DataBases Design & Relational Algebra

DataBase Foundations

Author: Eng. Carlos Andrés Sierra, M.Sc.
cavirguezs@udistrital.edu.co

Lecturer
Computer Engineer
School of Engineering
Universidad Distrital Francisco José de Caldas

2024-III

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS

Outline

Outline

1. Basic Concepts
2. Normalization
3. Relational Algebra

DataBases Design Foundations

- In the context of **databases**, the design of a database is the process of producing a **detailed** data model of a database.
- This **data model** contains all the needed logical and physical design **choices** and physical storage parameters needed to generate a design in a *data definition language*, which can then be used to create a database.
- A fully attributed data model contains detailed attributes for **each entity**.
- **Relational Data Models** avoid redundancy and inconsistency by ensuring that data is **normalized**.

Set Theory in Databases

- The **set theory** is a branch of hmathematical logic that studies sets, which are collections of objects.
- The **set theory** is applied in databases to define the relational model and the relational algebra.
- The **relational model** is a mathematical model of data for large shared data banks and it has a **solid theoretical foundation**.
- The **relational algebra** is a procedural query language, which takes relations as input and produces relations as output.

Outline

Normalization in Databases

- **Normalization** is the process of organizing the columns (attributes) and tables (relations) of a relational database to **minimize data redundancy**.
- **Normalization** involves decomposing a table into **smaller tables** and defining relationships between them.
- The objective is to **isolate data** so that additions, deletions, and modifications of a field can be made in just **one table** and then **propagated** through the rest of the database using the defined relationships.

Normalization in Databases

- **Normalization** is the process of organizing the columns (attributes) and tables (relations) of a relational database to **minimize data redundancy**.
- **Normalization** involves decomposing a table into **smaller tables** and defining relationships between them.
- The objective is to **isolate data** so that additions, deletions, and modifications of a field can be made in just **one table** and then **propagated** through the rest of the database using the defined relationships.

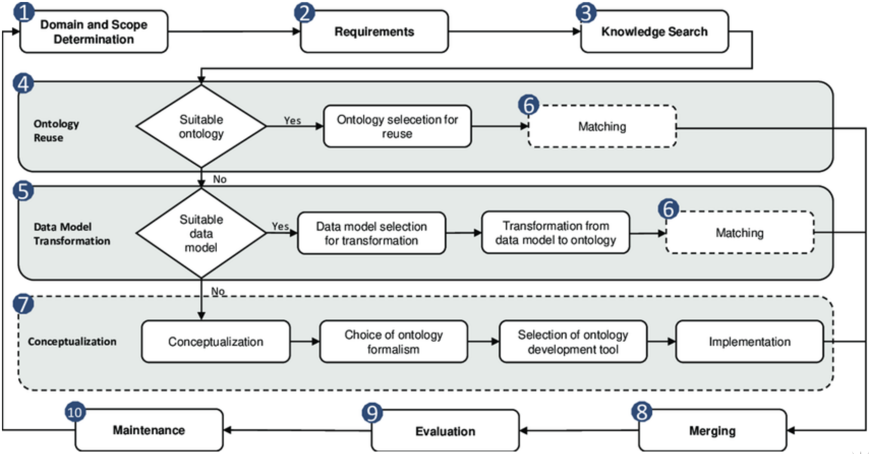
Normalization in Databases

- **Normalization** is the process of organizing the columns (attributes) and tables (relations) of a relational database to **minimize data redundancy**.
- **Normalization** involves decomposing a table into **smaller tables** and defining relationships between them.
- The objective is to **isolate data** so that additions, deletions, and modifications of a field can be made in just **one table** and then **propagated** through the rest of the database using the defined relationships.

Ontologies

- An **ontology** is a formal naming and definition of the types, properties, and interrelationships of the **entities** that really or fundamentally exist for a particular domain of discourse.
- **Ontologies** are used in databases to define the schema of the database.
- The **schema** of a database is a formal definition of the structure of the database: the `types of data` that are stored, the `relationships` between the data, and the `constraints` on the data.

Ontology Workflow



Normal Levels

1. **First normal form (1NF)**: The table is a two-dimensional table with rows and columns. Each column contains **atomic values**, and there are no repeating groups or arrays.
2. **Second normal form (2NF)**: The table is in first normal form and all the non-key attributes are fully functionally dependent on the primary key.
3. **Third normal form (3NF)**: The table is in second normal form and all the non-key attributes are non-transitively dependent on the primary key.
4. **Fourth normal form (4NF)**: The table is in third normal form and there are no multi-valued dependencies.

Outline

What is relational algebra?

- The **relational algebra** is a procedural query language, which takes relations as input and produces relations as output.
- The **relational algebra** is a set of operations that can be performed on a relation. Also, it is used to define the relational model, which is a mathematical model of data for large shared data banks.
- Let's take a look at the basic operations of the **relational algebra**. First, remember next table called Students:

ID	Name	Lastname	Address	Phone	Age
1	John	Doe	123 Fake St	555-1234	25
2	Jane	Smith	456 Elm St	555-5678	30
3	Mike	Johnson	789 Evergreen St	555-9012	35

Select Operation

Definition

Select: $\sigma_{\text{condition}}(R)$, is a unary operation that returns the rows (subset) of R that satisfy the condition.

For example, the following expression selects the students whose age is greater than 25:

$$\sigma_{\text{Age}>25}(\text{Students})$$

Project Operation

Definition

Project: $\pi_{\text{column\_list}}(R)$, is a unary operation that returns the columns (subset) of R that are specified in the column list.

For example, the following expression projects the name and lastname of the students:

$$\pi_{\text{Name, Lastname}}(\text{Students})$$

Union Operation

Definition

Union: $R \cup S$, is a binary operation that returns the rows that are in R or in S.

For example, the following expression returns the students whose age is greater than 25 or whose lastname is Johnson:

$$\sigma_{\text{Age}>25}(\text{Students}) \cup \sigma_{\text{Lastname}=\text{Johnson}}(\text{Students})$$

Set Different Operation

Definition

Set Different: $R - S$, is a binary operation that returns the rows that are in R but not in S.

For example, the following expression returns the students whose age is greater than 25 but not whose lastname is Johnson:

$$\sigma_{\text{Age}>25}(\text{Students}) - \sigma_{\text{Lastname}=\text{Johnson}}(\text{Students})$$

Cartesian Product Operation

Definition

Cartesian Product: $R \times S$, is a binary operation that returns the Cartesian product of R and S. A formal definition is:

$$R \times S = \{r \cup s \mid r \in R \wedge s \in S\}$$

For example, the following expression returns the Cartesian product of the students and the courses:

$$\text{Students} \times \text{Courses}$$

Rename Operation

Definition

Rename: $\rho_{\text{new\_name}}(R)$, is a unary operation that returns the relation R with the name R changed to new_name.

For example, the following expression returns the students relation with the name changed to People:

$$\rho_{\text{People}}(\text{Students})$$

Exercises

1. Select the students whose age is greater than 25 and whose lastname is Johnson.
2. Project the name and lastname of the students whose age is greater than 25.
3. Select the students whose age is greater than 25 and whose lastname is Johnson, and project the name and lastname of the students, and rename the relation to People.

UNIVERSIDAD DISTRITAL FRANCISCO JOSÉ DE CALDAS

Exercises

1. Select the students whose age is greater than 25 and whose lastname is Johnson.
2. Project the name and lastname of the students whose age is greater than 25.
3. Select the students whose age is greater than 25 and whose lastname is Johnson, and project the name and lastname of the students, and rename the relation to People.

Exercises

1. Select the students whose age is greater than 25 and whose lastname is Johnson.
2. Project the name and lastname of the students whose age is greater than 25.
3. Select the students whose age is greater than 25 and whose lastname is Johnson, and project the name and lastname of the students, and rename the relation to People.

UNIVERSIDAD DISTRITAL FRANCISCO JOSÉ DE CALDAS

Outline

Thanks!

Questions?

Repo: *https://github.com/EngAndres/ud-public/tree/main/courses/databases-foundations*

UNIVERSIDAD DISTRITAL FRANCISCO JOSÉ DE CALDAS