Membership test :-

$X \rightarrow Y$ FD member of FD set(F) X^+ must determine Y in FD set(F).

$$F = \{ \cdots\cdots \} \leftarrow X \rightarrow Y$$

$$X^+ = \{ \cdots\cdots Y \cdots \} \text{ then } X \rightarrow Y \in F$$

eg:- $\{AB \rightarrow C, BC \rightarrow D, CD \rightarrow E, E \rightarrow F\}$ Test FD's member of FD set ?

(i) $AB \rightarrow F$ ✓

$$(AB)^+ = \{A, B, C, D, E, F\}$$

(ii) $BCG \rightarrow E$ ✓

$$(BCG)^+ = \{B, C, G, D, E, F\}$$

(iii) $BC \rightarrow A$ ✗

$$(BC)^+ = \{B, C, D, E, F\}$$

(A) absent

Equality test:-

F & G are FD sets, F&G are equal iff

(i) F covers G :- Every FD of G, must member of F
$F \supseteq G$

(ii) G covers F :- Every FD of F, must be member of G
$G \supseteq F$

i.e $(F \supseteq G \text{ and } G \supseteq F) \rightarrow (F \equiv G)$

NOTE:-

F covers G	G covers F	Result
Yes	Yes	$G = F$
Yes	No	$F \supset G$
No	Yes	$G \supseteq F$
No	No	F&G not comparable

Q. $F = \{A \rightarrow B,\ B \rightarrow C,\ C \rightarrow A\}$

$G = \{A \rightarrow BC,\ B \rightarrow AC,\ AB \rightarrow C,\ BC \rightarrow A\}$

(a) $F \subset G$ (b) ✓ $F \supset G$ (c) $F \equiv G$ (d) None

since F covers G but G doesn't covers F
$\{C \rightarrow A\}$

F covers G : True

$F \supseteq G$

F	G
$A \to B$	$A \to BC$ ✓
$B \to C$	$B \to AC$ ✓
$C \to A$	$AB \to C$ ✓
	$BC \to A$ ✓

G covers F : False

$G \not\supseteq F$

G	F
$A \to BC$	$A \to B$ ✓
$B \to AC$	$B \to C$ ✓
$AB \to C$	$C \to A$ ✗
$BC \to A$	

Q. $F = \{A \to BC,\ BC \to AB,\ B \to F,\ D \to E\}$

$G = \{A \to BCDEF,\ BC \to ADEF,\ B \to F,\ BCD \to E,\ D \to E\}$

$G \supseteq F$ = True & $F \supseteq G$ = True

so $(F = G)$

Properties of Decomposition :-

(i) Loss Less join Decomposition

(ii) Dependency Preserving Decomposition

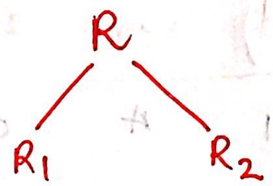
(i) Loss Less join :-

Relational schema 'R' with instance 'r' decomposed into subrelations $R_1, R_2, \ldots R_n$

In general $\{R_1 \bowtie R_2 \bowtie \ldots R_n\} \geq r$

if $\{R_1 \bowtie R_2 \bowtie \ldots R_n\} = r$ Loss Less Join

if $\{R_1 \bowtie R_2 \bowtie \ldots R_n\} \supset r$ Lossy Join



(i) $R_1 \bowtie R_2 = R$ possible (Loss Less)

(ii) $R_1 \bowtie R_2 \supset R$ possible (Lossy)

(iii) $R_1 \bowtie R_2 \subset R$ Not possible

NOTE :- in $(R_1 \bowtie R_2) \longrightarrow \forall$ tuples $\in R_1$ Joined to $\forall$ tuples of R_2 which have common attributes eg:-

$Sid \rightarrow Sname$

$CK = \{Sid \ \ Cid\}$

R

Sid	Sname	Cid
S_1	A	C_1
S_1	A	C_2
S_2	B	C_2
S_3	B	C_3

decomposition

R_1

Sid	Sname
S_1	A
S_2	B
S_3	B

R_2

Sid	Cid
S_1	C_1
S_1	C_2
S_2	C_2
S_3	C_3

Join

$R_1 \bowtie R_2$

Sid	Sname	Cid
S_1	A	C_1
S_1	A	C_2
S_2	B	C_2
S_3	B	C_3

Since, $R_1 \bowtie R_2 = R$ so, Loss Less Join eg:

$sid \rightarrow sname$

$CK = \{sid\ cid\}$

R

sid	sname	cid
s_1	A	c_1
s_1	A	c_2
s_2	B	c_2
s_3	B	c_3

decomposition

R_1

sid	sname
s_1	A
s_2	B
s_3	B

R_2

sname	cid
A	c_1
A	c_2
B	c_2
B	c_3

Join

$R_1 \bowtie R_2$

sid	sname	cid
s_1	A	c_1
s_1	A	c_2
s_2	B	c_2
s_2	B	c_3
s_3	B	c_2
s_3	B	c_3

As $R_1 \bowtie R_2 \supset R$

so <u>Lossy Decomposition</u>

spurious tuples {causes Inconsistency}

NOTE :-

if
Relational schema R with FD set (F) decomposed into sub relation R_1 and R_2 then

R_1: attr R_2: attr

(I) Decomposition loss less join :-

iff (i) $R_1 \cup R_2 = R$ (attr should'nt be lost)

(ii) $\underset{\text{common attr}}{(R_1 \cap R_2)} \rightarrow \underset{\text{all attr}}{R_1}$

OR

$\underset{\text{common attr}}{(R_1 \cap R_2)} \rightarrow \underset{\text{all attr}}{R_2}$

(common attr should be CK or SK for any one of relation R_1 or R_2)

Q. $R(ABCDE) = \{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$ Test given decomposition Loss less join ?

(i) $R_1(AB\underline{C}) \bowtie R_2(\underline{C}D)$ ✗

common attr = C which is not SK/CK for R_1 or R_2

(ii) $R_1(ABC) \bowtie R_2(DE)$ ✗

No common attributes.

(iii) $R_1(ABC) \bowtie R_2(CDE)$ X

$R_1 \cap R_2 = C$ and $C^+ = \{\cancel{E}, D\}$

C is not SK/CK for R_1 or R_2

(iv) $R_1(ABC) \bowtie R_2(BE)$ ✓

$R_1 \cap R_2 = B$ and $B^+ = \{B, E\}$

so, B is CK for R_2 so it is Loss Less

Q. $R(ABCDEFGH) = \{AB \to C, BC \to A, AC \to B, B \to D, D \to EF, F \to GH\}$

decomposed into

(i) $R_1(ABC)$ $R_2(FGH)$ $R_3(BD)$ $R_4(DEF)$

$R_1 \cup R_2 \cup R_3 \cup R_4 = R$ (no attributes is missed)

if $(R_i \cap R_j \to R_i / R_j)$ then $R_i \bowtie R_j$ is Loss Less join

$R_1(ABC) \bowtie R_3(BD)$; $B^+ = \{B, D, E, F, G, H\}$

so, B is SK for R_3

so $R_1 \bowtie R_3$ is LL

$R_{13}(ABCD)$

- $R_{13}(ABC\underline{D}) \bowtie R_4(\underline{D}EF)$ & $D^+ = \{D, E, F, G, H\}$

so, D is SK for R_4

then $R_{13} \bowtie R_4 = \boxed{R_{134}(ABCDEF)}$

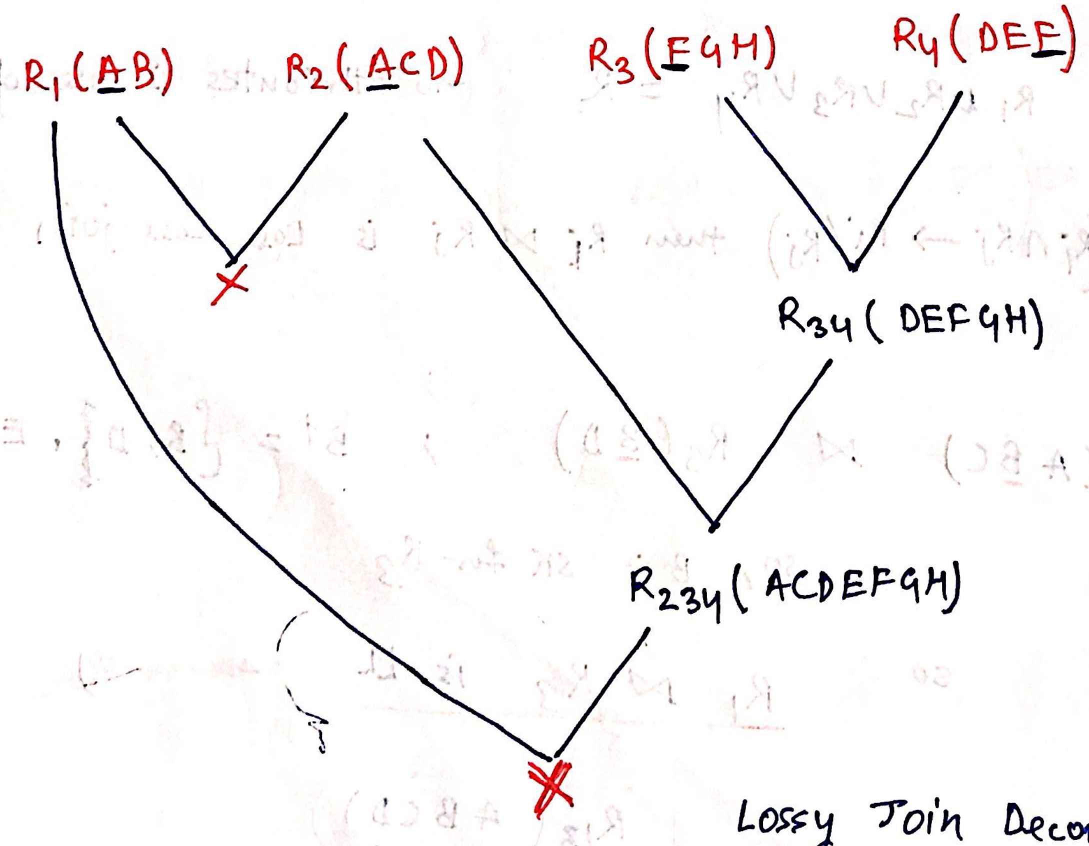
- $R_{134}(ABCDE\underline{F}) \bowtie R_2(\underline{F}GH)$ & $F^+ = \{F, G, H\}$

so F is SK for R_2 then

$R_{134} \bowtie R_2 = \boxed{R_{1342}(ABCDEFGH)}$

Hence decomposition is loss less join.

(ii)



Lossy Join Decomposition

(ii) Dendency Preserving decomposition :-

Relation schema 'R' with FD set 'F' decomposed into subrelation $R_1, R_2, R_3, \ldots\ldots R_n$ with FD sets $F_1, F_2, F_3, \ldots\ldots F_n$ respectively

In general,

$$\{F_1 \cup F_2 \cup \ldots\ldots F_n\} \subseteq F$$

if $\{F_1 \cup F_2 \cup \ldots\ldots F_n\} = F$ then dependency preserving

if $\{F_1 \cup F_2 \cup \ldots\ldots F_n\} \subset F$ then not dependency preserving

R with FD set $F = \{\ldots\ldots\}$

R_1: $F_1 = \{\ldots\ldots\}$

R_2: $F_2 = \{\ldots\ldots\}$

(i) $\{F_1 \cup F_2\} = F$ DP decomposition

(ii) $\{F_1 \cup F_2\} \subset F$ not DP decomposition

(iii) $\{F_1 \cup F_2\} \supset F$ (Not possible)

FD's F_1 and F_2 of R_1 and R_2 (decomposed relation) are not given so we have to find them:

Procedure to find FD's of sub rel^n :-

$R(\ldots\ldots) = F(\ldots\ldots)$

Assume R_1 one sub rel^n : $R_1(X, Y, Z)$ & $F_1 = \{ \text{———} \}$

check closures for each combination of (XYZ) –

$X^+ = \{ \ldots\ldots Y \ldots \} \Rightarrow X \rightarrow Y$

$Y^+ = \{ \ldots\ldots \} \Rightarrow$ No FD

$Z^+ = \{ \ldots \} \Rightarrow$ No FD

$(XZ)^+ = \{ \ldots Y \ldots \} \Rightarrow XZ \rightarrow Y$

$(YZ)^+ = \{ \ldots X \ldots \} \Rightarrow YZ \rightarrow X$

$(XY)^+ = \{ \ldots\ldots \} \Rightarrow$ No FD

so $\left(F_1 = \{ X \rightarrow Y, XZ \rightarrow Y, YZ \rightarrow X \} \right)$

Q. $R(ABCDE) = \{ A \rightarrow B, B \rightarrow C, C \rightarrow D, D \rightarrow BE \}$

decomposed into :

Check for dependency preservation –

$R_1(AB)$ $R_2(BC)$ $R_3(CD)$ $R_4(DE)$

$R_1(AB)$	$R_2(BC)$	$R_3(CD)$	$R_4(DE)$
$A^+ = \{A, \underline{B}\}$	$(B \to C)$	$(C \to D)$	$(D \to E)$
$(A \to B)$	$C^+ = \{C, D, \underline{B}, E\}$	$(D \to C)$	
$B^+ = \{B, C, D, E\}$	$(C \to B)$		
(F_1)	(F_2)	(F_3)	(F_4)

$$\underbrace{\quad\quad\quad\quad\quad\quad\quad\quad}_{\text{Non-trivial FD's}}$$

so, every FD's of relation R is member of sub Relation

$$\underline{(F_1 \cup F_2 \cup F_3 \cup F_4) = F}$$

DP decomposition

Q: $R(ABCD) = \{AB \to CD,\ D \to A\}$ decomposed into $\{ABC, AD, BCD\}$ test DP decomposition?

$R_1(ABC)$	$R_2(AD)$	$R_3(BCD)$
$(AB \to C)$	$(D \to A)$	$(BD \to C)$
F_1	F_2	F_3

$F = \{ AB \to C, \underline{AB \to D}, D \to A \}$

$F_1 \cup F_2 \cup F_3 = \{ AB \to C, D \to A \}$

so, $(F_1 \cup F_2 \cup F_3 \subset F)$ Not DP decomposition

Canonical Cover :-

- Also known as Minimal cover

Minimal cover of FD set (F) is minimal set of FD's which are equal to F (Non-redundant FD set which is equal to F).

$F = \{ A \to B, B \to C, \cancel{A \to C}, \cancel{AC \to B}, B \to B \}$

$\boxed{F_m = \{ A \to B, B \to C \}}$

- as $A \to B$ and $B \to C$ $\Rightarrow A \to C$
- $A \to B \Rightarrow AC \to BC$ $\hookrightarrow AC \to B$
- $B \to B$ (trivial)

Procedure to find minimal cover:-

Given FD set (F) :

(i) Remove extraneous Attributes from each determinant [LHS of FD] of FD set (F).

eg: $WXY \to Z$ and $W^+ = \{ \dots X \dots \}$

extraneous Attr

i.e $W \to X$

so, $\{ABC \to D, A \to B\} \equiv \{AC \to D, A \to B\}$

$\{PQ \to R, Q \to P\} = \{Q \to R, Q \to P\}$

(ii) Remove Redundant FD's from FD set (F).

i.e $X \to Y$ FD of FD set (F) is redundant iff $X \to Y$ must be a member of $\{F - (X \to Y)\}$

$F = \{ A \to B, B \to C, \cancel{A \to C} \}$

$A \to C$ is still member of F so,

$A \to C$ is redundant

Q. $F = \{AB \to CD,\ BC \to DEF,\ CD \to F,\ ABD \to E\}$, find minimal cover of FD set (F).

$$\left.\begin{array}{l} AB \to CD \\ BC \to DEF \\ CD \to F \\ ABD \to E \\ AB \to D \end{array}\right\} \xrightarrow{\text{Remove extraneous attr}} = \left\{\begin{array}{l} AB \to CD \\ BC \to DEF \\ CD \to F \\ AB \to E \end{array}\right.$$

split

$AB \to C$

× $AB \to D$ —— $(AB)^+ = \{A, B, C, D, E, F\}$

$BC \to D$

$BC \to E$ —— $(BC)^+ = \{B, C, D, F\}$

× $BC \to F$

$CD \to F$

× $AB \to E$

$$\left[\text{Minimal cover} = \{AB \to C,\ BC \to DE,\ CD \to F\}\right]$$

Q. $F = \{A \to BC,\ CD \to E,\ E \to C,\ D \to AH,\ ABH \to BD,\ DH \to BC\}$

Find minimal cover

$A \to B$

$A \to C$

$CD \to E$

$E \to C$

$D \to A$

$D \to H$

$$\left.\begin{array}{lll} ABH \to B & \Rightarrow & AH \to B \\ ABH \to D & \Rightarrow & AH \to D \\ DH \to B & \Rightarrow & D \to B \\ DH \to C & \Rightarrow & D \to C \end{array}\right\} \text{removing extraneous attr}$$

$A \to B$

$A \to C$

$CD \to E$

$E \to C$

$D \to A$

$D \to H$

$\cancel{AH \to B}$ — $A \to B$ so $AH^+ = \{\ldots B \ldots\}$

$AH \to D$

$\cancel{D \to B}$ — $D \to A$ and $A \to B$

$\cancel{D \to C}$ — $D \to A$ and $A \to C$

Minimal cover $= \{A \to BC,\ CD \to E,\ E \to C,\ D \to AH,\ AH \to D\}$

Q. Find minimal cover of $\{A \to BCD,\ BC \to AD\}$

$A \to B$

$A \to C$

$A \to D$

$BC \to A$

$BC \to D$

] — no extraneous attributes

so, remove redundant FD's:-

$\cancel{A \to D}$ as $A \to BC$ & $BC \to D$

Minimal cover $= \{A \to BC,\ BC \to AD\}$

OR

~~BC → D~~ = as BC → A and A → D

so we have two minimal covers

$$\begin{pmatrix} A \to BC \\ BC \to AD \end{pmatrix} \qquad \begin{pmatrix} A \to BCD \\ BC \to D \end{pmatrix}$$

NOTE:- Minimal cover of FD set F may not be unique but all minimal covers are logically equal which also equal to given FD set (F).

Normal Forms :-

Used to identify degree of redundancy and also used to eliminate redundancy.

Over FD ($X \to Y$)

1NF
⇓
2NF
⇓
3NF
⇓
BCNF

0% dependency over single value FD

Over MVF ($X \to\to Y$)

BCNF
⇓
4 NF

0% dependency over MVD

Redundancy in Relational schema

Over Non trivial FD

$X \rightarrow Y$

[Single value Dependency]

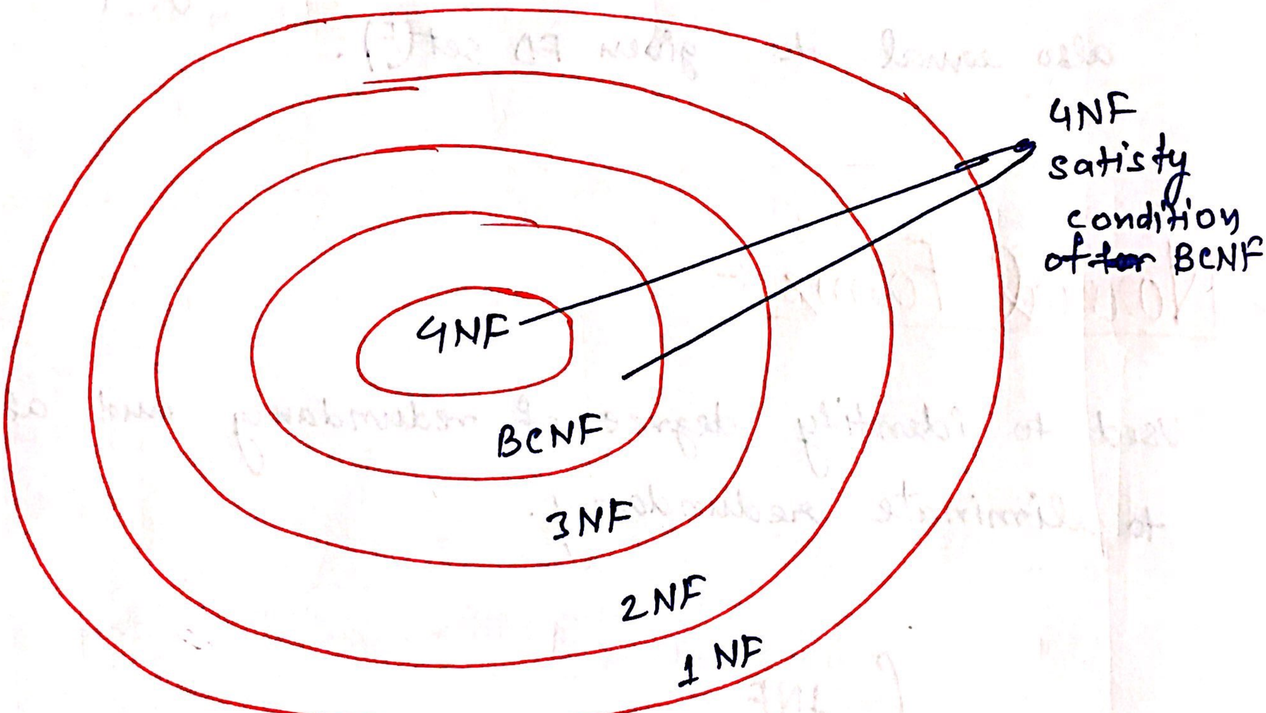
To eliminate redundancy of FD's of relⁿ schema, schema should decomposed into BCNF

Over Non-trivial MVD

$X \rightarrow\rightarrow Y$

[Multi Valued Dependency]

To eliminate redundancy over MVD's, relⁿ schema should decomposed into 4NF



(i) 1 - NF :-

- Default NF of RDMS table

- Relation R in 1-NF iff no multivalued attribute in R. (Every attribute of R must be Atomic/ Single valued)

Multivalued attribute:- Set of values over attribute for some record

FD: Sid → Sname

R

Sid	Sname	Cid
s_1	A	c_1/c_2
s_2	B	c_2
s_3	B	c_3

Multivalue attr

⇓ 1NF design

design candidate keys by using FD set

FD: Sid → Sname

R

Sid	Sname	Cid
s_1	A	c_1
s_1	A	c_2
s_2	B	c_2
s_3	B	c_3

(CK: Sid Cid)

Multivalue attr. added to sid For CK

" MV attribute is added to PK to make CK of 1NF relation" eg:-

multivalued attr

PK

R

Sid	Sname	DOB	Cid	Phone	Email
S_1	A	1995	c_1/c_2	$P_1/P_2/P_3$	$E_1/E_2/E_3$
			2	* 3	* 3
S_2	B	1994	c_1/c_3	$P_4/P_5/P_6$	E_4/E_5
			2	* 3	* 2

18 cases

12 cases

1NF design

(CK : Sid Cid Phone Email)

R

	Sid	Sname	dob	Cid	Phone	Email
1	S_1	A	1995	c_1	P_1	E_1
2	S_1	A	1995	c_1	P_1	E_2
⋮	⋮	⋮	⋮	⋮	⋮	⋮
18	S_1	A	1995	c_2	P_3	E_3
19	S_2	B	1994	c_1	P_4	E_4
⋮	⋮	⋮	⋮	⋮	⋮	⋮
30	S_2	B	1994	c_3	P_6	E_5

18 tuples

12 tuples

All combination of MVattr

redundancy

NOTE:- Degree of Redundancy is very high in 1NF relⁿ

- 1NF is only default RDBMS table

- Condition to reduce or eliminate redundancy are starts from 2NF.

NOTE :-

Redundant FD's	Non Redundant FD's
$X \rightarrow Y$ is Non-trivial & X is not superkey	$X \rightarrow Y$ is Trivial FD or X is superkey

R_1

Sid	Sname	Cid
S_1	A	C_1
S_1	A	C_2
S_1	A	C_3
S_2	B	C_1

Not CK

FD = { Sid → Sname }

Non trivial

CK = Sid Cid

R_2

Sid	Sname	DOB
S_1	A	D_1
S_2	A	D_2
S_3	B	D_3
S_4	B	D_3

CK

FD = Sid → Snam DOB

non trivial

CK = Sid

eg:

eid	ename	rating	hourly wages

FD = { eid → ename rating , rating → hourlywages }

Non trivial

eid → ename rating

SK

Not Redundant

Non trivial

rating → hourly wages

Not SK

Redundant

So redundancy can occurs

Q. R(ABCDEF) = { AB → C, B → D, D → E, AE → F, C → A }

Check which FD is creating redundancy.

SK

AB → C ✗

Not SK

D → E ✓

Not CK

C → A ✓

Not SK

B → D ✓

Not SK

AE → F ✓

CK = {AB, BC}

$AB \rightarrow C$

$B \rightarrow D$ — Proper subset of CK $\rightarrow$ Non prime

$D \rightarrow E$ — Non-prime $\rightarrow$ Non prime

$AE \rightarrow F$ — Combination of proper subset of ck & non-prime $\rightarrow$ Non prime

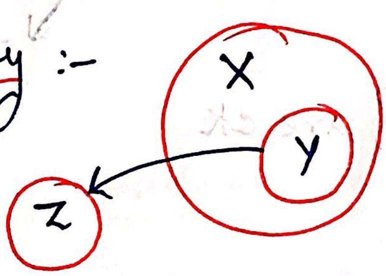
$C \rightarrow A$ — Proper subset of CK $\rightarrow$ Prime

Form's redundancy

(ii) 2-NF:-

Relational schema R is is 2NF iff No partial dependency in R

Partial dependency :-



X : any CK

$Y \subset X$ (proper subset)

& Z is non prime

then $(Y \rightarrow Z)$ is PD

(Proper subset of CK $\longrightarrow$ Non-prime)

$\hookrightarrow$ $\left[\left(\text{Proper subset of CK} \right)^{+} = \{ \ldots\ldots \text{Non prime} \ldots\ldots \} \right]$

(iii) 3-NF :-

Relational schema R in 3NF iff every non trivial FD :

X → Y in R with

- X must be superkey

OR

- Y must be prime attribute

$$\underset{SK}{X} \rightarrow \underset{prime}{Y}$$

sk or prime

eg: R(ABC) = { AB → C , C → A } in 3NF

forms redundancy

and {AB , BC} are CK

(Proper subset of cand key → Proper subset of some other CK)

forms redundancy and allowed in 3NF

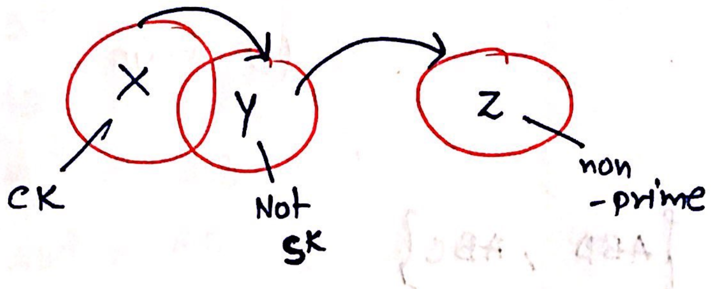
(iv) Boyce Codd NF (BCNF) :-

Relational schema R is in BCNF iff every non-trivial FD

X → Y with X must be superkey

$\forall (\underbrace{X}_{SK} \rightarrow Y)$

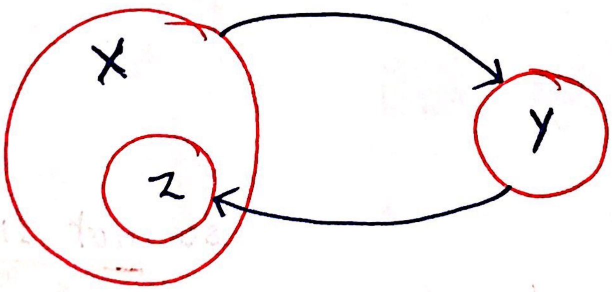
- Non-prime Attribute transitively determined by superkey is not allowed in ~~B~~ 3NF.



$\{X \rightarrow Y \ \& \ Y \rightarrow Z\}$

not allowed in 3NF

- Prime Attribute transitively determined by superkey is allowed in 3NF but not in BCNF



$\{X \rightarrow Y \ \& \ Y \rightarrow Z\}$

allowed in 3NF

not allowed in BCNF

Q. $R(ABCDE) = \{ ABD \to C, BC \to D; CD \to E \}$ what is the highest NF satisfied by R?

(a) ✓ 1NF

(b) 2NF

(c) 3NF

(d) BCNF

Candidate keys : $\{ABD, ABC\}$

prime attr = $\{A, B, C, D\}$

Non-prime attr = $\{E\}$

$ABD \to C$

$\left.\begin{array}{l} BC \to D \\ CD \to E \end{array}\right\}$ causes redundancy   so not BCNF

in $CD \to E$ → not prime   so not 3NF

Now for 2NF : check PD $\left[\left(\begin{array}{c} \text{Proper subset} \\ \text{of CK} \end{array} \right)^+ = \begin{array}{c} \text{Non} \\ \text{Prime} \end{array} \right]$

$CK_1 = ABD$

$A^+ = A$

$B^+ = B$

$D^+ = D$

$AB^+ = A, B$

$BD^+ = B, D$

$AD^+ = AD$

No PD

$CK_2 = ABC$

$BC^+ = B, C, D, E$

non-prime

so PD exist

Thus Not 2NF

So, it must be 1NF

Q. $R(ABCD) = \{AB \to C, BC \to D\}$ CK = AB

check PD for CK:

$A^+ = A$

$B^+ = B$

so, No partial dependency

Hence 2NF

Now $\underset{\text{Not SK}}{BC} \to \underset{\text{Not prime}}{D}$

so not 3NF and hence not BCNF

1 NF	2 NF	3NF	BCNF
✓	✓	×	×

Q. R(ABCDEF) = { AB → C, C → DE, E → F, F → A }

check highest Normal form.

(CK = AB, BF, BE, BC)

prime attr = {A, B, C, E, F}

non-prime = {D}

C → DE so not BCNF

C: Not SK

C → D so not 3NF

C: Not SK; D: Not prime

C → D PD so not 2NF

C: proper subset; D: not prime

1 NF	2 NF	3NF	BCNF
✓	×	×	×

Q. $R(ABCD) = \{AB \rightarrow C, C \rightarrow A, AC \rightarrow B\}$

$CK = \{CD, ABD\}$

so prime Attr = $\{A, B, C, D\}$

since all FD's " determining prime attr

so they are in 3NF,

But not in BCNF as AB is not SK.

Now check PD:

since all are prime attributes so there will be no chances for

$$\left((\text{Proper subset})^{+} \longrightarrow \text{Non-prime}\right)$$

So it is in 2NF

1NF	2NF	3NF	BCNF
✓	✓	✓	✗

Q.

$$R(ABCD) = \{A \to B,\ B \to AC,\ C \to D\}$$

$CK = \{A, B\}$

prime attributes = $\{A, B\}$

Non prime = $\{C, D\}$

since $C \to D$ — Not SK, Non-prime — so it is <u>not in 3NF</u>

And there are no proper subset of CK so no chances for PD.

Hence it is in <u>2NF</u>

1NF	2NF	3NF	BCNF
✓	✓	✗	✗

Q. $R(ABCDEF) = \{AB \to C,\ C \to D,\ CD \to AE,\ DE \to F,\ EF \to B\}$

$CK = \{AB,\ AEF,\ ADE,\ C\}$

All are prime attributes so in 3NF

$DE \to F$ so not in BCNF

Not SK

1NF	2NF	3NF	BCNF
✓	✓	✓	✗

Q. $R(ABCDE) = \{A \to B,\ B \to C,\ C \to D,\ D \to A\}$

$CK = \{AE,\ BE,\ CE,\ DE\}$

All are prime attributes so it follows 3NF

1NF	2NF	3NF	BCNF
✓	✓	✓	✗

Q. $R(ABCD) = \{ AB \to C, C \to A, AC \to D \}$

$CK = \{AB, BC\}$

prime attr = $\{A, B, C\}$

Non-prime = $\{D\}$

$AC \to D$ so not 3NF

Not SK

non prime

$(C \subset BC) \Rightarrow C^+ = \{C, A, D, ...\}$ so not 2NF

non prime

1NF	2NF	3NF	BCNF
✓	✗	✗	✗

NOTE:-

- Simple candidate key - CK only one attribute
- Compound candidate key - CK contains atleast 2 attributes

→ If relⁿ R consist only simple CK then relation R always in 2NF but may or may not in 3NF

→ If relⁿ R with only prime attributes then relation will always in 3NF but may or may not in BCNF.

→ A relⁿ R with no non-trivial FD's then R always in BCNF (all are non-redundant FD's)

→ Relⁿ R with only two attributes will be in BCNF & 4NF also.

R(AB)

$\{A \to B\}$	$\{B \to A\}$	$\{A \to B, B \to A\}$	$\{$No non-trivial FD's$\}$
$A \to CK$	$B \to CK$	$(A, B) \to CK$	0% redundancy
BCNF	BCNF	BCNF	Always BCNF ~~may or may not 4.~~ + 4NF