

# UNIT 2

Lecture 33

Normalization

3NF & BCNF

# Third Normal Form (3NF)

- Third normal form (3NF) is based on the concept of *transitive dependency*.
- A relation schema R is in 3NF if it is in 2NF and no nonprime attribute of R is transitively dependent on the primary key.
- A relation schema R is in 3NF if it is in 2NF and no nonprime attribute is dependent on other non prime attribute.
- **General Def. Of 3NF** – A relation schema R is in third normal form (3NF) if, whenever a nontrivial functional dependency  $X \rightarrow A$  holds in R, either
  - X is a super key of R, or
  - A is a prime attribute of R.

# Third Normal Form (3NF)

E.g. 1 Consider a relation R (A, B, C, D) with a set of FDs

$F = \{ \begin{array}{l} A \rightarrow B, \\ B \rightarrow C, \\ A \rightarrow C, \\ C \rightarrow D \end{array} \}$

is not in 3NF, because it has 3 transitive dependencies  $B \rightarrow C$ ,  $C \rightarrow D$  and  $B \rightarrow D$ , with candidate key as A.

# 3NF Decomposition Algorithm

1. Compute the canonical cover  $F_C$ . (Remove Redundant FDs from  $F$ )
2. For every dependency  $X \rightarrow Y$  in  $F_C$ , create a relation  $R_i(X, Y)$ .
3. If none of the relations preserve the candidate key, then create a relation to preserve the candidate key. (If the key  $K$  of  $R$  does not occur in any relation  $R_i$ , create one more relation  $R_i(K)$ ).
4. If possible merge 2 or more relations on the basis of common candidate keys.

# Third Normal Form (3NF)

E.g. 1 Consider a relation R (A, B, C, D) with a set of FDs

$$F = \{ \begin{array}{l} A \rightarrow B, \\ B \rightarrow C, \\ A \rightarrow C, \\ C \rightarrow D \end{array} \}$$

Sol : First we have to find  $F_C$ .

$$F_C = \{ \begin{array}{l} A \rightarrow B, \\ B \rightarrow C, \\ C \rightarrow D \end{array} \}$$

So, the required 3NF decomposition of R is R1(A, B), R2(B, C) and R3(C, D).

# Third Normal Form (3NF)

E.g. 2 Consider a relation R (A, B, C, D, E) with a set of FDs

$$F = \{ \begin{array}{l} A \rightarrow B, \\ B \rightarrow E, \\ A \rightarrow C, \\ C \rightarrow D, \\ A \rightarrow E \end{array} \}$$

Sol : First we have to find  $F_C$ .

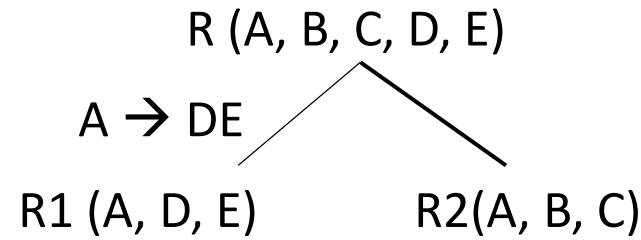
$$F_C = \{ \begin{array}{l} A \rightarrow BC, \\ B \rightarrow E, \\ C \rightarrow D \end{array} \}$$

So, the required 3NF decomposition of R is R1(A, B, C), R2(B, E) and R3(C, D).

# Third Normal Form (3NF) (Approach – I)

E.g.3 Consider a relation R (A, B, C, D, E) with a set of FDs

$F = \{$   
     $AB \rightarrow C,$   
     $A \rightarrow D,$   
     $D \rightarrow E \}$



Sol : First we compute  $F^+$ .

So.  $F^+ = \{ AB \rightarrow CDE,$   
     $A \rightarrow DE,$   
     $D \rightarrow E \}$

From  $F^+$ , we have 2 partial dependencies  $A \rightarrow D$ , and  $A \rightarrow E$ .

So, relations R1 (A, D, E) with  $F1 = \{A \rightarrow DE, D \rightarrow E\}$  and R2 (A, B, C) with  $F2 = \{AB \rightarrow C\}$  are the required 2NF decompositions of R.

Now, relation R2 is already in 3NF but R1 is not in 3NF because it contains a transitive dependency  $D \rightarrow E$ . So again we decompose R1(A, D, E) into R11(A, D) with  $F11 = \{A \rightarrow D\}$  and R12(D, E) with  $F12 = \{D \rightarrow E\}$ . So, R11 (A, D), R12 (D, E) and R2 (A, B, C) are the required 3NF decomposition of R.

# Third Normal Form (3NF) (Approach – II)

E.g.3 Consider a relation R (A, B, C, D, E) with a set of FDs

$$F = \{ \begin{array}{l} AB \rightarrow C, \\ A \rightarrow D, \\ D \rightarrow E \end{array} \}$$

Sol : First we compute  $F_c$ .

$$\text{So. } F_c = \{ \begin{array}{l} AB \rightarrow C, \\ A \rightarrow D, \\ D \rightarrow E \end{array} \}$$

From  $F_c$ , we have 3 dependencies  $AB \rightarrow C$ ,  $A \rightarrow D$  and  $D \rightarrow E$ .

So, relations R1 (A, B, C), R2 (A, D), and R3 (D, E) are the required 3NF decompositions of R.



# Third Normal Form (3NF) (Approach – I)

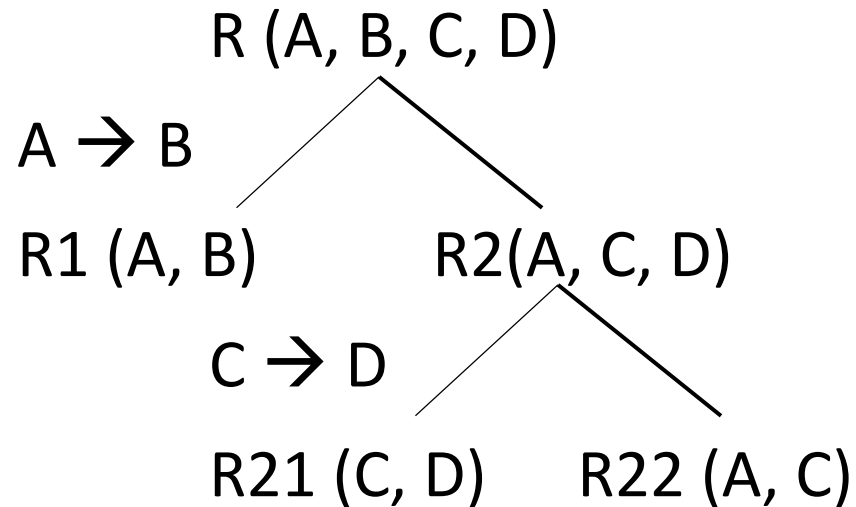
E.g.4 Consider a relation  $R(A, B, C, D)$  with a set of FDs

$$F = \{ A \rightarrow B, \\ C \rightarrow D \}$$

Sol : First we compute  $F^+$ .

$$\text{So. } F^+ = \{ A \rightarrow B, \\ C \rightarrow D \}$$

From  $F^+$ , we have 2 partial dependencies  $A \rightarrow B$ , and  $C \rightarrow D$ .



So, relations  $R1(\underline{A}, B)$ ,  $R21(\underline{C}, D)$  and  $R22(\underline{A}, \underline{C})$  are the required 2NF decompositions of  $R$ .

Now, relations  $R1(\underline{A}, B)$ ,  $R21(\underline{C}, D)$  and  $R22(\underline{A}, \underline{C})$  are also in 3NF, because they do not contain any transitive dependencies.

# Third Normal Form (3NF) (Approach – II)

E.g.4 Consider a relation R (A, B, C, D) with a set of FDs

$$F = \{ \begin{array}{l} A \rightarrow B, \\ C \rightarrow D \end{array} \}$$

Sol : First we compute  $F_c$ .

$$\text{So. } F_c = \{ \begin{array}{l} A \rightarrow B, \\ C \rightarrow D \end{array} \}$$

From  $F_c$ , we have 2 dependencies  $A \rightarrow B$ , and  $C \rightarrow D$ .

So, we create 2 relations R1 (A, B), and R2 (C, D).

Now, none of the relations preserve the candidate key AC, so we create a relation R3 (A, C) to preserve the candidate key. So, R1 (A, B), R2 (C, D) and R3 (A, C) are the required 3NF decompositions of R.

# Boyce Codd Normal Form (BCNF)

- **General Def. Of BCNF** – A relation schema R is in BCNF if whenever a nontrivial functional dependency  $X \rightarrow A$  holds in R, then X is a super key of R.
- A relation schema R is in BCNF if it is in 3NF and every determinant is a candidate key of R.
- Boyce-Codd normal form (BCNF) was proposed as a simpler form of 3NF, but it was found to be stricter than 3NF. That is, every relation in BCNF is also in 3NF; however, a relation in 3NF is not necessarily in BCNF.

# Boyce Codd Normal Form (BCNF)

E.g. 1 Consider a relation  $R(A, B, C)$  with a set of FDs

$$F = \{ \quad AB \rightarrow C, \\ \quad \quad C \rightarrow A \}$$

is not in BCNF, because it has 2 candidate keys  $AB$  and  $BC$ , and the determinant of  $C \rightarrow A$  is not a super key of  $R$ .

# BCNF Decomposition Algorithm

1. Compute the closure of set of FDs  $F^+$ .
2. For every dependency  $X \rightarrow Y$  in  $F^+$ , where  $X$  is not a super key of  $R$ , create 2 relations  $R_i(X, Y)$  and  $R_j(R - Y)$ .
3. If possible merge 2 or more relations on the basis of common candidate keys.

# Boyce Codd Normal Form (BCNF)

E.g.1 Consider a relation  $R(A, B, C)$  with a set of FDs

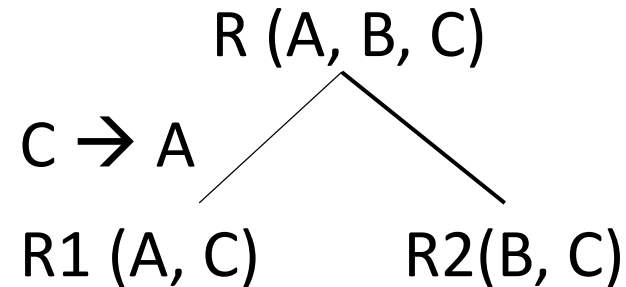
$$F = \{ \quad AB \rightarrow C, \\ \quad \quad C \rightarrow A \}$$

Sol : First we compute  $F^+$ .

$$\text{So. } F^+ = \{ \quad AB \rightarrow C, \\ \quad \quad C \rightarrow A \}$$

From  $F^+$ , we have 1

dependency  $C \rightarrow A$ , which violates BCNF property.



So, relations  $R_1(A, \underline{C})$  with  $F_1 = \{C \rightarrow A\}$ , and  $R_2(\underline{B}, \underline{C})$  with  $F_2 = \{ \emptyset \}$  are the required BCNF decompositions of  $R$ .

# Boyce Codd Normal Form (BCNF)

E.g.2 Consider a relation  $R(A, B, C, D)$  with a set of FDs

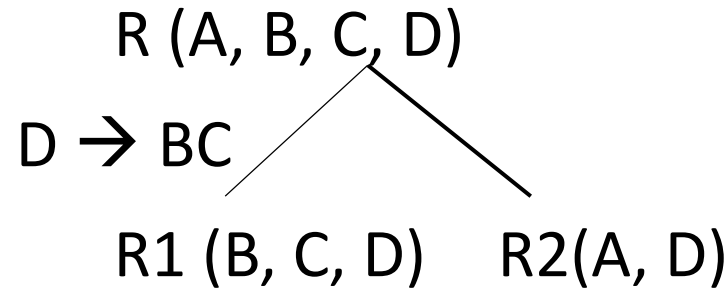
$F = \{ \quad ABC \rightarrow D,$   
 $\quad \quad D \rightarrow B,$   
 $\quad \quad D \rightarrow C \}$

Sol : First we compute  $F^+$ .

So.  $F^+ = \{ \quad \quad ABC \rightarrow D,$   
 $\quad \quad \quad D \rightarrow BC \}$

From  $F^+$ , we have 1

dependency  $D \rightarrow BC$  which violates property.

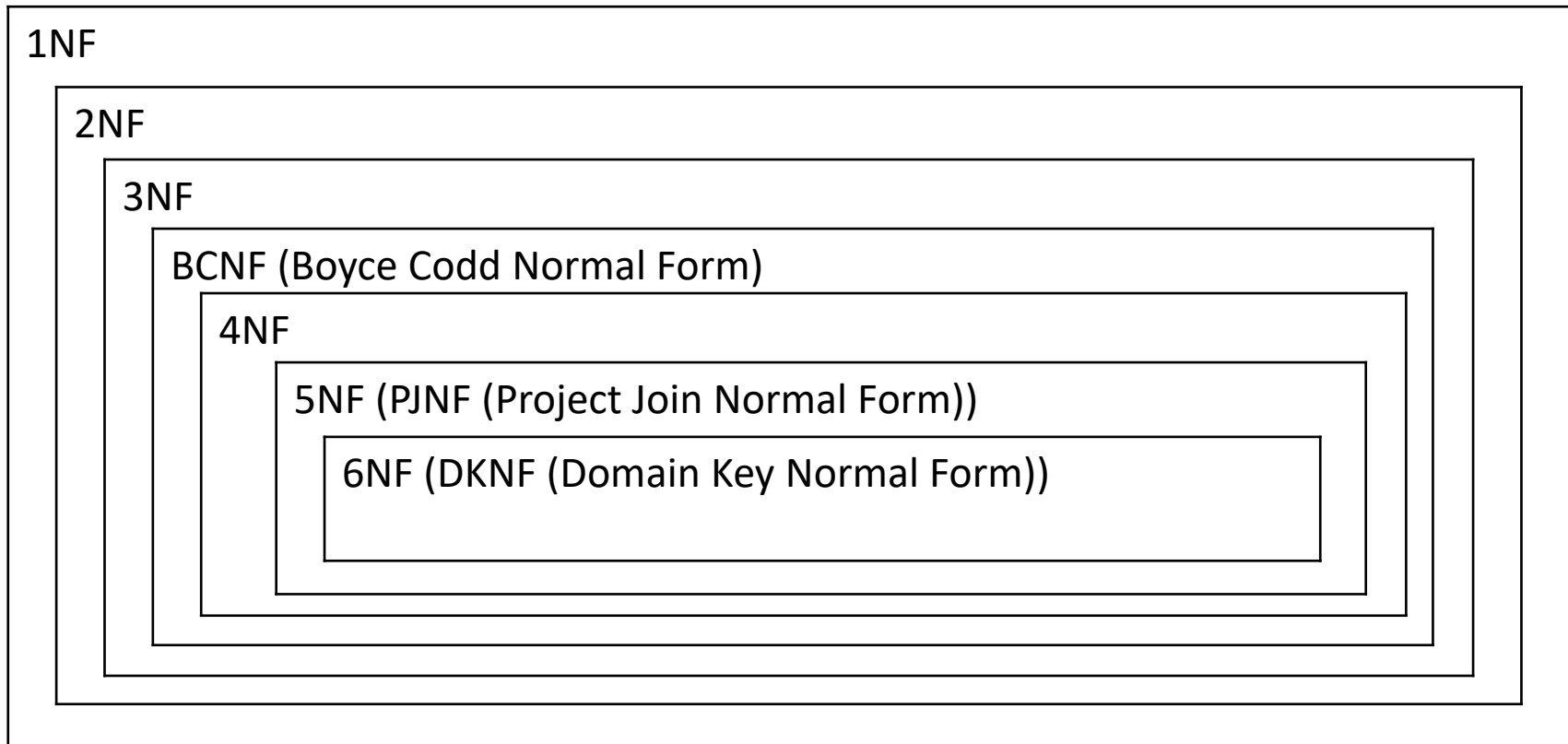


So, relations  $R_1(B, C, \underline{D})$  with  $F_1 = \{D \rightarrow BC\}$ , and  $R_2(\underline{A}, \underline{D})$  with  $F_2 = \{ \emptyset \}$  are the required BCNF decompositions of  $R$ .

# Objective of Normalization

- *“to create relations where every dependency is on the key, the whole key, and nothing but the key”.*

## ***Levels of Normalization***





# Practice Question

Consider a relation schema  $R = (A, B, C, D)$  with a set of functional dependencies  $F = \{C \rightarrow D, C \rightarrow A, B \rightarrow C\}$ .

1. Identify all candidate keys for  $R$ .
2. Identify the best normal form that  $R$  satisfies.
3. Decompose  $R$  into a set of BCNF relations.
4. Decompose  $R$  into a set of 3NF relations.

For Video lecture on this topic please subscribe to my youtube channel.

The link for my youtube channel is

[https://www.youtube.com/channel/UCRWGtE76JITp1iim6aOTRuW?sub\\_confirmation=1](https://www.youtube.com/channel/UCRWGtE76JITp1iim6aOTRuW?sub_confirmation=1)