Database and its Applications

Data Models and Mathematical Foundations

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Computer Applications

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Relational Algebra: Select, Project, Union, Intersection

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Relational Algebra – Introduction

- Relational Algebra is a **procedural query language** for relational databases.
- Characteristics:
  - Operates on relations (sets of tuples).
  - Each operation produces a new relation (closure property).
  - Provides the theoretical foundation for SQL.
- We explore four key operations:
  - Select (σ)
  - Project (π)
  - Union ($\cup$)
  - Intersection ($\cap$)

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Cartoon Dataset – Example

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- Relation: CartoonCharacter(id, name, show, species, catchphrase)
- Sample Data:
  - (1, Mickey, Mickey Mouse Clubhouse, Mouse, “Oh boy!”)
  - (2, Bugs, Looney Tunes, Rabbit, “What’s up Doc?”)
  - (3, Tom, Tom & Jerry, Cat, “Meow”)
  - (4, Jerry, Tom & Jerry, Mouse, “Squeak”)
  - (5, Homer, Simpsons, Human, “D’oh!”)

Select Operation (σ) – Definition

- The **Select** operation filters rows that satisfy a condition.
- Notation:

$$\sigma_{\theta}(R)$$

  where θ is a logical predicate.
- Properties:
  - Output schema = schema of R.
  - Returns only those tuples satisfying condition.

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Select Operation (σ) – Example

- Query: Find all cartoon characters who are Mice.
- Expression:

$$\sigma_{species='Mouse'}(CartoonCharacter)$$

- Input: {(1, Mickey, Mouse), (2, Bugs, Rabbit), (4, Jerry, Mouse)}
- Output: {(1, Mickey, ...), (4, Jerry, ...)}
- SQL Equivalent: `SELECT * FROM CartoonCharacter WHERE species = 'Mouse';`

Project Operation (π) – Definition

- The **Project** operation selects specific attributes (columns).
- Notation:

$$\pi_{A1,A2,\ldots,An}(R)$$

- Properties:
  - Eliminates duplicates.
  - Reduces schema to selected attributes.

Project Operation (π) – Example

- Query: List the shows of cartoon characters.
- Expression:

$$\pi_{show}(CartoonCharacter)$$

- Input: {(Mickey Mouse Clubhouse), (Looney Tunes), (Tom & Jerry), (Simpsons)}
- Output: {Mickey Mouse Clubhouse, Looney Tunes, Tom & Jerry, Simpsons}
- SQL Equivalent: `SELECT DISTINCT show FROM CartoonCharacter;`

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Venn Diagram Representation

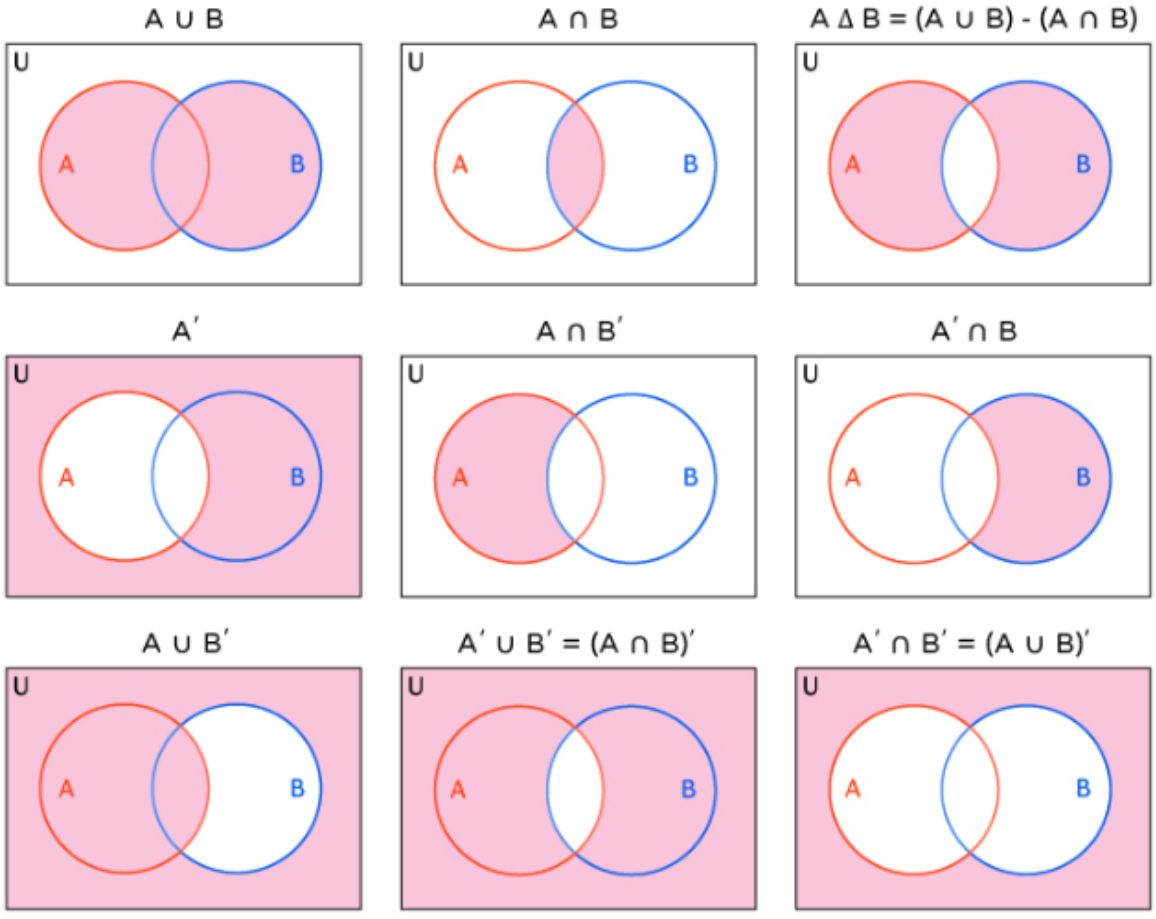

Figure: Representation of Common Set Operations (Union, Intersection, Difference, Complement, and Symmetric Difference

Union Operation ($\cup$) – Definition

- The **Union** operation returns tuples in either relation.
- Notation:

$$R \cup S$$

- Requirements:
  - Same number of attributes.
  - Same domains for corresponding attributes.
- Properties:
  - Duplicate tuples removed.
  - Commutative: $R \cup S = S \cup R$.

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Union Operation (∪) – Example

- Relations:
  - DisneyCharacters(id, name) = {(1, Mickey), (6, Goofy)}
  - LooneyCharacters(id, name) = {(2, Bugs), (7, Daffy)}
- Query: Find all cartoon characters from Disney or Looney Tunes.
- Expression:

$$DisneyCharacters \cup LooneyCharacters$$

- Output: {(1, Mickey), (6, Goofy), (2, Bugs), (7, Daffy)}
- SQL Equivalent:

```
SELECT id, name FROM DisneyCharacters
UNION
SELECT id, name FROM LooneyCharacters;
```

Intersection Operation (∩) – Definition

- The **Intersection** operation returns tuples common to both relations.
- Notation:

$$R \cap S$$

- Requirements:
  - Relations must be union-compatible.

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Intersection Operation (∩) – Example

- Relations:
  - CharactersWithCatchphrases(name) = {Mickey, Bugs, Homer}
  - CharactersWithShows(name) = {Mickey, Bugs, Tom, Jerry}
- Query: Find cartoon characters with both a catchphrase and a show.
- Expression:

$$CharactersWithCatchphrases \cap CharactersWithShows$$

- Output: {Mickey, Bugs}
- SQL Equivalent:

```
SELECT name FROM
CharactersWithCatchphrases
INTERSECT
SELECT name FROM CharactersWithShows;
```

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Problem Solving – Practice

- Q1: Find all Rabbits from the cartoon dataset.

$$\sigma_{species='Rabbit'}(CartoonCharacter)$$

- Q2: List all distinct catchphrases.

$$\pi_{catchphrase}(CartoonCharacter)$$

- Q3: Find all characters in either Disney or Looney Tunes.

$$DisneyCharacters \cup LooneyCharacters$$

- Q4: Find all characters with both a catchphrase and a show.

$$CharactersWithCatchphrases \cap CharactersWithShows$$

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Summary – Relational Algebra Operations

- Select (σ): Filters rows by condition (e.g., all Mice).
- Project (π): Extracts attributes (e.g., list of shows).
- Union ($\cup$): Tuples in either relation (e.g., Disney $\cup$ Looney).
- Intersection ($\cap$): Tuples common to both (e.g., characters with shows and catchphrases).
- All results are relations $\rightarrow$ enabling composition of operations.

Thank You

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