Relational Algebra: Basic Operators for Combining Relations

Computing on Data

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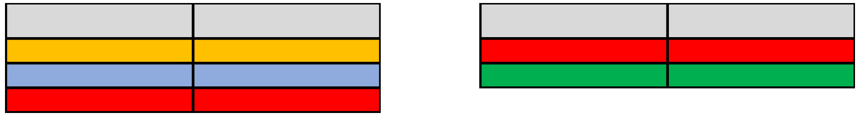
Learning Objectives

By the end of this video, you will be able to:

- Identify the basic operators that combine tables.
- Use these operators to write RA expressions.

Combination Operators

- Combining two relations R_1 and R_2 :



Two relations

- Set operations
  - Union: $R_1 \cup R_2$ (addition)
  - Difference: $R_1 - R_2$ (like subtraction)

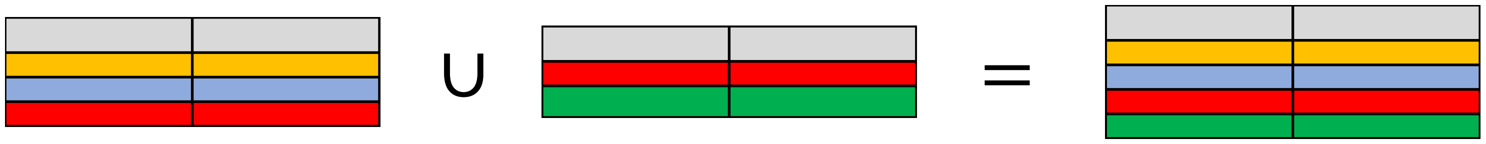
Union

Difference

- Cartesian product (multiplication)
  - $R_1 \times R_2$

Cartesian product

Set Union



Union of two relations

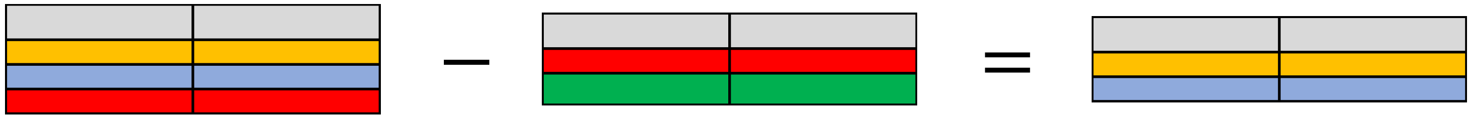
- Notation: $R_1 \cup R_2$
- Input: R_1 and R_2, which have the same schema.
- Output:
  - A relation with all tuples in R_1 and R_2 (no duplicates)
  - Schema: same as R_1 and R_2

- *What are all the people in the Academic World?*
  - $\pi_{\text{name}}(\text{Students}) \cup \pi_{\text{name}}(\text{Professors})$

Union Examples

- *Q1: Find beers that are drunk or favorited by some drinkers.*
- *Q2: Find beer-drinker pairs where a bar is drunk or favorited by a drinker.*

Set Difference



Difference of two relations

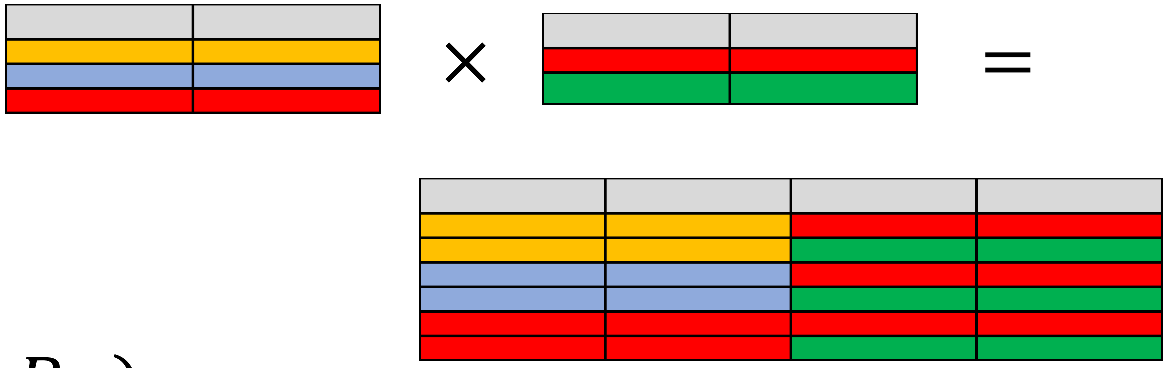
- Notation: $R_1 - R_2$
- Input: R_1 and R_2, which have the same schema.
- Output:
  - A relation with all tuples in R_1 but not in R_2
  - Schema: same as R_1 and R_2

- *What students took CS411 but not CS412?*
  - $\pi_{\text{name}}(\sigma_{\text{number}=\text{“CS411”}}\text{Enrolls}) - \pi_{\text{name}}(\sigma_{\text{number}=\text{“CS412”}}\text{Enrolls})$

Difference Examples

- *Q1: Find beers that are drunk by some but not favorited by any drinkers.*

Cartesian Product



Cartesian product of two relations

- Notation: $R_1 \times R_2$
- Input: $R_1(A_1, \ldots, A_n), R_2(B_1, \ldots, B_m)$.
- Output:
  - A relation consisting of all pairs of each tuple from R_1 and each tuple from R_2
  - Schema: $(A_1, \ldots, A_n, B_1, \ldots, B_m)$
    - Assume no attribute name clash. Or, use $R_1.A$ vs. $R_2.A$ to distinguish.

Cartesian Product: Example

Students S

id	name	major	birthday
1	Bugs Bunny	CS	2004-11-06
2	Donald Duck	ECE	1997-02-01
3	Peter Pan	SS	1998-10-01
4	Mickey Mouse	Music	1995-04-01

X

Enrolls E

id	number	term	grade
1	411	Fall 2017	A+
4	411	Fall 2017	B
1	426	Fall 2017	A

=

S.id	name	major	birthday	E.id	number	term	grade
1	Bugs Bunny	CS	2014-11-06	1	411	Fall 2017	A+
1	Bugs Bunny	CS	2014-11-06	4	411	Fall 2017	B
1	Bugs Bunny	CS	2014-11-06	1	426	Fall 2017	A
2	Donald Duck	ECE	1997-02-01	1	411	Fall 2017	A+
2	Donald Duck	ECE	1997-02-01	4	411	Fall 2017	B
2	Donald Duck	ECE	1997-02-01	1	426	Fall 2017	A
…	…	…	…	…	…	…	…

Cartesian product of Students and Enrolls

- Is the result of this operation useful?

Cartesian Product:
Useful for Collecting Data into One Table

- $SE :=$ Students $\times$ Enrolls =

S.id	name	major	birthday	E.id	number	term	grade
1	Bugs Bunny	CS	2014-11-06	1	411	Fall 2017	A+
1	Bugs Bunny	CS	2014-11-06	4	411	Fall 2017	B
1	Bugs Bunny	CS	2014-11-06	1	426	Fall 2017	A
2	Donald Duck	ECE	1997-02-01	1	411	Fall 2017	A+
2	Donald Duck	ECE	1997-02-01	4	411	Fall 2017	B
2	Donald Duck	ECE	1997-02-01	1	426	Fall 2017	A
…	…	…	…	…	…	…	…

Cartesian product of Students and Enrolls

- Upon A, we can now ask:

What courses did Bugs Bunny take?

$$BB := \sigma_{\text{S.id=E.id AND name="Bugs Bunny"}}(SE)$$
$$Answer := \pi_{\text{number}}(BB) = \{(411), (426)\}$$

Overall:

$$\pi_{\text{number}}\, \sigma_{\text{S.id=E.student AND name="Bugs Bunny"}}(\text{Students} \times \text{Enrolls})$$

Cartesian-Product Examples

- *Q1: Find "happy drinkers": those drinkers who live on the same street (address equal) as some bars.*