Module 3

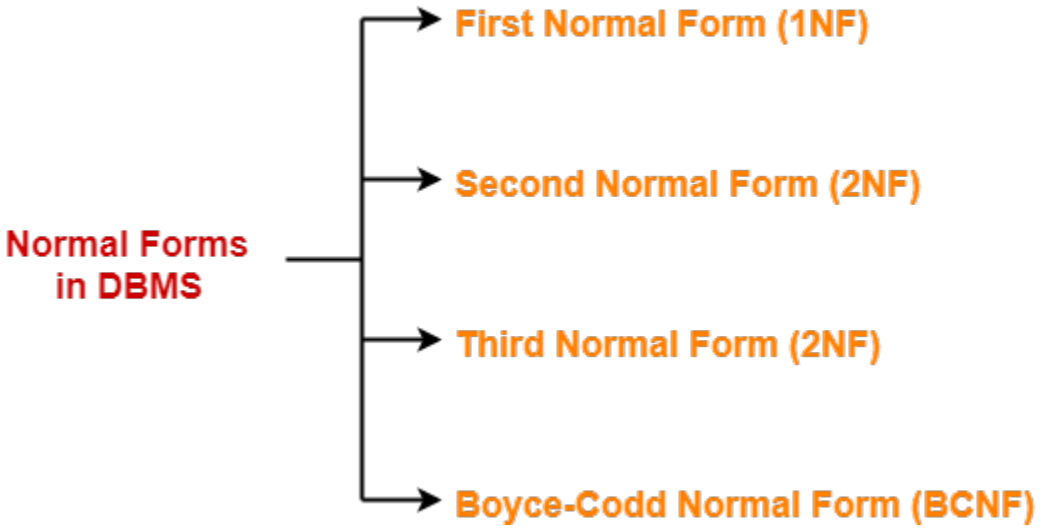
Module:3 Relational Database Design

Database Design – Schema Refinement - Guidelines for Relational Schema – Functional dependencies - Axioms on Functional Dependencies- Normalization: First, Second and Third Normal Forms - Boyce Codd Normal Form, Multi-valued dependency and Fourth Normal form - Join dependency and Fifth Normal form

- **Reference :**
- ***R. Elmasri & S. B. Navathe, Fundamentals of Database Systems, Addison Wesley, 7th Edition, 2016***
- ***A. Silberschatz, H. F. Korth & S. Sudarshan, Database System Concepts, McGraw Hill,7th Edition 2019.***

Normalization

Normalization is the process of organizing data in a database to reduce redundancy and improve data integrity. It involves decomposing relations into well-structured tables based on functional dependencies.



First Normal Form

- A given relation is called in First Normal Form (1NF) if each cell of the table contains only an atomic value.

OR

- A given relation is called in First Normal Form (1NF) if the attribute of every tuple is either single valued or a null value.

The following relation is not in 1NF

Student_id	Name	Subjects
100	Akshay	Computer Networks, Designing
101	Aman	Database Management System
102	Anjali	Automata, Compiler Design

First Normal Form

- This relation can be brought into 1NF.
- This can be done by rewriting the relation such that each cell of the table contains only one value.

Relation is in 1NF

Student_id	Name	Subjects
100	Akshay	Computer Networks
100	Akshay	Designing
101	Aman	Database Management System
102	Anjali	Automata
102	Anjali	Compiler Design

First Normal Form

NOTE-

- By default, every relation is in 1NF.
- This is because formal definition of a relation states that value of all the attributes must be atomic.

Second Normal Form

A given relation is called in Second Normal Form (2NF) if and only if,

- Relation already exists in 1NF.
- No partial dependency exists in the relation.

Partial Dependency

A partial dependency is a dependency where few attributes of the candidate key determines non-prime attribute(s).

A partial dependency is a dependency where a portion of the candidate key or incomplete candidate key determines non-prime attribute(s).

In other words,

A → B is called a partial dependency if and only if-

1. A is a subset of some candidate key

2. B is a non-prime attribute.

If any one condition fails, then it will not be a partial dependency.

NOTE-

To avoid partial dependency, incomplete candidate key must not determine any non-prime attribute.

However, incomplete candidate key can determine prime attributes.

Example-

Consider a relation- R (V , W , X , Y , Z) with functional dependencies-

$$VW \rightarrow XY$$

$$Y \rightarrow V$$

$$WX \rightarrow YZ$$

The possible candidate keys for this relation are-

VW , WX , WY

From here,

- Prime attributes = { V , W , X , Y }
- Non-prime attributes = { Z }

Now, if we observe the given dependencies-

- There is no partial dependency.
- This is because there exists no dependency where incomplete candidate key determines any non-prime attribute.

Thus, we conclude that the given relation is in 2NF.

Third Normal Form

A given relation is called in Third Normal Form (3NF) if and only if-

1.Relation already exists in 2NF.

2.No transitive dependency exists for non-prime attributes.

OR

A relation is called in Third Normal Form (3NF) if and only if-

Any one condition holds for each non-trivial functional dependency A → B

1.A is a super key

2.B is a prime attribute

Transitive Dependency

$A \rightarrow B$ is called a transitive dependency if and only if-

- A is not a super key.
- B is a non-prime attribute.

If any one **condition fails,** then it is not a transitive dependency.

NOTE-

Transitive dependency must not exist for non-prime attributes.
However, transitive dependency can exist for prime attributes.

Example-

Consider a relation- R (A , B , C , D , E) with functional dependencies-

$$A \rightarrow BC$$
$$CD \rightarrow E$$
$$B \rightarrow D$$
$$E \rightarrow A$$

The possible candidate keys for this relation are-

A , E , CD , BC

From here,

- Prime attributes = { A , B , C , D , E }
- There are no non-prime attributes

Now,

- It is clear that there are no non-prime attributes in the relation.
- In other words, all the attributes of relation are prime attributes.
- Thus, all the attributes on RHS of each functional dependency are prime attributes.