NORMAL FORMS:

Certainly! Let's dive deeper into Normal Forms in DBMS with detailed explanations and examples:

1. First Normal Form (1NF)

Definition: A table is in First Normal Form (1NF) if it meets the following criteria:

- Contains only atomic (indivisible) values.
- There are no repeating groups or arrays within a row.

Explanation: 1NF ensures that each column in a table contains only a single value, and each value is atomic. It eliminates complex data types such as arrays or nested tables within a single row.

Example: Consider a table of students and their courses:

StudentID | StudentName | Courses

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1 | Alice | Math, Physics

2 | Bob | Chemistry

This table is not in 1NF because the Courses column contains multiple values (Math, Physics) for Alice. To convert it to 1NF, we split the courses into separate rows:

StudentID | StudentName | Course

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1 | Alice | Math

1 | Alice | Physics

2 | Bob | Chemistry

2. Second Normal Form (2NF)

Definition: A table is in Second Normal Form (2NF) if:

- It is in 1NF.
- All non-key attributes are fully functionally dependent on the primary key.

Explanation: 2NF addresses the concept of partial dependency, where attributes depend on only part of the primary key. By ensuring all non-key attributes depend on the whole primary key, 2NF eliminates redundancy and improves data integrity.

Example: Consider a table that records orders and products:

OrderID | ProductID | ProductName | Category

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1 | 101 | Laptop | Electronics

2 | 102 | Mouse | Electronics

3 | 101 | Laptop | Electronics

In this table, (OrderID, ProductID) is the composite key. ProductName and Category depend only on ProductID, not the entire composite key. To adhere to 2NF, we split the table into:

Orders:

OrderID | ProductID

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1 | 101

2 | 102

3 | 101

Products:

ProductID | ProductName | Category

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101 | Laptop | Electronics

102 | Mouse | Electronics

3. Third Normal Form (3NF)

Definition: A table is in Third Normal Form (3NF) if:

- It is in 2NF.
- All transitive dependencies are removed.

Explanation: 3NF further refines the normalization process by eliminating transitive dependencies, where non-key attributes depend on other non-key attributes rather than on the primary key.

Example: Consider a table of employees, projects, and managers:

EmployeeID | ProjectID | ProjectName | ManagerID | ManagerName

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101 | 1 | ProjectA | 201 | Alice

102 | 2 | ProjectB | 202 | Bob

In this table, ManagerName depends on ManagerID, which is not the primary key. To achieve 3NF, we separate manager information into its own table:

Employees:

EmployeeID | ProjectID | ProjectName | ManagerID

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101 | 1 | ProjectA | 201

102 | 2 | ProjectB | 202

Managers:

ManagerID | ManagerName

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201 | Alice

202 | Bob

Boyce-Codd Normal Form (BCNF)

Definition: A table is in Boyce-Codd Normal Form (BCNF) if every determinant is a candidate key.

Explanation: BCNF is an extension of 3NF and ensures that there are no non-trivial functional dependencies where the determinant is not a candidate key. It's a stricter form of normalization.

Example: Consider a table where the determinant (non-key attribute) determines another non-key attribute:

StudentID | CourseID | Instructor | InstructorOffice

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1 | 101 | Mr. Smith | Room 101

2 | 102 | Mr. Jones | Room 102

Here, InstructorOffice depends on Instructor, which is not a candidate key. To achieve BCNF, we split the table into:

Courses:

CourseID | Instructor

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101 | Mr. Smith

102 | Mr. Jones

Instructors:

Instructor | InstructorOffice

Mr. Smith | Room 101

Mr. Jones | Room 102

4. Fourth Normal Form (4NF)

Definition: A table is in Fourth Normal Form (4NF) if it is in BCNF and has no multi-valued dependencies.

Explanation: 4NF focuses on eliminating multi-valued dependencies, where one or more attributes determine multiple independent sets of values for other attributes.

Example: Consider a table where multiple values are dependent on part of the primary key:

EmployeeID | Skills | Certifications

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101 | Java, SQL | Oracle Certified, AWS Certified

102 | Python | Microsoft Certified

Here, Skills (Java, SQL) and Certifications (Oracle Certified, AWS Certified) are multi-valued attributes dependent on EmployeeID. To achieve 4NF, we split these attributes into separate tables:

Employees:

EmployeeID

101

102

Skills:

EmployeeID | Skill

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101 | Java

101 | SQL

102 | Python

Certifications:

EmployeeID | Certification

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101 | Oracle Certified

101 | AWS Certified

102 | Microsoft Certified

5. Fifth Normal Form (5NF) or Project-Join Normal Form (PJNF)

Definition: A table is in Fifth Normal Form (5NF) or Project-Join Normal Form (PJNF) if it is in 4NF and does not contain join dependencies or join dependencies are minimized.

Explanation: 5NF deals with join dependencies, where a table may need to be decomposed further to eliminate redundancies arising from join operations.

Example: Consider a table where information about courses and textbooks is stored together:

CourseID | TextbookID | TextbookTitle | Author

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101 | 501 | Physics | Smith

102 | 502 | Chemistry | Johnson

Here, TextbookTitle and Author are attributes dependent on TextbookID, not directly on CourseID. To achieve 5NF, we split this into:

Courses:

CourseID | TextbookID

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101 | 501

102 | 502

Textbooks:

TextbookID | TextbookTitle | Author

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501 | Physics | Smith

502 | Chemistry | Johnson

Conclusion

Normal Forms in DBMS are crucial for database design to minimize redundancy and dependency issues, ensuring efficient data storage and integrity. Each normal form builds upon the previous one, offering progressively stricter guidelines for table design and normalization