
L		S		

 $r \bowtie s$

A	В	С	D	E	
α	1	α	а	α	
α	1	α	а	γ <	<u>_</u>
α	1	γ	а	α	
α	1	γ	а	γ	
δ	2	β	b	δ	

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\sigma_{r.B = s.B \ r.D = s.D} (r \ x \ s))$$

• Relations r, s:



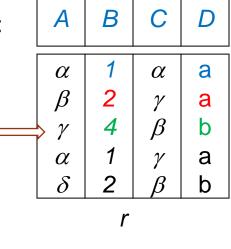
В	D	E	
1 3 1 2 3	a a a b b	$\begin{array}{ccc} \alpha \\ \beta \\ \gamma \\ \delta \\ \epsilon \end{array}$	
	S		

 $r \bowtie s$

A	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	$\gamma \Leftarrow$
α	1	γ	а	α
α	1	γ	а	$ \gamma $
δ	2	β	b	δ

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



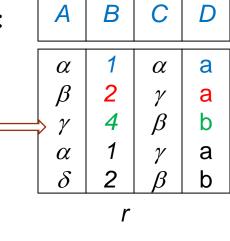
В	D	E
1 3 1 2 3	a a a b b	$\begin{bmatrix} \alpha \\ \beta \\ \gamma \\ \delta \\ \in \end{bmatrix}$
1 2	a b	$\delta \longleftarrow$
3	b	€
	S	

 $r \bowtie s$

Α	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	$\gamma \Leftarrow$
α	1	γ	а	α
α	1	γ	а	γ
δ	2	β	b	δ

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\sigma_{r.B = s.B \ r.D = s.D} (r \ x \ s))$$

• Relations r, s:



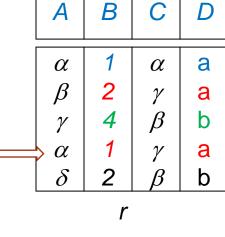
В	D	E
1 3 1 2 3	a a a b b	$\begin{array}{c c} \alpha \\ \beta \\ \gamma \\ \delta \\ \in \end{array}$
	S	

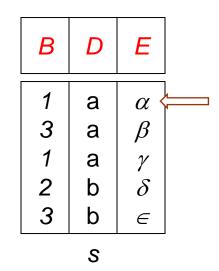
 $r \bowtie s$

Α	В	С	D	E	
α	1	α	а	$\alpha \Leftarrow$	_
α	1	α	а	$\gamma \Leftarrow$	
α	1	γ	а	α	
α	1	γ	а	γ	
δ	2	β	b	δ	

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\sigma_{r.B = s.B \ r.D = s.D} (r \ x \ s))$$

• Relations r, s:



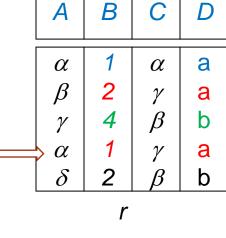


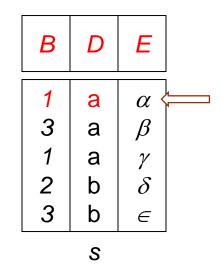
 $r \bowtie s$

Α	В	С	D	E	
α	1	α	а	$\alpha \Leftarrow$	_
α	1	α	а	$\gamma \Leftarrow$	
α	1	γ	а	α	
α	1	γ	а	γ	
δ	2	β	b	δ	

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



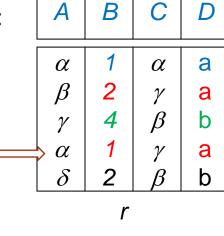


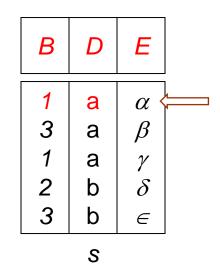
 $r \bowtie s$

A	В	С	D	E	
α	1	α	а	α	\
α	1	α	а	γ <	1
α	1	γ	а	α	
α	1	γ	а	γ	
δ	2	β	b	δ	

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



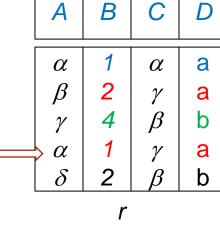


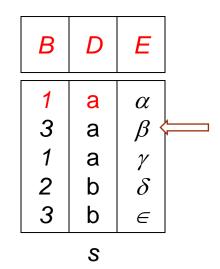
 $r \bowtie s$

A	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	γ 🚐
α	1	γ	а	$\alpha \longleftarrow$
α	1	γ	а	$ \gamma $
δ	2	β	b	δ

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



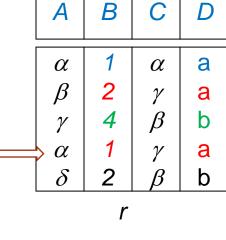


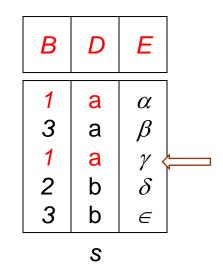
 $r \bowtie s$

A	В	C	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	γ 🚐
α	1	γ	а	$\alpha \longleftarrow$
α	1	γ	а	γ
δ	2	β	b	$\mid \delta \mid$

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



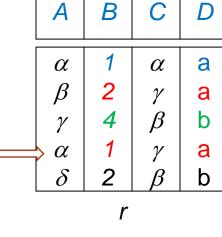


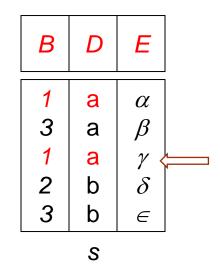
 $r \bowtie s$

A	В	С	D	E
α	1	α	а	α 💳
α	1	α	а	γ 🚐
α	1	γ	а	$\alpha \longleftarrow$
α	1	γ	а	γ
δ	2	β	b	$\mid \delta \mid$

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



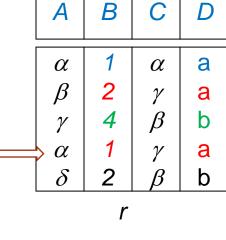


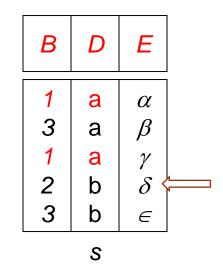
 $r \bowtie s$

A	В	C	D	E
α	1	α	а	α 💳
α	1	α	а	γ 🚐
α	1	γ	а	$\alpha \longleftarrow$
α	1	γ	а	γ 🚐
δ	2	β	b	$\mid \delta \mid$

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



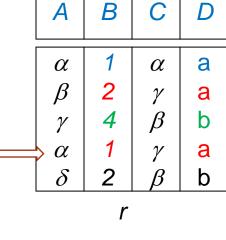


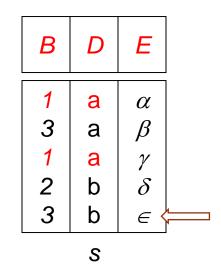
 $r \bowtie s$

A	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
$ \alpha$	1	α	а	γ 🚐
$\mid \alpha \mid$	1	γ	а	$\alpha \longleftarrow$
$\mid \alpha \mid$	1	γ	а	γ 🚐
δ	2	β	b	$\mid \delta \mid$

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



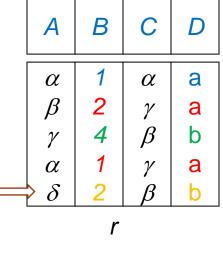


 $r \bowtie s$

Α	В	C	D	E	
α	1	α	а	$\alpha \Leftarrow$	
α	1	α	а	$\gamma \Leftarrow$	
α	1	γ	а	$\alpha \Leftarrow$	
α	1	γ	а	$\gamma \Leftarrow$	
δ	2	B	b	δ	

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



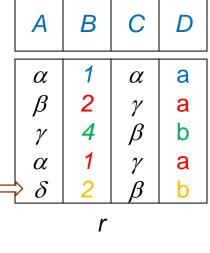
В	D	E	
1 3	a a	$\alpha < \beta$	
1 3 1 2 3	aaabb	$\alpha \leftarrow \beta$ γ $\delta \in$	
	S		

 $r \bowtie s$

A	В	С	D	E
α	1	α	а	α 💳
α	1	α	а	γ 🚐
α	1	γ	а	$\alpha \longleftarrow$
α	1	γ	а	γ 🚐
δ	2	В	b	δ

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:



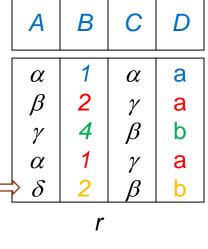
	В	D	E	
	1 3 1 2 3	a a a b b	$\begin{array}{c} \alpha \\ \beta \\ \gamma \\ \delta \\ \epsilon \end{array}$	
L		S		1

 $r \bowtie s$

A	В	C	D	E
α	1	α	а	$\alpha \leftarrow$
α	1	α	а	$\gamma \longleftarrow$
α	1	γ	а	$\alpha \longleftarrow$
α	1	γ	а	γ 🚐
δ	2	β	b	δ

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\mathbf{O}_{r.B = s.B \ r.D = s.D} (r \times s))$$

• Relations r, s:



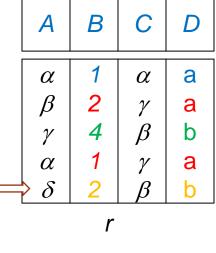
В	D	E
1 3 1 2 3	a a a b b	$\begin{bmatrix} \alpha \\ \beta \\ \gamma \\ \delta \\ \epsilon \end{bmatrix}$
	<u> </u>	

 $r \bowtie s$

A	В	C	D	E	
α	1	α	а	α	
α	1	α	а	γ <	
α	1	γ	а	α	
α	1	γ	а	γ .	
δ	2	В	h	δ	

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\sigma_{r.B = s.B \ r.D = s.D} (r \ x \ s))$$

• Relations r, s:



В	D	E	
1 3 1 2 3	a a a b b	$\begin{array}{c} \alpha \\ \beta \\ \gamma \\ \delta \\ \in \end{array}$	
	S		

 $r \bowtie s$

Α	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	γ 🚐
α	1	γ	а	$\alpha \longleftarrow$
α	1	γ	а	γ 🚐
δ	2	В	b	$\mid \delta \mid$

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

• Relations r, s:

	A	В	C	D
	α	1	α	а
	β	2	γ	a
	γ	4	β	b
	α	1	γ	a
\Rightarrow	δ	2	β	b
		r		

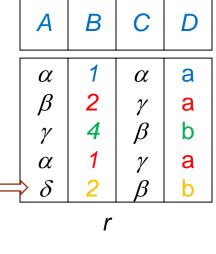
В	D	E
1	а	α
1 3 1	a a a	β
1	а	$\begin{array}{c c} \alpha \\ \beta \\ \gamma \\ \delta \end{array}$
3	b	$\delta \longleftarrow$
3	b	ϵ
	S	

 $r \bowtie s$

A	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	γ 🚐
α	1	γ	а	$\alpha \longleftarrow$
α	1	γ	а	γ 🚐
δ	2	β	b	$\delta \Leftarrow$

$$\prod_{r.A, r.B, r.C, r.D, s.E} (\mathbf{O}_{r.B = s.B \ r.D = s.D} (r \times s))$$

• Relations r, s:



	В	D	E
	1 3 1 2 3	a a a b b	$\begin{bmatrix} \alpha \\ \beta \\ \gamma \\ \delta \\ \in \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$
<u> </u>		S	<u> </u>

 $r \bowtie s$

A	В	С	D	E
α	1	α	а	$\alpha \Leftarrow$
α	1	α	а	γ 🚐
α	1	γ	а	$\alpha \longleftarrow$
α	1	γ	а	γ 🚐
δ	2	β	b	$\delta \longleftarrow$

$$\prod_{r,A, r,B, r,C, r,D, s,E} (\mathbf{O}_{r,B=s,B} \mid_{r,D=s,D} (r \mid \mathbf{x} \mid s))$$

Natural Join - Example Queries

Find all customers who have an account from at least the "Downtown" and the "Uptown" branches.

• Query:

$$\prod_{CN} (\sigma_{BN=\text{``Downtown''}}(depositor \bowtie account)) \cap \\ \prod_{CN} (\sigma_{BN=\text{``Uptown''}}(depositor \bowtie account))$$

where CN denotes customer-name and BN denotes branch-name.

Division Operation

- Suited to queries that include the phrase "for all".
- Let r and s be relations on schemas R and S respectively where
 - $\bullet R = (A_1, \ldots, A_m, B_1, \ldots, B_n)$
 - $\bullet S = (B_1, \ldots, B_n)$

The result of $r \div s$ is a relation on schema

$$R - S = (A_1, \ldots, A_m)$$

$$r \div s = \{ t \mid t \in \prod_{R \in S}(r) \land \forall u \in s (tu \in r) \}$$

Relations *r*, *s*:

Α	В	
α	1	
α	2	
α	3	
β	1	
γ	1	
δ	1	
δ	3	
δ	4	
\in	6	
\in	1	
β	2	
r		

```
    B

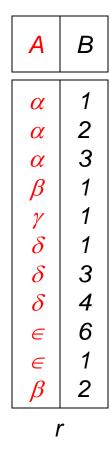
    1

    2

    s
```

 $r \div s = \{ t \mid t \in \prod_{R-s}(r) \land \forall u \in s (tu \in r) \}$

Relations *r*, *s*:



B S

$$R = \{A, B\}$$
$$S = \{B\}$$
$$R-S = \{A\}$$

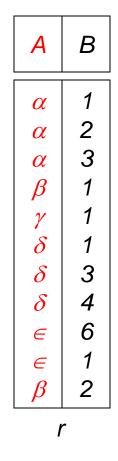
$$r \div s$$
: α

$$\alpha$$

$$(\alpha)$$
 (α)

$$\begin{array}{cc} (1) & (\alpha, 1) \\ (2) & (\alpha, 2) \end{array}$$

 $r \div s = \{ t \mid t \in \prod_{R-s}(r) \land \forall u \in s (tu \in r) \}$



$$R = \{A, B\}$$

$$S = \{B\}$$

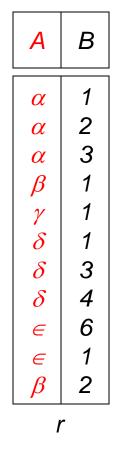
$$R-S = \{A\}$$

$$r \div s$$
: α

$$(\beta) \quad (\beta) \quad (1) \quad (\beta, 1)$$

$$(2) \quad (\beta, 2)$$

Relations r, s:



$$R = \{A, B\}$$

$$S = \{B\}$$

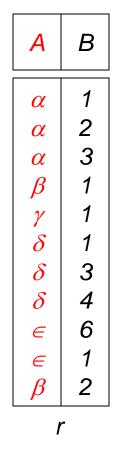
$$R-S = \{A\}$$

$$r \div s$$
:
$$\frac{A}{\alpha}$$

$$(\beta) \quad (\beta) \quad (\beta) \quad (\beta, 1)$$

$$(\beta) \quad (\beta) \quad (\beta, 2)$$

 $r \div s = \{ t \mid t \in \prod_{R-s}(r) \land \forall u \in s (tu \in r) \}$



$$R = \{A, B\}$$

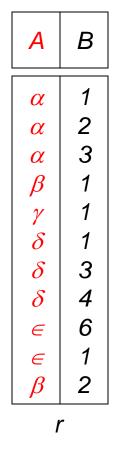
$$S = \{B\}$$

$$R-S = \{A\}$$

$$r \div s$$
:
$$\frac{A}{\alpha}$$



$$r \div s = \{ t \mid t \in \prod_{R-s}(r) \land \forall u \in s (tu \in r) \}$$



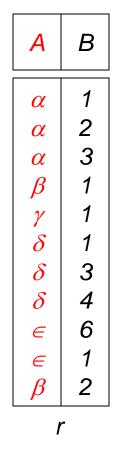
$$R = \{A, B\}$$

$$S = \{B\}$$

$$R-S = \{A\}$$

$$(\delta)$$
 (δ)





$$R = \{A, B\}$$

$$S = \{B\}$$

$$R-S = \{A\}$$

$$r \div s$$
:
$$\frac{A}{\alpha}$$

$$r \div s = \{ t \mid t \in \prod_{R-s}(r) \land \forall u \in s (tu \in r) \}$$

Relations r, s:

A	В
α	1
α	2
α	3
β	1
γ	1
δ	1
δ	3
δ	4
\in	6
\in	1
β	2
	<u>^</u>

1 2 S

$$R = \{A, B\}$$

$$S = \{B\}$$

$$R-S = \{A\}$$

$$r \div s$$
:
$$\frac{A}{\alpha}$$

Result

$$r \div s = \{ t \mid t \in \prod_{R-s}(r) \land \forall u \in s (tu \in r) \}$$

Another Division Example

Relations r, s:

Α	В	С	D	E
α	а	α	а	1
α	а	γ	а	1
α	а	γ	b	1
	а	γ	a	1
β	а	γ	b	3
$eta \ eta \ \gamma \ \gamma$	а	γ	а	1
γ	а	γ	b	1
γ	а	β	b	1

r ÷ s: ?

Another Division Example

Relations *r*, *s*:

A	В	С	D	E
α	а	α	а	1
α	a	γ	а	1
α	a	γ	b	1
β	a	$\gamma \\ \gamma$	а	1
β	a	γ	b	3
γ	a	γ	а	1
$eta \ eta \ \gamma \ \gamma$	a	γ	b	1
γ	a	β	b	1
r				

D	Ε	
а	1	
b	1	
S		

r ÷ s:

Α	В	С
α	а	γ
γ	a	γ

Example Queries

- Find all customers who have an account from at least the "Downtown" and the Uptown" branches.
 - Query 1

$$\prod_{CN} (\sigma_{BN=\text{``Downtown''}}(depositor \bowtie account)) \cap \prod_{CN} (\sigma_{BN=\text{``Uptown''}}(depositor \bowtie account))$$

where CN denotes customer-name and BN denotes branch-name.

• Query 2

$$\Pi_{customer-name, branch-name}$$
 (depositor \bowtie account)
 $\div \rho_{temp(branch-name)}(\{("Downtown"), ("Uptown")\})$

Example Queries

Find all customers who have an account at all branches located in Brooklyn city.

$$\prod_{customer-name, branch-name} (depositor \bowtie account)$$

$$\div \prod_{branch-name} (\sigma_{branch-city} = \text{``Brooklyn''}(branch))$$

THANK YOU