Computer Science & IT

Database Management System

Relational Model & Normal Forms

Lecture No. 14

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Recap of Previous Lecture

Topic — Redundancy in relation because of FD

Topic — Second normal form (2NF)

Topic — Third normal form (3NF)

Topic — Boyce codd normal form (BCNF)

Topic — Decomposition of relation

Slide

Topics to be Covered

Topic Decomposition of relation

#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.

$$C.K = A, BC$$

$$P.A = \{A, B, C\}$$

$$N.P.A = \{D, E, F\}$$

$$A \longrightarrow BCDEF \ (BCNF)$$
$$\text{S.K}$$

$$BC \longrightarrow ADEF \ (BCNF)$$
$$\text{S.K}$$

$$D \longrightarrow E \quad (2NF)$$
$$\text{N.P.A} \qquad \text{N.P.A.}$$

$$E \longrightarrow F \quad (2NF)$$
$$\text{N.P.A} \qquad \text{N.P.A}$$

$R(A,B,C,D,E,F)$
Not in 3NF because of $D \rightarrow E$ & $E \rightarrow F$

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

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

for lossless Join

$R_1(E,F)$ BCNF

$F_1 = \{E \rightarrow F\}$ BCNF

    s.k

c.k :: E

$R_2(A,B,C,D,E)$

$F_2 = \left\{ \begin{array}{l} A \rightarrow BCDE \; (BCNF) \\ BC \rightarrow ADE \; (BCNF) \\ D \rightarrow E \end{array} \right\} (2NF)$

   N.P.A   N.P.A

c.k : A, BC

2 NF

overall normal
form of DB = 2NF
+
lossless Join
decomposition
+
Dep. preserving
decomposition

$R_2(A,B,C,D,E)$ is not in 3NF
because of $D \rightarrow E$
∴ Decompose w.r.t. $D \rightarrow E$

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

for lossless

$R_1(E,F)$ BCNF

$F_1 = \{E \rightarrow F\}$ BCNF

    s.k

c.k :: E

$R_3(D,E)$

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

    s.k

BCNF

CK = D

$R_4(A,B,C,D)$

$F_4 = \left\{ \begin{array}{l} A \rightarrow BCD \; (BCNF) \\ BC \rightarrow AD \; (BCNF) \end{array} \right.$
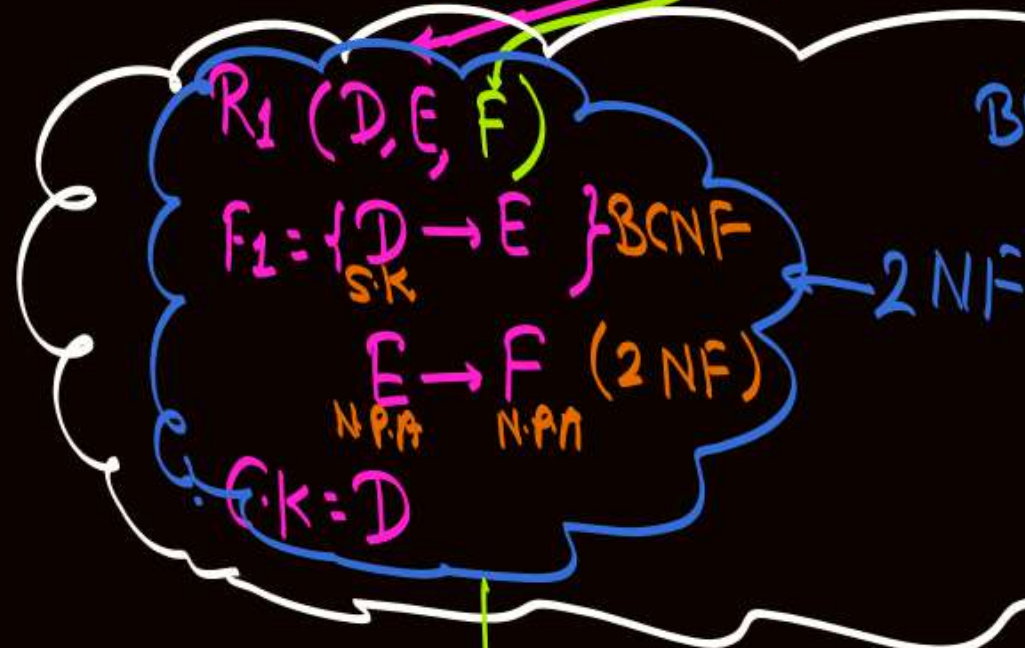
BCNF

c.k = A, BC

3NF + BCNF
lossless Join
+
Dep. preserving

$R(A,B,C,D,E,F)$
Not in 3NF because of $D \to E$ & $E \to F$

Decompose w.r.t. $D \to E$
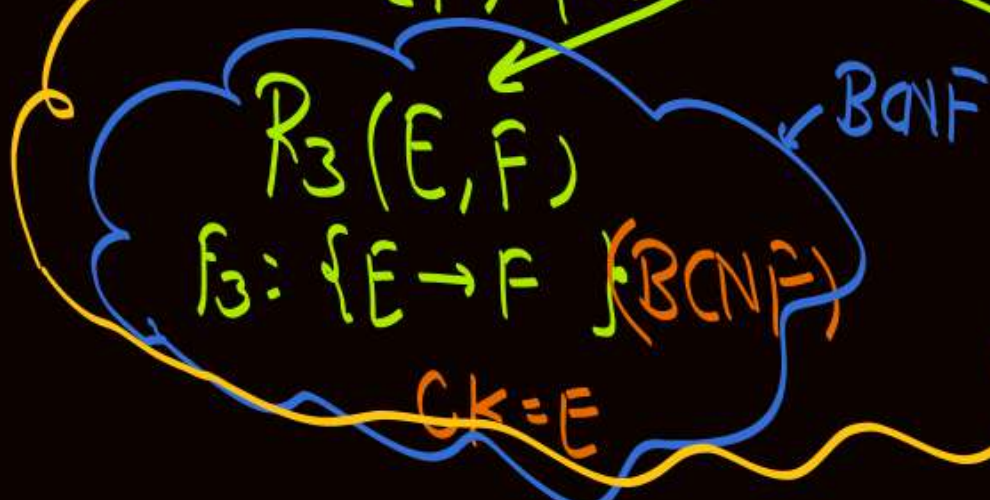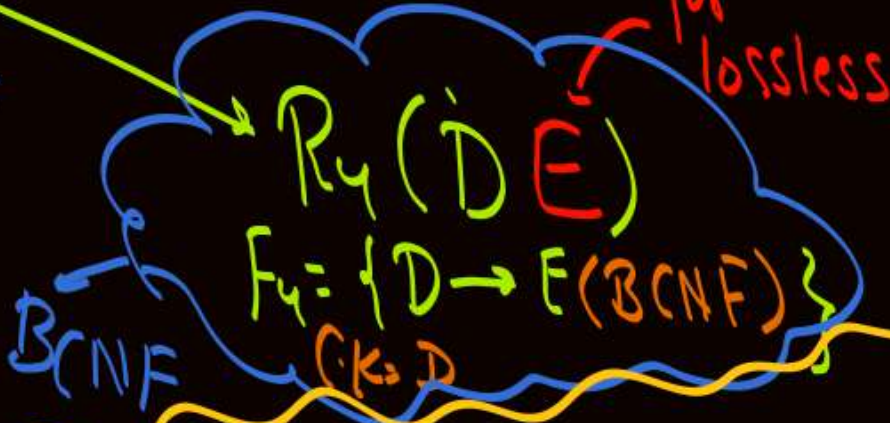
$(DE)^+ = \{D,E,F\}$

for lossless

$R_1(D,E,F)$

$F_1 = \{D \to E\}$ BCNF
S.K

$E \to F$ (2NF)
N.P.A   N.P.A

2NF

C.K = D

BCNF

$R_2(A,B,C,D)$

$F_2 = \{\begin{array}{l} A \to BCD \ (BCNF) \\ BC \to AD \ (BCNF) \end{array}$

C.K = A, BC
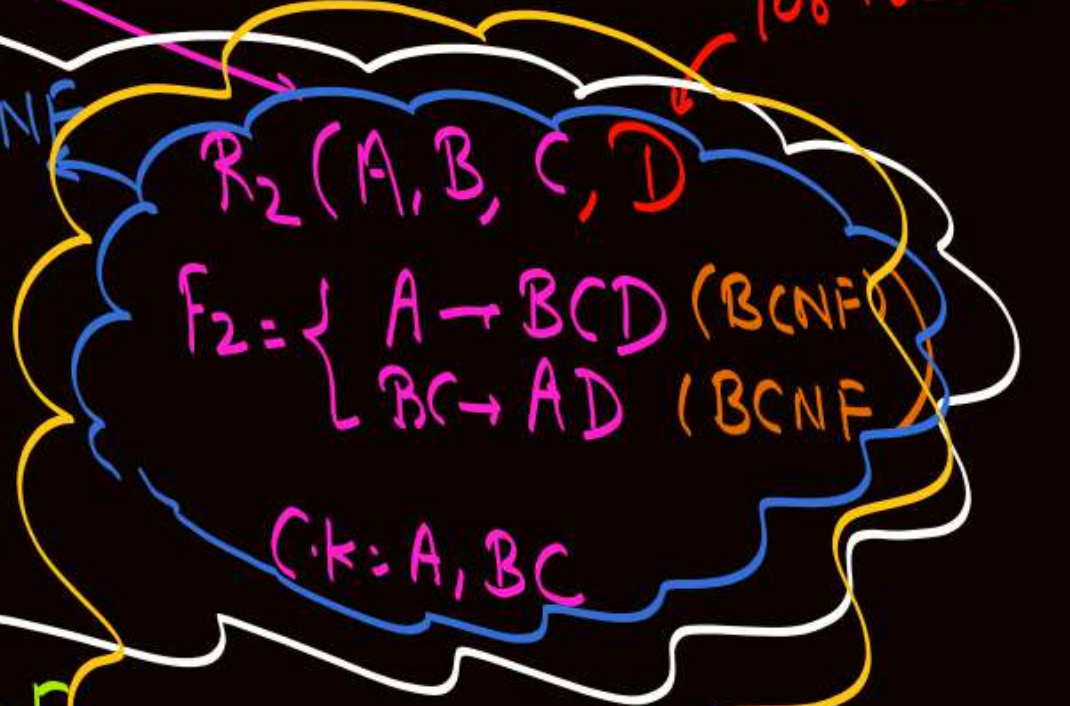
Not in 3NF because of $E \to F$
∴ Decompose w.r.t. $E \to F$

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

$R_3(E,F)$

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

BCNF

C.K = E

for lossless

$R_4(D,E)$

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

C.K = D

BCNF

BCNF + 3NF
+
lossless join decomposition
+
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.

$C.K = AB$

$P.A. = \{A, B\}$

$N.P.A. = \{C, D\}$

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

$\underbrace{BC}_{(P.S.C.K \;+\; N.P.A)} \longrightarrow \underbrace{D}_{(N.P.A.)} \; (2\,NF)$

Relation is in 2NF

Case ②
{ Allowed in 2NF
but, not allowed in 3NF }

$R(A, B, C, D)$
not in 3NF because of $BC \rightarrow D$
$\therefore$ Decompose w.r.t. $BC \rightarrow D$

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

for lossless

overall
Normal Form = BCNF+3NF
$+$
Lossless join
$+$
Dep. Preserving

$R_1(B\ C\ D)$ — BCNF — BCNF — $R_2(A,\ B,\ C)$

$f_1 = \{\ \underset{s.k}{BC} \longrightarrow D\ (BCNF)\}$

$C.K = BC$

$F_2 = \{\ \underset{s.k}{AB} \longrightarrow C\ (BCNF)\}$

$C.K = AB$

#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.

$CK = AB$

$P.A. = \{A, B\}$

$N.P.A = \{C, D, E, F, G, H, I, J\}$

$$\left\{ \begin{array}{l} \underset{SK}{AB} \to C \; (BCNF) \\ \underset{PSCK}{A} \to \underset{N.P.A}{DE} \; (1\,NF) \\ \underset{PSCK}{B} \to \underset{N.PA}{F} \; (1\,NF) \\ \underset{NPA}{D} \to \underset{NPA}{IJ} \; (2\,NF) \\ \underset{NPA}{F} \to \underset{NPA}{GH} \; (2\,NF) \end{array} \right.$$

Normal form of relation is 1 NF

$R(A B C D E F G H I J)$

Not in 2NF bcoz of $A \to DE$ & $B \to F$
let us first decompose w.r.t. $A \to DE$

$(ADE)^+ = \{A, D, E, I, J\}$

for lossless

$R_1(A, D, E, I, J)$

$F_1 = \{ \begin{array}{l} A \to DE \ (BCNF) \\ D \to IJ \ (2NF) \end{array}$ 2NF

C.K: A

$R_2(A, B, C, F, G, H)$

1NF

$F_2 = \{ \begin{array}{l} AB \to C \ (BCNF) \\ PSCK \ B \to F \ (1NF) \\ NPA \ F \to GH \ (2NF) \\ NPA \end{array}$

C.K: AB

1NF
+
lossless Join
+
Dep. preserving

Not in 2NF because of $B \to F$
∴ Decompose w.r.t $B \to F$

$(BF)^+ = \{B, F, G, H\}$

2NF
+
lossless join
+
Dep. preserving

$R_5(DIJ)$

$F_5 \{ D \to IJ \}$ BCNF
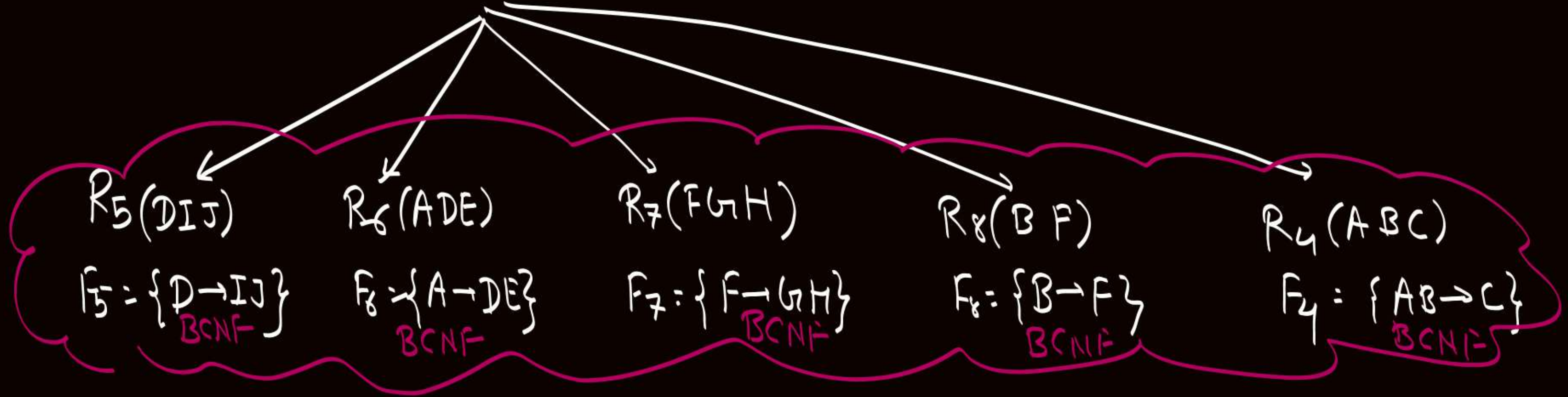
CK: D

$R_6(ADE)$

$F_6 \{ A \to DE \}$ BCNF

C.K: A

$R_3(B, F, G, H)$

$F_3 = \{ \begin{array}{l} B \to F \ (BCNF) \\ F \to GH \ (2NF) \end{array}$

Ck: B

$R_4(ABC)$

for lossless

$F_4 = \{ AB \to C \ (BCNF) \}$

CK: AB

$R_7(FGH)$

$F_7 = \{ F \to GH \}$ BCNF

CK: F

$R_8(BF)$

$F_8 = \{ B \to F \}$ BCNF

CK: B

$$R(ABCDEFGHIJ)$$

$R_5(DIJ)$

$F_5 = \{D \rightarrow IJ\}$

BCNF

$R_6(ADE)$

$F_6 = \{A \rightarrow DE\}$

BCNF

$R_7(FGH)$

$F_7 = \{F \rightarrow GH\}$

BCNF

$R_8(BF)$

$F_8 = \{B \rightarrow F\}$

BCNF

$R_4(ABC)$

$F_4 = \{AB \rightarrow C\}$

BCNF

BCNF + 3NF
+
lossless join
+
Dep. preserving

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

NPA (over B→PT), NPA NPA (over T→L), NPA (over A→D)

PSCK ↓   ↓   PSCK ↓

1NF   2NF   1NF

Find the normal form of the relation, and if relation is not already in

BCNF then decompose the relation up to BCNF. $CK := AB$

R(ABDLPT) is not in 2NF Because of $B \to PT$ & $A \to D$

Decompose w.r.t $A \to D$

$(AD)^+ = \{A, D\}$

for lossless

$R_1(AD)$ BCNF

$F_1 = \{A \to D\}$ BCNF

C.K := A

1 NF $R_2(ABLPT)$, $F_2 := \begin{cases} B \to PT & (1NF) \\ T \to L & (2NF) \end{cases}$

C.K := (AB)

$(BPT)^+ = \{B, P, T, L\}$ Decompose w.r.t $B \to PT$

for lossless

2NF

$R_3(BPTL)$

$f_3 := \begin{cases} B \to PT & (BCNF) \\ T \to L & (2NF) \end{cases}$

C.K := B

$R_4(AB)$

$f_4 = \{it\ will\ be\ Empty\}$

Decompose w.r.t $T \to L$
& it will be in
BCNF

$R_5(BPT)$ $R_6(TL)$
$B \to PT$ $T \to L$

$R_4 (AB)$
is a sub-relation
with Empty FD set
$F_4 = \{ \quad \}$

C.k = (AB)

→ If there exist a
non-trivial FD $X \rightarrow y$
in which 'X' is not a S.k
then it causes redundancy.

↓

But if there is no
non-trivial FD, then there
will be 0% redundancy
because functional dependencies

↓

No redundancy because of FD
∵ A relation with Empty FD set
will always be in BCNF

it is in
BCNF

(i) If there are
no non-trivial FDs
in FD set of a relation,
then candidate key of that
relation will be formed by
combining all the attributes
of that relation

#e.g.   Given R(ABCDE) and F:{A→BC, CD→E, B→D, E→A}

S.k — A→BC — BCNF

S.k — CD→E — BCNF

P.S. of one C.k — B→D — P.S of another C.k — 3NF

S.k — E→A — BCNF

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

C.k = A, E, CD, BC

$R(ABCDE)$

Not in **BCNF** because of $B \to D$

∴ Decompose w.r.t $B \to D$

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

for lossless join

BCNF

$R_1(BD)$

$F_1 = \{B \to D \text{ (BCNF)}\}$

$Ck : B$

$R_2(ABCE)$

$F_2 = \begin{cases} A \to BC \text{ (BCNF)} & A \to BCE \\ E \to A \text{ (BCNF)} & E \to ABC \\ & BC \to AE \end{cases}$

$Ck : A, E$

BCNF
+
Lossless Join ✓

∴ Not dep preserving

BCNF
+
lossless join decomposition
+
Dep. preserving

To Preserve $CD \to E$
We can create a new
sub-relation $R_3(CDE)$

$R_3(CDE)$

$F_3 = CD \to E$ BCNF

$Ck : CD$

$(CD)^+$ w.r.t $F_1 \cup F_2 = \{C, D\}$
$E \notin (CD)^+$ w.r.t. $F_1 \cup F_2$

Note:- While decomposing a relation into BCNF, and we loose some functional dependency then we will try to preserve those functional dependencies by creating new sub-relations w.r.t. those functional dependencies, if possible.

important

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

$\underset{\text{S.K}}{AB}$ → CD (P.S.CK, BCNF), $\underset{\text{PSCK}}{D}$→A (3NF)

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

C.K = (AB), (DB)

$R(ABCD)$ is not in BCNF because of $D \to A$

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

$(DA)^+ = \{D, A\}$

for lossless

$R_1(DA)$

$F_1 = \{D \to A \text{ (BCNF)}\}$

$Ck: D$

$R_2(BCD)$

$F_2 = \{\underset{sk}{BD} \to C\}$ BCNF

$Ck: BD$

BCNF
+
lossless Join
+
But not dep.
Preserving

To Preserve $AB \to CD$
we can not create a
sub-relation $R'(ABCD)$
because $D \to A$ will also
exist in $R'(ABCD)$
And hence sub-relation will remain in 3NF
i.e, Normal form will not improve to BCNF

$(AB)^+$ w.r.t. $F_1 \cup F_2 = \{A, B\}$
$\therefore AB \to CD$ is lost

W.r.t. Relation   R(ABCD)
$\&$ FDset F = { AB → CD, }
                  D → A

→ Dep. preserving decomposition
   into BCNF
      is not possible

① We can always ensure Lossless join decomposition While decomposing a relation upto BCNF.

② We can always ensure dependency perserving decomposition While decomposing a relation upto 3NF.

But while trying to decompose a relation into BCNF some times it may not be possible to preserve some of the functional dependencies.

③ Upto 3NF we can ensure both lossless join decomposition as well as dependency preserving decomposition { During BCNF decomposition we may loose some FDs }

∴ Most adequate normal form of database is 3NF.

Topic Decomposition of relation