

Module 11 - Data Normalization

What is Database Normalization?

Database Normalization is a process used to organize data in a database to:

- Reduce data redundancy (avoid storing the same data multiple times).
- Improve data integrity (keep data accurate and consistent).
- Make database efficient and easy to maintain.

Why Normalize a Database?

Imagine a database where the same information is repeated in many places. This causes problems like:

- Wasted storage space.
- Inconsistent data if one copy is updated but others aren't.
- Difficulty in inserting, updating, or deleting data without errors.

Normalization helps by breaking data into smaller tables and defining relationships between them, so each piece of information is stored only once.

Importance of Normalization

Normalization is very important because it helps **organize data efficiently** in a database. Without normalization, data can become messy, redundant, and inconsistent, which makes it hard to maintain and use.

Why is Normalization Important?

1. **Avoids Data Redundancy**

- Redundancy means storing the same data multiple times in different places.
- Normalization reduces duplication, saving storage space and preventing errors.

2. **Improves Data Integrity**

- Ensures that the data remains **accurate and consistent**.
- For example, if a student's name changes, you only update it in one place, not many.

3. **Simplifies Data Maintenance**

- Easier to insert, update, or delete data without causing anomalies or errors.
- Avoids problems like inconsistent data updates.

4. **Enables Better Organization of Data**

- Breaks complex data into logical, related tables.

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- Makes the structure clearer and easier to understand.
- 5. Supports Efficient Queries**
  - Well-organized data improves performance and makes queries more efficient.
- 6. Helps Enforce Business Rules**
  - With keys and constraints, normalization enforces relationships and rules, preventing invalid data entry.

**How does Normalization Work?**

It is done in stages called **Normal Forms (NFs)**. Each stage has rules to improve the database design.

Normal Forms Explained with Example

Let's say we have a simple table storing student enrollment information:

StudentID	StudentName	CourseID	CourseName	Instructor
101	Alice	C101	Math	Mr. Smith
101	Alice	C102	English	Mrs. Johnson
102	Bob	C101	Math	Mr. Smith
103	Charlie	C103	History	Mr. Brown

**First Normal Form (1NF)**

**Rule:**

- Each column should have **atomic values** (no multiple values in one cell).
- Each row should be unique.
- No repeating groups or arrays in a column.

**Does our table satisfy 1NF?**

- Yes, because every cell has a single value.
- No multi-valued columns.
- Each row is unique (StudentID + CourseID combination).

**Second Normal Form (2NF)**

**Rule:**

- Table must be in 1NF.
- Every non-key column must depend on the **whole primary key**, not just part of it.

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- Applies to tables with composite keys.

Our table's primary key is (StudentID, CourseID) because together they uniquely identify each enrollment.

Problem:

- StudentName depends only on StudentID (part of the key).
- CourseName and Instructor depend only on CourseID (part of the key).

This causes redundancy. For example, "Alice" repeats for every course she takes.

To fix this, split the table into:

Students

StudentID	StudentName
101	Alice
102	Bob
103	Charlie

Courses

CourseID	CourseName	Instructor
C101	Math	Mr. Smith
C102	English	Mrs. Johnson
C103	History	Mr. Brown

Enrollments

StudentID	CourseID
101	C101
101	C102
102	C101
103	C103

Now:

- Each non-key column depends on the **whole key**.
- No redundant data in Enrollments.

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Third Normal Form (3NF)

Rule:

- Table must be in 2NF.
- No **transitive dependency**: non-key columns should not depend on other non-key columns.

Example problem:

If we add a column InstructorPhone in the Courses table:

CourseID	CourseName	Instructor	InstructorPhone
C101	Math	Mr. Smith	555-1234

Here, InstructorPhone depends on Instructor, not on CourseID directly.

This is a transitive dependency (CourseID → Instructor → InstructorPhone).

To fix this:

Split into two tables:

Courses

CourseID	CourseName	Instructor
C101	Math	Mr. Smith

Instructors

Instructor	InstructorPhone
Mr. Smith	555-1234
Mrs. Johnson	555-5678

Beyond 3NF

- There are higher normal forms (BCNF, 4NF, 5NF), but 3NF usually covers most practical needs.

Summary: What happens after normalization?

- Data is divided into logical tables.
- Redundancy is minimized.
- Updates and deletions are safer (less chance of inconsistency).

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- Queries can be more complex (need to join tables), but data integrity improves.

Assignment

Q1. Which of the following is the main purpose of database normalization?

- A) Increase redundancy
- B) Improve performance by storing data in one big table
- C) Organize data to reduce duplication
- D) Make queries slower

Q2. A table is in 1NF if:

- A) It contains null values
- B) It has multi-valued attributes
- C) Each cell has only a single value
- D) It contains repeating groups



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