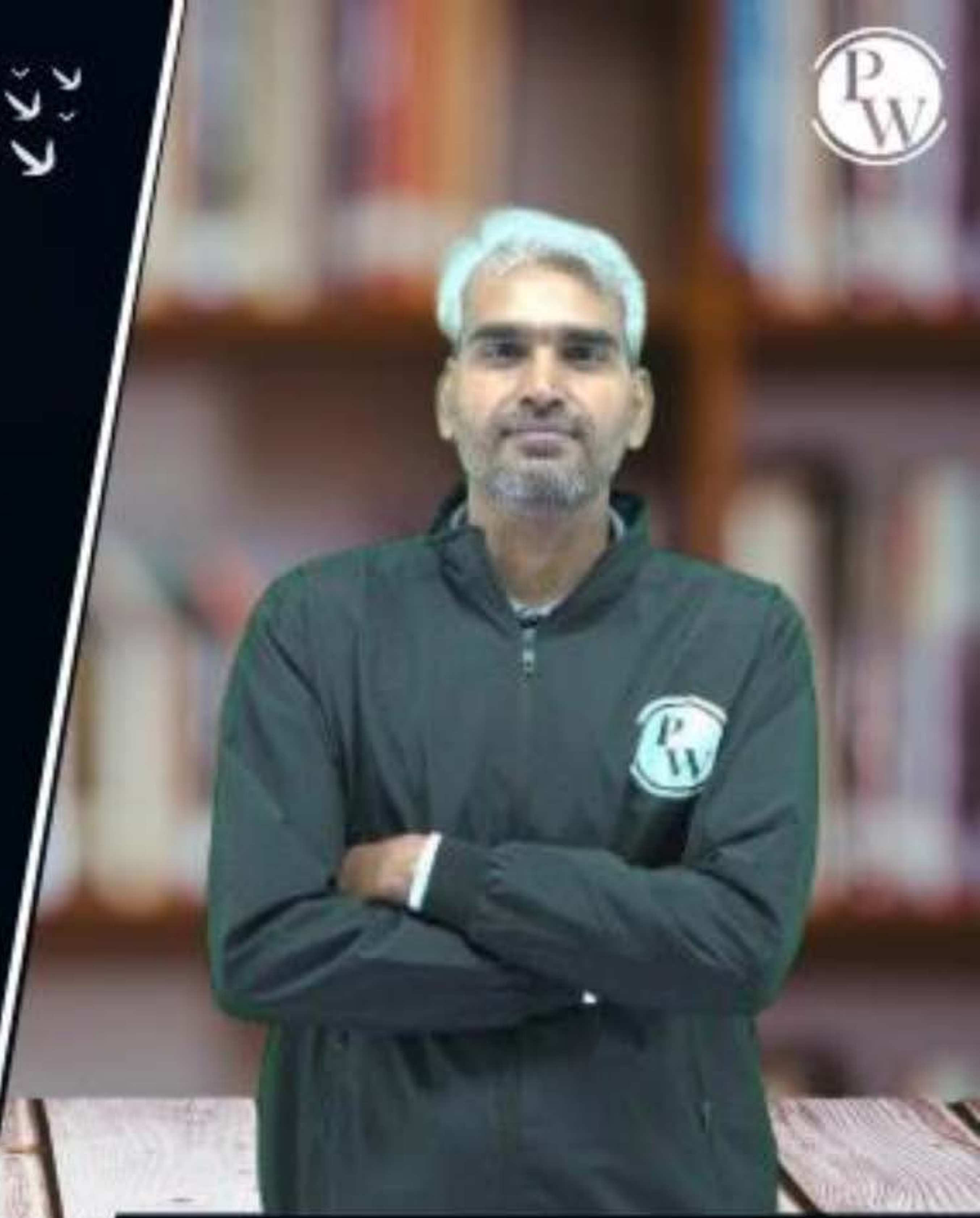
Computer Science & IT

Database Management System

Relational Model & Normal Forms

Lecture No. 10



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Recap of Previous Lecture

Topic Lossless join decomposition

Topic Normal forms

Topics to be Covered

- **Topic** Normal forms
- **Topic** Decomposition of relation up to BCNF

Topic : Normalization

- Normalization is the process of decomposing the relation into sub-relations, such that redundancy is reduced or eliminated.

Topic : Normal forms

There are various normal forms

1 NF	2 NF	3 NF	BCNF	4 NF

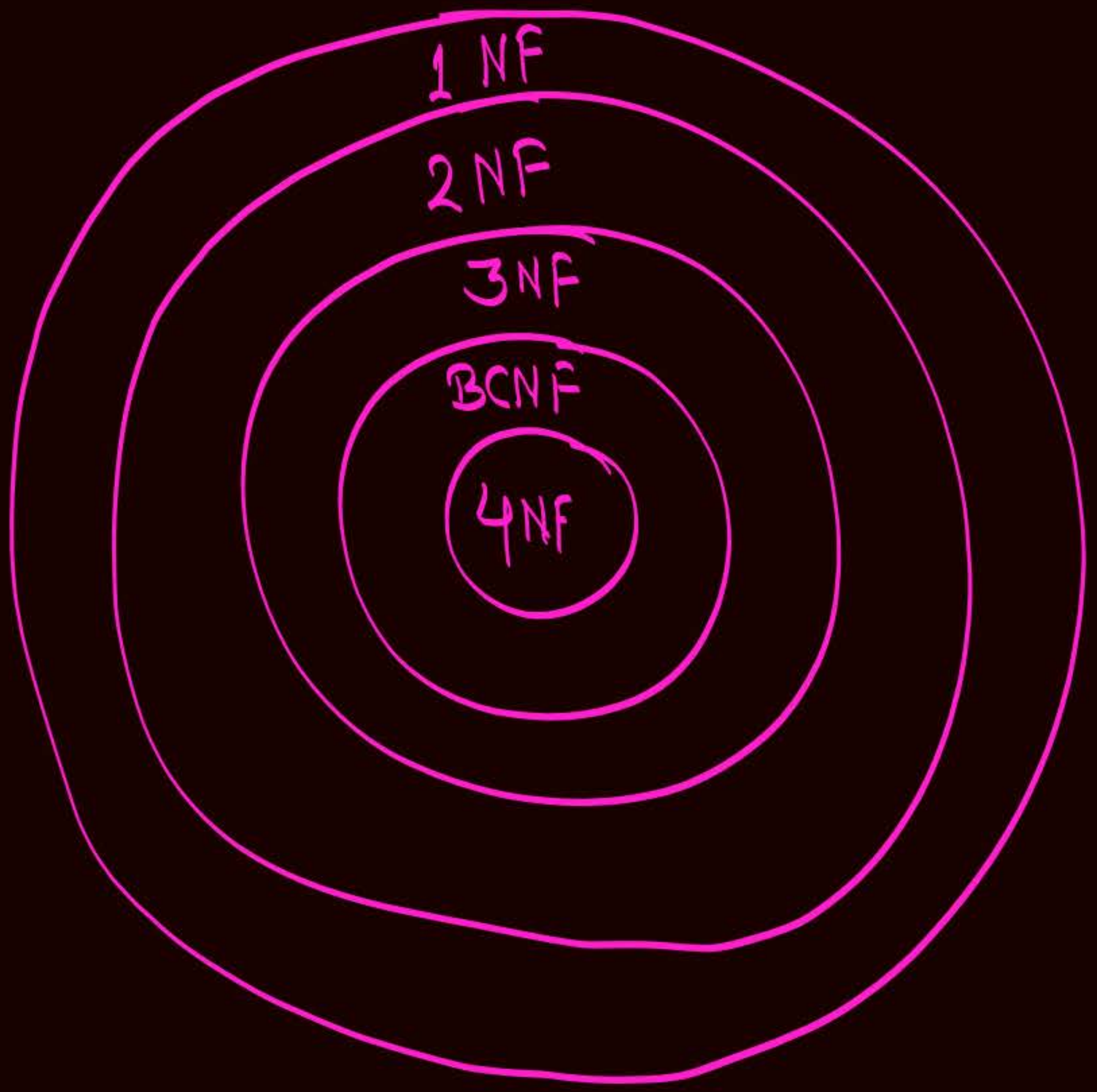
- Upto BCNF we try to eliminate the redundency present in the relation because of functional dependencies.
- If relation is in BCNF, then there will be no redundancy in that relation because of functional dependencies, but a relation in BCNF may still suffer from redundancies present in it because of multivalued dependency.

- 4 NF is related to multi-valued dependency.
- In 4NF we try to eliminate the redundancy present in the relation because of multi-valued dependency.

* Every relation which is in 2NF, is also in 1 NF.
* Every relation which is in 3NF, is also in 2NF and hence also in 1 NF.

⋮

and so on



Topic : First normal form (1NF)

For a database to be in "1NF" it must not contain any muti-valued attribute { i.e. all attributes must be simple and single (atomic) valued }

eg:

Multi-valued attribute

Sid	Courses
S_1	$\{C_1, C_2\}$
S_2	$\{C_2, C_3\}$
S_3	C_3

it is not a relation

Multi-valued attribute are Present ∴ it is not in "1NF"

Convert multi-valued attribute in to single valued attribute

Sid	Course
S_1	C_1
S_1	C_2
S_2	C_2
S_2	C_3
S_3	C_3

Now, Course is a single valued attribute

No multi-valued attribute is present ∴ It is at least in "1NF"

* By default normal form of relation is 1NF.

{i.e, Every relation is at least in 1NF}

Topic : Redundancy in relation because of FD

Rule 1 :- In a functional dependency "$X \rightarrow Y$", if "X" is a Super Key, then it does not cause any redundancy in the relation

Rule 2 :- In a functional dependency "$X \rightarrow Y$" if X is not a super Key, then it may cause redundancy in the relation

Possible types of non-trivial FDs which may cause redundancy in the relation

<u>Note</u>:- In $X \rightarrow Y$, if X is not a Superkey, then Y can never be a Super key.

∴ If $X \rightarrow Y$ causes redundancy in the relation, then neither L.H.S. <u>nor</u> R.H.S. of that FD can be a Super key.

Possible types of non-trivial FDs which may cause redundancy in the relation

X ⟶ Y

- Type ① Proper subset of a C.K ⟶ Non-Prime attributes
- Type ② (Proper Subset of a Candidate Key + Non-prime attributes) ⟶ Non-prime attribute
- Type ③ Non-prime attributes ⟶ Non-prime attributes

$\boxed{\text{Non-Prime Attributes} \longrightarrow \text{P.S.C.K.}}$ {Such FDs are not Possible}

$\boxed{\text{Proper subset of a C.K} \longrightarrow \text{Proper subset of same C.K}}$ Such FD is not Possible

- Type ④ Proper subset of one C.K ⟶ Proper Subset of some other C.K
- Type ⑤ (Proper Subset of one Candidate Key + Non-prime attributes) ⟶ Proper Subset of some other C.K

Note :-

FD type / Normal Form	Type 1	Type 2	Type 3	Type 4	Type 5
1 NF	Allowed	Allowed	Allowed	Allowed	Allowed
2 NF	Not allowed	Allowed	Allowed	Allowed	Allowed
3 NF	Not allowed	Not allowed	Not allowed	Allowed	Allowed
BCNF	Not allowed	Not allowed	Not allowed	Not allowed	Not allowed

Topic : Second normal form (2NF)

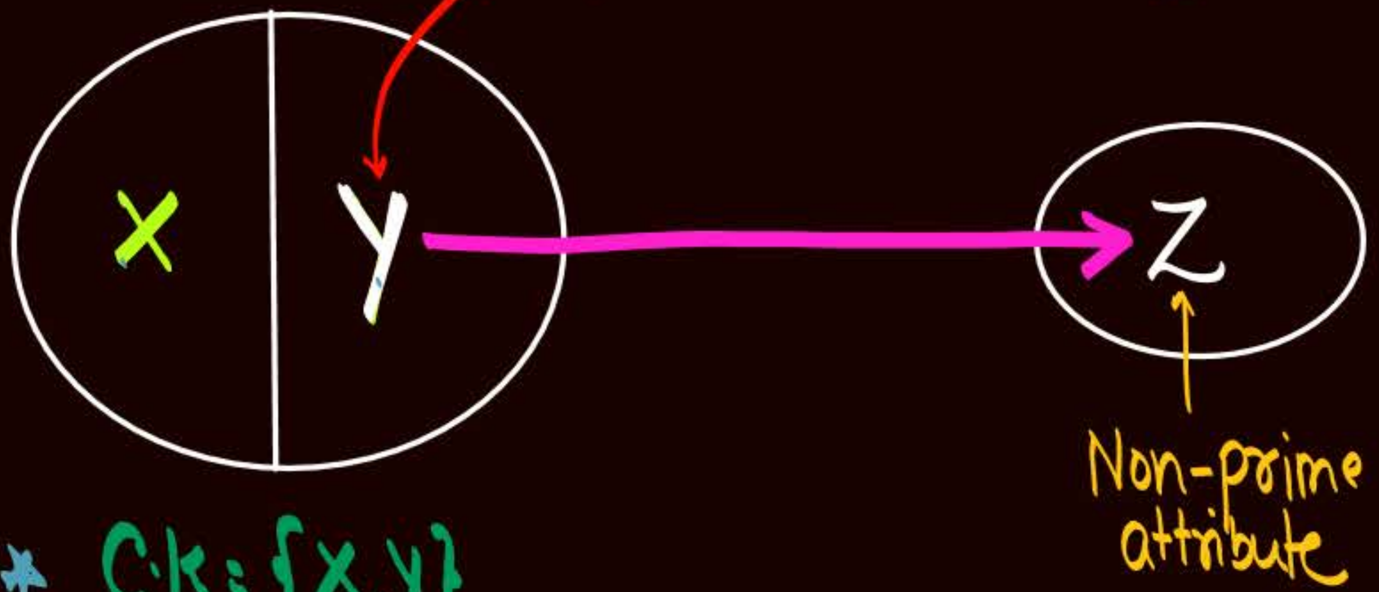
- A relation R is in 2NF if and only if,

  (1) R is in 1NF

  and (2) Relation R must not contain any $\underbrace{\text{Partial dependency}}$

Partial Functional dependency

Y is proper subset of C.K
{because (XY) is C.K}



* C.K = {X, Y}

if $Y \rightarrow Z$ exists, (or) { $X \rightarrow Z$ exists }
then $XY \rightarrow Z$ is
Partial functional dependency

* Let (XY) is the candidate key and 'Z' is some non-Prime attribute in relation R

1. If "Z" is fully dependent on candidate key {i.e, No proper subset of Candidate key can determine "Z"}, then
"$XY \rightarrow Z$" is called full functional dependency.

2. If proper subset of Candidate key {X, Y} can determine "Z", then
$XY \rightarrow Z$ is Called
Partial Functional dependency

* If type 1 functional dependency { Proper subset of C.K $\longrightarrow$ Non-prime attribute } exists in the relation, then Partial functional dependency exist in the relation.

∴ for 2NF,

1. Relation must be in 1NF

and 2. Relation must not contain any functional dependency of "type 1"

Topic : Third normal form (3NF)

A relation R is in 3NF if and only if,

1. R is in 1NF

and 2. Every non-trivial functional dependency $X \to Y$ must have,

X as a super key

(or)

Y as a prime attribute

In Type①, Type② & Type③ FDs neither X is a super key nor Y is a prime attribute.

∴ Type①, Type② & Type③ FDs are not allowed in 3NF

Note :- A relation R is in 3NF, only if $\underbrace{\text{transitive functional dependency}}$ does not excist in relation.

A functional dependency is called transitive FD if and only if non-prime attribut is transitively (Not directly) dependent on Candidate Key/Super Key.

$\boxed{C.K/S.K. \longrightarrow NPA_1}$

NPA is not transitively dependent on C.K/S.K.
∴ Not a transitive FD

$\boxed{\text{Not a } C.K \longrightarrow NPA_2}$

Not a C.K: PSCK (Type ①), (PSCK+NPA) (Type ②), NPA (Type ③)

NPA_2 is not directly dependent on CK/S.K
∴ Transitive FD

Topic : Boyce codd normal form (BCNF)

- A relation R is in BCNF if and only if, Every non-trivial functional dependency "$X \longrightarrow Y$" must have "X" as a super key.

#e.g. Given R(ABCDEF) and

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

Find the normal form of the relation.

CK = (AB), (DB)

Prime Attribute = {A, B, D}

Non-prime attributes = {C, E, F}

$\underbrace{AB}_{S.K} \longrightarrow CD$ ∴ Allowed up to BCNF

$C \longrightarrow E$

$NPA \longrightarrow NPA$

"Type-3"

Allowed in 2NF but not allowed in 3NF

Allowed up to 3NF but not allowed in BCNF

$\underbrace{D}_{\text{Proper subset of one C.K}} \longrightarrow \underbrace{A}_{\text{Proper subset of another C.K}}$

"Type-4" FD

$\underbrace{B}_{PSCK} \longrightarrow \underbrace{F}_{NPA}$

"Type-1"

Allowed in 1NF

Not allowed in 2NF

#e.g. Given R(ABCDEF) and

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

Find the normal form of the relation.

CK = (AB), (DB)

Prime Attribute = { A, B, D }

Non-prime attributes = { C, E, F }

FD	Highest Normal form satisfied by FD
$AB \rightarrow CD$	BCNF
$D \rightarrow A$	3NF
$C \rightarrow E$	2NF
$B \rightarrow F$	1NF

Least of the highest normal form satisfied by any of its FD is "1NF"

∴ Normal form of relation is '1NF'

Normal form of a relation will be the least of highest normal form satisfied by any of its FD.

#e.g. Given R(ABCDE) and F={AB→C, C→D, B→E }

CK = (AB)

N.P.A. = {C, D, E}

Find the normal form of the relation, and if relation is not already in BCNF then decompose the relation up to BCNF.

$$F: \begin{cases} \underset{S.K}{AB} \longrightarrow C & (BCNF) \\ \underset{NPA}{C} \xrightarrow[Type3]{} \underset{NPA}{D} & (2NF) \\ \underset{PSCK}{B} \xrightarrow[Type1]{} \underset{NPA}{E} & (1NF) \end{cases}$$

∴ Normal form of relation is 1NF

$F = \{AB \to C,\ C \to D,\ B \to E\}$

$R(ABCDE)$ is not in 2NF because of $B \to E$

$\therefore$ Decompose w.r.t. $B \to E$

$(BE)^+ = \{B, E\}$

added to make the decomposition lossless.

BCNF

$R_1(BE)$

$F_1 = \{ \underbrace{B}_{S.K} \to E \}$ (BCNF)

$CK = B$

2NF

$R_2(ABCD)$

$F_2 = \{ \underbrace{AB}_{SK} \to C$ (BCNF)

$\overset{NPA}{C} \to \overset{NPA}{D}$ (2NF) $\}$

$CK = AB$

Overall NF of database is 2NF + lossless + Dep. preserving

already in BCNF

Not in 3NF because of $C \to D$

$\therefore$ Decompose w.r.t. $C \to D$

$(CD)^+ = \{C, D\}$

for lossless

BCNF

$R_1(BE)$

$F_1 = \{ \underbrace{B}_{S.K} \to E \}$ (BCNF)

$CK = B$

BCNF

$R_3(CD)$

$F_3 = \{ \underbrace{C}_{SK} \to D \}$ BCNF

$CK = C$

BCNF

$R_4(ABC)$

$F_4 = \{ \underbrace{AB}_{SK} \to C \}$ BCNF

$CK = AB$

3NF + BCNF + lossless Join + Dep. preserving

$R(A\,B\,C\,D\,E)$ $\quad F = \{AB \to C,\ C \to D,\ B \to E\}$

$R_1(BE)$ $\quad R_2(CD)$ $\quad R_3(ABC)$

$F_1 = \{B \to E\}$ $\quad F_2 = \{C \to D\}$ $\quad F_3 = \{AB \to C\}$

#e.g. Given R(ABCDEF) and F={A→BCDEF, BC→ADEF, D→E , E→F}

Find the normal form of the relation, and if relation is not already in BCNF then decompose the relation up to BCNF.

CK: {A} & (BC)

$A \rightarrow BCDEF$ (BCNF)

$BC \rightarrow ADEF$ (BCNF)

$D \rightarrow E$ (2NF)

$E \rightarrow F$ (2NF)

$R(ABCDEF)$

Decompose w.r.t. $D \rightarrow E$

$(DE)^{+} = \{D, E, F\}$

$R_1(DEF)$

$F_1 = \{ \underset{SK}{D} \rightarrow E$ (BCNF)
$\overset{NPA}{E} \rightarrow \overset{NPA}{F}$ (2NF) $\}$

$CK = D$

$R_2(ABCD)$ — for lossless

$F_2 = \{ A \rightarrow BCD$ (BCNF)
$BC \rightarrow AD$ (BCNF) $\}$

$CK = A, (BC)$

2NF + Lossless + Dep. preserving

Not in 3NF because of $E \rightarrow F$

∴ Decompose w.r.t. $E \rightarrow F$

$\{EF\}^{+} = \{E, F\}$

$R_3(EF)$

$F_3 = \{E \rightarrow F$ (BCNF) $\}$

$CK = E$

$R_4(DE)$ — for lossless

$F_4 = \{D \rightarrow E$ (BCNF) $\}$

$CK = D$

3NF + BCNF + lossless + Dep preserving

#e.g. Given R(ABCD) and F={AB→C, BC→D}

Find the normal form of the relation, and if relation is not already in BCNF then decompose the relation up to BCNF.

CK = (AB)

$\underbrace{AB}_{S.K} \longrightarrow C$ (BCNF)

$BC \longrightarrow D$ (2NF)

(PSCK + NPA) ⟶ (NPA)

"Type 2"

R(ABCD)

Decompose w.r.t. BC ⟶ D

$(BCD)^+ = \{B, C, D\}$

$R_1(BCD)$

$F_1 : \{ \underbrace{BC}_{SK} \longrightarrow D$ (BCNF) $\}$

CK = (BC)

$R_2(A\,\overbrace{BC}^{\text{for lossless}})$

$F_2 : \{ \underbrace{AB}_{SK} \longrightarrow C$ (BCNF) $\}$

CK = AB

3NF + BCNF + lossless + Dep. Preserving

H.W. ~~#e.g.~~ Given R(ABCDEFGHIJ) and F={AB→C, A→DE, B→F, F→GH, D→IJ}

Find the normal form of the relation, and if relation is not already in BCNF then decompose the relation up to BCNF.

H.W.

#e.g. Given R(ABDLPT) and $F=\{B \to PT, T \to L, A \to D\}$

Find the normal form of the relation, and if relation is not already in BCNF then decompose the relation up to BCNF.

2 mins Summary

Topic Normal forms

Topic Decomposition of relation up to BCNF

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THANK - YOU

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