Schema Refinement

Problems due to Redundancy:-

1. Repeated storage.
2. Insertion Problems
3. Updation Problems
4. Deletion Problems

Requirement:-

Professors of same seniority should have same salary.

Professor:-

functional dependency: Seniority → Salary

SSN	Name	Seniority	Salary	
1	A	5	50K	+10K X
2	B	5	50K	
3	C	5	50K	
4	D	10	1L	delete X
5	E	10	1L	delete X
<6	F	10	1.2L>	Insert X

Prof

SSN	Name	Seniority FK	
1	A	5	
2	B	5	
3	C	5	
4	D	10	delete
5	E	10	delete
<6	F	10>	Insert

Prof - Salary

Seniority → Salary

Seniority PK	Salary
5	50K
10	1L

Functional dependency:- (FD)

A Functional dependency $X \rightarrow Y$ says that if any two tuples agree on the values on attribute X, they must also agree on the values of attribute Y.

Ex:- $X \longrightarrow Y$

- $X_1 \longrightarrow Y_1$
- $X_1 \longrightarrow Y_1$
- $X_1 \longrightarrow Y_1$
- $X_2 \longrightarrow Y_4$
- $X_2 \longrightarrow Y_4$
- $X_3 \longrightarrow Y_7$
- $X_4 \longrightarrow Y_7$

If $X \rightarrow Y$ is a functional dependency, then X may become Key for the relation.

Q. Consider the following relation instance, find Which of the following dependencies are satisfying on the above relation instances.

R

A	B	C
a_1	b_1	c_1
a_1	b_2	c_1
a_2	b_1	c_1

a) $A \rightarrow B$ ✗
b) $A \rightarrow C$ ✓
c) $B \rightarrow C$ ✓
d) $C \rightarrow A$ ✗
e) $AB \rightarrow C$ ✓

Not trivial functional dependencies

(f) $AC \rightarrow B$ ✗

(g) $AC \rightarrow C$ ✓ → Trivial "odd man-out" dependency.

$AC \rightarrow C$

$C \subset AC$

A functional dependency $X \rightarrow Y$ is said to be trivial if and only if $Y \subseteq X$.

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①

A	B	C
1	2	1
1	2	2
1	3	1
2	3	2

$A \rightarrow BC$ ✗

$AC \rightarrow B$ ✗

$AB \rightarrow C$ ✗

$BC \rightarrow A$ ✓

②

X	Y	Z
1	4	2
1	5	3
1	6	3
3	2	2

a) ✗

b) ✓

(c) ✗

(d) ✗

③ a)

A	B	C	D
2	2	3	4
2	2	3	4
2	2	3	6

b)

A	B	C	D
3	2	3	4
2	3	3	4
3	2	3	6

✓ c)

A	B	C	D
4	2	3	4
4	2	5	6
4	2	3	6

violates

Properties of Functional Dependency:-

1. Reflexivity:-

if $X \supseteq Y$ then $X \rightarrow Y$ is a Functional Dependency.

Ex:- Producer, Hero ⟶ Hero

2. Augumentation:-

if $X \rightarrow Y$ then $XZ \rightarrow YZ$ is a Functional Dependency.

Ex:- Producer ⟶ Hero

Producer, Banner ⟶ Hero, Banner

3. Transitivity:-

if $X \rightarrow Y$ and $Y \rightarrow Z$ then $X \rightarrow Z$ is a Functional Dependency.

Ex:- Producer ⟶ Banner

Banner ⟶ director

⟶ Producer ⟶ director.

4. Union:- if $X \to Y$ and $X \to Z$ then,
$X \to YZ$ is a functional dependency.

Ex:- Producer $\to$ Banner
Producer $\to$ Heroine

Producer $\to$ Banner, Heroine.

5. Decomposition:- if $X \to YZ$ then $X \to Y$ and $X \to Z$ is a functional Dependency.

Ex:- Producer $\to$ Banner, Heroine

Producer $\to$ Banner
Producer $\to$ Heroine

Closure Set of Functional Dependencies (F^+):-

It is a set of all functional dependencies, that can be determined, using the given set F of functional dependencies.

Ex:- R(ABC) F: $\{A \to B, B \to C\}$

$F^+ = \{A \to B, B \to C\}$

- $A \to C$ Transitivity
- $A \to BC$ Union
- $AC \to BC$ Augumentation
- $AC \to B$, $AC \to C$ decomposition
- $AC \to A$, $AC \to AC$ Reflexivity

Attribute closure:- $[X^+]$

It is a set of all attributes that can be determined using the set (given set) X of attributes and it is denoted by X^+.

Ex:- 1) $R(ABC)$ $F: \{A \to B, B \to C\}$

$A^+ = \{A, B, C\}$ – S.Key, C.K, P.K

$B^+ = \{B, C\}$

$C^+ = \{C\}$

$AB^+ = \{A, B, C\}$ – S.Key

$AC^+ = \{A, C, B\}$ – S.Key

$BC^+ = \{B, C\}$

$ABC^+ = \{A, B, C\}$ – S.Key

Q. $R(ABCDE)$

$f: \{AB \to C, A \to D, B \to E, E \to B\}$

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

$A^+ = \{A, D\}$

$B^+ = \{B, E\}$

$E^+ = \{E, B\}$

$AE^+ = \{A, E, D, B\}$

Applications of Attribute closure:-

1. Additional functional dependencies.
2. Equivalence of functional dependencies.
3. Minimal set of functional dependencies.
4. Keys of a relation (Primary Key, Candidate Key, Foreign Key).

1. Additional Functional dependencies:-

$X \rightarrow Y$

X^+ contains Y.

A Functional Dependency $X \rightarrow Y$, is possible, if and only if X^+ (X closure) contains Y.

Q. R (ABC) F: $\{A \rightarrow B, B \rightarrow C\}$

i) IS $AB \rightarrow C$ possible?

$AB^+ = A, B, C$ Yes. $AB \rightarrow C$ is possible.

ii) IS $BC \rightarrow A$ Possible?

$BC^+ = B, C$ Not possible.

2a1p

(4) $A \rightarrow B$ $ED \rightarrow A$ $E \rightarrow F$

$BC \rightarrow E$ $EF \rightarrow G$

$AC^+ = A, C, B, E, F, G$

(5) a) $CF^+ = C, F, G, E, A, D.$

b) $BG^+ = B, G, A, C, D,$

c) $AF^+ = A, F, E, D$

d) $AB^+ = A, B, C, D, G$

(6) Trivial = subset (c)

(7) $CD^+ = C, D, E, A, B, C$ ✓ $BD^+ = B, D,$ ✗

$BC^+ = B, C, D,$ ✓ $AC^+ = A, C, B, D, E$ ✓

(8) $A^+ = A$ ✗

$C^+ = J, C, I$ ✗

$AC^+ = A, C, J, I$ ✓ $AGH^+ = A, G, H,$ ✗

2. Equivalance of Functional Dependency:-

The two sets of functional dependencies f and g are said to be equivalent if and only if

$F^+ = G^+$

[OR]

If every dependency of F is determined using G and every dependency of G is determined using F then F and G are said to be equivalent. i.e.,

Both F covers G and G covers F HOLDS. satisfies

Q. $F: \{A \to B,\ AB \to C,\ D \to AC\}$

$G: \{A \to BC,\ D \to A\}$

F covers G

$A \to BC$

- $A^+ = A, B, C$

$D \to A$

- $D^+ = D, A, C$

G covers F

$A \to B$

- $A^+ = A, B, C$

$AB \to C$

- $AB^+ = A, B, C$

$D \to AC$

- $D^+ = D, A, B, C$

$\therefore F = G$

Q. $F: \{A \to C,\ AC \to D,\ E \to AD,\ E \to H\}$

$G: \{A \to CD,\ E \to AH\}$

F covers G

$A \to CD$

$A^+ = \{C, A, D,$

$E \to AH$

$E^+ = E, A, D, C, H$

$\therefore F = G$

G covers F

$A \to C$

$A^+ \to A, C, D$

$AC \to D$

$AC^+ = A, C, D$

$E \to AD$

$E^+ \to A, H, C, D$

$E \to H$

$E^+ \to A, H, C, D$

(9) F covers G ✓

$A \rightarrow BC$

$A^+ = A, B, C$

$D \rightarrow AB$ ✗

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

Only F covers G ✓

G covers F ✗

$A \rightarrow B$

$A^+ = B, C$

$AB \rightarrow C$

$AB^+ = A, B, C$

$D \rightarrow AC$

$D^+ = D, A, B, C$

$D \rightarrow E$

$D^+ = D, A, B, C$

(10) $C \rightarrow D$

$1 \rightarrow 2$ $\quad$ $2 \rightarrow 1$

$C^+ = C,$

(b) $E \rightarrow AH$ $\quad$ $C \rightarrow D$

$E^+ \rightarrow E, H, A, D$ $\quad$ $C^+ =$

(c) $D \rightarrow C$ $\quad$ $C \rightarrow D$

$D^+ =$ $\quad$ $C^+ =$

Canonical set / irreducable set:- (OR) Minimal set of Functional dependency:-

A minimal cover for the set of functional dependencies F is a set of functional dependencies G such that every dependency of F is in the closure of G.

Step-1:- if $X \rightarrow Y$ is a Functional dependency and if both X and Y are present in LHS / RHS of dependency, then remove 'Y'.

case ii) $\left[\begin{array}{l} X \to Y \\ XY \to Z \\ Z \to XY \end{array}\right]$ case (i)

(i)

$X \to Y$

$X \to Z$

(ii)

$X \to Y$

$Z \to X$

Step 2:-

Verify each functional dependency such that it can be determined from the remaining set of dependencies, if possible consider such dependency as redundant and can be eliminated.

$X \to Y$ ✓

$Y \to Z$ ✓

$X \to Z$ ✗

Ex:-

$A \to B$
$AB \to C$
$D \to AC$

$A \to B$
$AB \to C$
$D \to AC$

$A \to B$
$A \to C$
$D \to AC$

$A \to B$
$A \to C$
$D \to A$

$A \to BC$
$D \to A$

Ex:-

$A \to B$
$AB \to C$
$B \to C$

$A \to B$
$A \to C$
$B \to C$

$A \to B$
$B \to C$

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(11)

$A \to B$
$AB \to C$
$A \to BC$
$B \to C$

$A \to B$
$AB \to C$
$A \to BC$
$B \to C$

$A \to BC$
$B \to C$

$A \to B$
$B \to C$

(12)

$A \to B$
$CD \to A$
$CB \to D$
$CE \to D$
$AE \to F$
$AC \to D$

$A \to B$
$A \to D$
$CD \to A$
$CB \to D$
$CE \to D$
$AE \to F$

$A \to BD$
$CD \to A$
$CB \to D$
$CE \to D$
$AE \to F$

* If at the right-hand side, only one time repetition, no-need to check.
If repetition, there is a possibility for reduction.

$CB \to D$ $\quad CB^+ = CB$

$CE \to D$ $\quad CE^+ = CE$

$AC \to D$ $\quad AC^+ = ACBD$

(13) $BCD \to A$

$\left.\begin{array}{l} C \to E \\ E \to B \end{array}\right\} C \to B$

$\therefore$ B can be dropped from X.

(14) $BC \to A$ $\quad BC^+ = B, C, D, E, F, A$

$B \to D$ ✓

$D \to EF$ ✓

$C \to F$ ✓ $\quad C^+ = C$

$EF \to A$ ✓ $\quad EF^+ = E, F,$

Ans:- $BC \to A$ (or) $X \to A$

(15) $R\ \{V, W, X, Y, Z\}$

$V \to W$

$VW \to X$

$Y \to VX$

$Y \to Z$

(a) $V \to W$ ✓

$V \to X$ ✓

$Y \to V$ ✓

$Y \to Z$ ✓

(b) ~~$V \to W$~~

~~$W \to X$~~

~~$Y \to V$~~

~~$Y \to Z$~~

(16) $A \to BC$ ✓ $\quad A \to B \quad A \to C$ ~~$A^+ = A$~~

$ABE \to CDGH$ $\quad$ ~~$ABE^+ = A, B, E, F, C, G,$~~ D

$C \to GD$ ✓ $\quad$ ~~$C^+ =$~~ C

$D \to G$ ✓

$E \to F$ ✓

$A \to B$
$A \to C$
$AE \to CH \begin{cases} AE \to C \\ AE \to H \end{cases}$
$C \to GD$
$D \to G$
$E \to F$

$A \to B$
$A \to C$
$AE \to C$
$AE \to H$
$C \to G$
$C \to D$
$D \to G$
$E \to F$

$A \to B$
$A \to C$
$AE \to CH$
$C \to D$
$D \to G$
$E \to F$

18.10.19

Finding the Keys of a Relation:-

If X^+ (X closure) contains all the attributes of a relation, then X is called Super-Key of the relation. If X is minimal set, then X is called candidate Key of the relation. We can select Primary Key among candidate Keys.

If $X \to Y$, then X may become Key.

Ex:- R (ABC) F : $\{A \to B, B \to C\}$

$A^+ = A, B, C \longrightarrow$ S.K

$B^+ = B, C$ ✗

candidate Key : A

B, C $\to 2^2 = 4$ S.K

$A \begin{cases} \phi = A \\ B = AB \\ C = AC \\ BC = ABC \end{cases}$ 4 $\to$ S.K

R(ABCD) $AB \to C$, $B \to D$

$AB^+ = A, B, C, D$ ✓ $\to$ S.K

~~$C^+ = C$~~ ✗ $B^+ = B, D$

candidate Key = AB

C, D $\to 2^2 = 4$ S.K

$AB \begin{cases} \phi = AB \\ C = ABC \\ D = ABD \\ CD = ABCD \end{cases}$

(3) R (ABCD) F: $\{AB \rightarrow C, A \rightarrow B, B \rightarrow D\}$

$AB \rightarrow C$

$AB^+ = A, B, D, C$ ✓ SK

$A \rightarrow B$

$A^+ = A, \cancel{B}B, C, D$ ✓ SK

$B \rightarrow D$

$B^+ = BD$ ✗ "AB" cannot be a C.K

Candidate Key :- A

$\phi = A$
B = AB
C = AC
D = AD
BC = ABC
BD = ABD
CD = ACD
BCD = ABCD

→ 8 Super Keys

B, C, D → 2^3 = 8 S.K

If the relation contains one candidate Key, then the no. of Super Keys are equals to 2 power of remaining Keys.

(4) R: (ABCD) F: $\{AB \rightarrow C, BC \rightarrow AD\}$

$AB \rightarrow C$

$AB^+ = A, B, C, D$

$BC \rightarrow AD$

$BC^+ \rightarrow B, C, A, D$

Candidate Key = AB

AB:
ϕ — AB
C — ABC
D — ABD
CD — ABCD

6 Super-Keys

Candidate Key = BC

BC:
ϕ — BC
A — ABC
D — BCD
AD — ABCD

∴ "8" S.K 2 repeated.

(5) R (ABC) F: $\{AB \to C,\ C \to AB\}$

$AB \to C$ $\qquad$ $C \to AB$

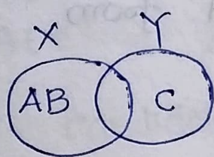
$AB^+ = A, B, C$ $\qquad$ $C^+ = C, A, B$

$C^+ = C.K$ $\qquad$ $AB^+ = C.K$

C
- ϕ — C
- A — CA
- B — CB
- AB — CAB

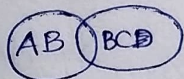
AB
- ϕ — AB
- C — ABC

$\therefore$ No. of Super Keys = 5.



$= X \cup Y = AB \cup C = 2^1 + 2^2 - 2^0 = 5$ ✓

(4)



$= AB \cup CD = 2^2 + 2^2 - 2^1 = 6$ ✓

(6) $\{A \to B,\ B \to C,\ C \to A\}$ $\qquad$ R (ABC)

$A \to B$ $\qquad$ $B \to C$ $\qquad$ $C \to A$

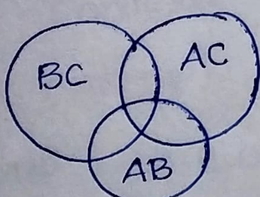
$A^+ = A, B, C$ $\qquad$ $B^+ \to B, C, A$ $\qquad$ $C^+ = C, A, B$

A, B, C are candidate keys.

$A \to$
- ϕ — A
- B — AB
- C — AC
- BC — ABC

$B \to$
- ϕ — B
- A — AB
- C — BC
- AC — ABC

$C \to$
- ϕ — C
- A — AC
- B — BC
- AB — ABC



$\to (BC \cup AC \cup AB)$

$= 2^2 + 2^2 + 2^2 - 2^1 - 2^1 - 2^1 + 2^0$

$= 4 + 4 + 4 - 6 + 1 = 7$. S.K

(7) R (ABCD) F: $\{A \to B,\ B \to C\}$

$A \to B$ $\qquad$ $B \to C$

$A^+ = A, B, C$ ✗ $\qquad$ $B^+ = B, C$ ✗

For a relation, there is atleast one candidate Key.

So, we need to find the independent Attributes [Those are not present at RHS]

In this problem, A & D not present at R.H.S So, they cannot be derived from other attributes. So, they can be derived from themselves.

$\frac{AD^+}{C.K} = A, D, B, C$

(8) R: (ABCD) F $\{A \to B, C \to D\}$

$A \to B$ $\quad$ $C \to D$

$A^+ = AB$ $\quad$ $C^+ = CD$

$AC^+ \to C.K$

(9) R: (ABCDE) F $\{AB \to C \quad BD \to E \quad ED \to B\}$

$AB \to C$ $\quad$ $BD \to E$ $\quad$ $ED \to B$

$AB^+ = A, B, C$ ✗ $\quad$ $BD^+ = B, D, E,$ ✗ $\quad$ $ED^+ = E, D, B$ ✗

$(A, D) \to$ Independent

$AD^+ = A, D,$ ✗

along with Independent add other attributes.

$ABD^+ = A, B, D, C, E$ ✓

$ACD^+ = A, C, D,$ ✗

$AED^+ = A, E, D, B, C$ ✓

(10) R (ABCDE)

F: $\{A \rightarrow B, CD \rightarrow E, CE \rightarrow D\}$

$A \rightarrow B$ $\quad CD \rightarrow E$ $\quad CE \rightarrow D$

$A^+ = A, B$ $\quad CD^+ = C, D, E,$ $\quad CE^+ = C, E, D$

Independent terms : A, C

$AC^+ = A, C, B,$

$ABC^+ = A, B, C,$

$ADC^+ = A, D, C, E, B$ ✓

$AEC^+ = A, E, C, B, D$ ✓

∴ Candidate Keys = ACD, ACE.

(11) R(ABC) F: $\{AB \rightarrow C, C \rightarrow A\}$

$AB \rightarrow C$ $\quad C \rightarrow A$

$AB^+ = A, B, C$ $\quad C^+ = C, A$

C.K = AB

attributes of candidate Key = Prime attributes.

AB → attributes → A, B, C

See, whether they are at RHS. If present Replace with LHS

C → "A" So, Replace "A" with "C"

∴ Candidate Keys are AB, CB.

(12) R (ABCDE) F: $\{AB \rightarrow C, B \rightarrow D, \cancel{C \rightarrow AE}\}$ $D \rightarrow B, C \rightarrow A$

$AB^+ = A, B, C, D, E$ ✓

$B^+ = B, D,$

$C^+ = C, A, E$

candidate Key = AB

check prime attributes $\quad D \rightarrow B$ $\quad C \rightarrow A$

AB
AD
CB
CD

Q. R(ABCDE) F: { AB → C, B → D, C → AE }

$AB^+ = A, B, C, E, D$

$B^+ = B, D$

$C^+ = A, E, C$

C.K = AB ✓ $C \rightarrow AE$

= CB ✓

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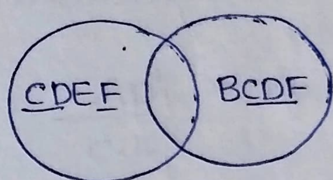
(17) R(A, B, C, D, E, F)

Candidate Keys = AB, AE

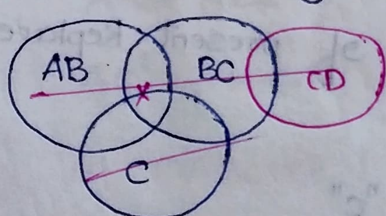


$= 2^4 + 2^4 - 2^3 = 16 + 16 - 8$

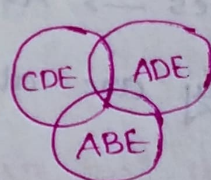
$= 24$

(18) R(A, B, C, D, E)

Candidate Keys = AB, BC, CD



⇒



$2^3 + 2^3 + 2^3 - 2^2 - 2^2 - 2^1 + 2^1$

$= 8 + 8 + \cancel{8} - \cancel{4} - \cancel{4} = 16$

(19) R = (A, B, C, D, E, F)

$C \rightarrow F$ $E \rightarrow A$ $EC \rightarrow D$ $A \rightarrow B$

$C^+ = C, F$

$E^+ = E, A$

$EC^+ = E, C, A, B, D$

∴ Candidate Key (Key) = EC.

Shortcut:- To see Given attributes are present in RHS

C → E
E → A
EC → D
AB → B

among these "C" and "E" are not present

∴ check the options. "EC" is correct.

(20) In the given dependencies "A,B,C,D,K" are not there.

So, ABCDK is answer.

(21) A, D are not there But AD present in (a) & (d)

So, check closure for both of them. So, ABD is correct.

(22) "A, H" both are present in (b) so, ACEH is ans.

(23) To see "EH" common, so, option (d) is correct.

(24) F = { CH → G
A → BC
B → CFH
E → A
F → EG

ABCDEFGH

CH^+ = C, H, G, X
A^+ = A, B, C, F, H, E, G X
B^+ = B, C, F, H, E, G, X
E^+ = X
F^+ = X

AD^+ = A, D, B, C, F, H, E, G

BD
CD
ED
FD
GD
HD

Need not check

Candidate Key : AD

E → A	ED
F → EG	FD
B → CFH	BD
A → BC	AD Repeated.

∴ No. of candidate keys = 4.

(25) $AB^+ = A, B, C, D, E, F$

$F^+ = F, C, A, B, D, E$

$C^+ \times \quad B^+ \times \quad D^+ \times \quad F^+ \times$

Candidate Key: F, AB

$C \to A$ CB

$F \to C$ FB → No use Because F is already candidate Key.

∴ No. of candidate Keys = 3.

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(26) $A^+ = A, C, E,$

$AB^+ = A, B, D, C, E$ ✓

$B^+ = B, D,$

$C^+ = C, E, A, C$

$E^+ = E, A, C$

$D^+ = D, B,$

AB $(E \to A)$

EB $(D \to B)$

ED $(C \to E)$

AD

CD

CB

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(27)

$A^+ = A, B, C$ ✗

$CD^+ = C, D, E$ ✗

$E^+ = E, C$ ✗

$D^+ = D, A, E, H, B, C$ ✓

$ABH^+ = A, B, H, \cancel{B}, D, C, E$ ✓

$DH^+ = D, H, B, C$

super Keys because

$D \to$ candidate Key.

ABH ← $(A \to BC)$

$A \to B$

AAH $A \to C$

AH

ABH is super Key because AH is candidate Key.

∴ No. of candidate Keys = 2

D, AH.

(28)

(1) CK → all attributes ✓

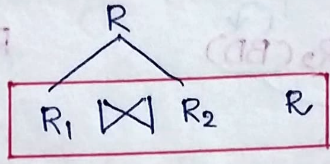
(2) Part of C.K → all attributes ✗

(3) S.K → all attributes. ✓

* Properties of decomposition *

1. Lossless join decomposition:-

The decomposition of R into R_1 and R_2 is said to be lossless if and only if R_1 join R_2 = R.



The decomposition of R into R_1 and R_2 is said to be lossless if and only if the attribute common to R_1 and R_2, must be a key in either R_1 या R_2 या both.

Ex:- R(ABC) F: $\{A \to B\}$

R_1(AB) R_2(BC)

Common : B

Key : A B is not a key it is lossy.

② R(ABC) F: $\{B \to C\}$

R_1(AB) R_2(BC)

Common : B

Key : B → it is lossless.

③ R(ABCDE) R_1(ABCD) R_2(DE)

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

Common : D

D is key in R_2

∴ It is lossless.

④ R(ABCDE) F: $\{AB \to C, B \to D, C \to E\}$

R_1(ABC) R_2(BD) R_3(CE)

Common : B

B is key in R_2.

R_{12} (ABCD) R_3 (CE)

Common

'c' is Key in R_3

∴ It is lossless.

⑤ R (ABCDE)   F: { AB→C, B→D, E→C }

R_1 (ABC) R_2 (BD) R_3 (CE)

Common: B

R_{12} (ABCD) R_3 (CE)

Common: C

"c" is not Key in R_3

∴ It is lossy.

3a/P

① R (ABCD)

<1> B→C , D→A

BC   AD

No - common attribute ∴ lossy decomposition.

<2> AB→C   C→A   C→D

ACD   BC

Common (C)

loss less

<3> A→BC, C→AD

ABC , AD

A

A→BC

∴ loss-less

(4) A→B, B→C, C→D

AB   AD   CD

A

(ABD)   (CD)

D

"not loss-less."

Because A is Key in Both R_1 and R_2 But "D" is not Key. It is lossy.

2. dependency Preserving decomposition:-

The decomposition of R with dependencies F into R_1 and R_2 (is said to be dependen) with dependencies F_1 and F_2 respectively is said to be dependency preserving decomposition if and only if

$F^+ = (F_1 \cup F_2)^+$

Q. R (ABC) F: $\{A \to B, B \to C, C \to A\}$ ✓

R_1 (AB) R_2 (BC)

R_1 (AB)	R_2 (BC)
$A \to B$	$B \to C$
$B \to A$	$C \to B$
$B^+ = BCA$	$C^+ = CAB$

$C \to A$; C^+ using $(F_1 \cup F_2)$

$C^+ = CBA$

∴ decomposition is dependency Preserving.

Step 1:- Write the given dependencies Based on Relation.

Step 2:- if for any relation, the dependency is not given check whether indirect relation is present or not with the help of closures.

Step 3:- After finding all, check whether the remaining are obtained indirectly or not, if not came i.e., decomposition preservence is not satisfied. otherwise decomposition Preservence is possible.

(2) $R(ABCD)$ $F: \{A \to B, B \to A, AC \to D\}$

$R_1(AB)$ $R_2(BCD)$

$F_1: A \to B$
$B \to A$

$F_2: BC \to D$

$A^+ = A, B$
$B^+ = B, A$

$B^+ = B, A$ ✗
$C^+ = C$ ✗
$D^+ = D$ ✗
$BC^+ = A, B, C, D$ ✓
$CD^+ = C, D,$
$BD^+ = B, D, A$

Now, find the dependency $AC \to D$

AC^+ using $(F_1 \cup F_2)$

$AC^+ = A, C, B, D$

$\therefore$ decomposition Preservance possible.

39/P

(2) $R(ABCD)$

$A \to B$ $B \to C$ $C \to D$ $D \to B$

$R_1(AB)$ $R_2(BC)$ $R_3(BD)$

$A \to B$ $B \to C$

"B common"

$\therefore$ lossless join

$R_{12}(ABC)$ $R_3(BD)$

B common

$A \to B$
$B \to C$

$\therefore$ lossless join.

Better to do first check D.P.

$R_1(AB)$ $\quad$ $R_2(BC)$ $\quad$ $R_3(BD)$

$F_1:$ $A \to B$

$B^+ = BCD$

$F_2:$ $B \to C$, $C \to B$

$C^+ = CDB$

$F_3:$ $B^+ = B, C, D$ ✓

$D^+ = D, B, C$

$B \to D$

$D \to B$ ✓

$C \to D$; C^+ using $(R_1 \cup R_2 \cup R_3)$

$C^+ = C, B, D$

$\therefore$ dependency preserving ~~not~~ satisfied. ✓

② $AB \to C$, $C \to A$, $C \to D$

$R_1(ACD)$

F_1 $C \to A$, $C \to D$

$R_2(B \to C)$

$B^+ = B$ ✗

$C^+ = A, C, D$ ✗

$(AB \to C)$: $AB^+ = (F_1 \cup F_2)$

$= A, B,$

$\therefore$ Not decomposition Preservence.

③ $A \to BC$, $C \to AD$

$R_1(ABC)$

$A \to BC$

$C^+ = C, A, D, B$

$R_2(AD)$

$A^+ = A, B, C, D$ ✓ $A \to D$

$D^+ = D.$

$(C \to AD)$: $C^+ = (F_1 \cup F_2)$

$\Rightarrow C^+ \Rightarrow$ $C \to AB$, $A \to BC$:, $A \to D$

$C^+ = C, A, B, D$

$\therefore$ decomposition Preservence.

(4) $A \to B$ $\quad B \to C$ $\quad C \to D$

$R_1(AB)$ $\quad R_2(AD)$ $\quad R_3(CD)$

$A \to B$ $\quad A \to D$ $\quad C \to D$

$B^+ = B, C, D$

$A^+ = A, B, C, D$

$C^+ = C, D$

$D^+ = D$

$(B \to C)$: $B^+ = (F_1 \cup F_2 \cup F_3)$

$= B,$

∴ Not decomposition Preservence.

Normal Forms

1NF:- One-NF was designed to disallowed multi-valued attributes, composite attributes and their combinations. i.e., 1NF allows only atomic values [The attribute of a tuple must be either one value or NULL value].

Un normalized Relation

↓ Remove MVA, Composite Attributes

1NF (Only Atomic Values)

Ex:- Professor : Table Name

SSN	Name	Professor salary
1	Sai	{ 40K, 30K, 20K, 10K }

Unnormalized Relation

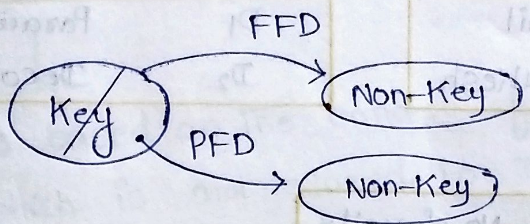
SSN	Name	Basic	TA	DA	HRA
1	Sai	40K	30K	20K	10K

} 1NF

Note:-
Every relation in the Relational Model must be in 1NF.

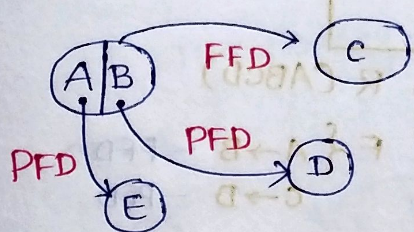
2-NF:-

It is based on the Concept of full functional dependencies and not allows Partial functional dependencies.



PFD:- Part of Key $\longrightarrow$ Non-Key.

Ex:- CK : AB



1NF
$\downarrow$ Remove PFD
2NF (only FFD).

definition:- A relation schema "R" is in 2NF, if no non-prime attribute of R is partial functional dependency on Primary Key of R.

Medication

Patient No	DrugNo	No.of Units	Pname	Dname
P_1	D_1	10	Anil	Paracetomal
P_1	D_2	20	Anil	decold
P_2	D_2	15	Mukesh	decold

FFD:- Patient No, DrugNo $\longrightarrow$ No. of units

PFD:- Patient NO $\rightarrow$ Pname

PFD:- drugNO $\longrightarrow$ Dname

CK:- (PatientNo, DrugNo)

Medication is in 1NF but not in 2NF.

Patient

Patient No	Pname
P_1	Anil
P_2	Mukesh

Drug

DrugNo	DrugName
D_1	Paracetemol
D_2	Decold

Medication

PatientNo (F.K)	DrugNo (F.K)	No. of units
P_1	D_1	10
P_1	D_2	20
P_2	D_2	15

Q. R (ABCDE)

F { AB $\rightarrow$ C

PFD A $\rightarrow$ D

PFD B $\rightarrow$ E }

CK : AB

R is in 1NF

2NF:

(A, D) R_1

(B, E) R_2

(A, B, C) R_3

Q. R (ABCD)

F { A $\rightarrow$ B – PFD

C $\rightarrow$ D – PFD

$A^+ = A, B$

$C^+ = C, D$

$AC^+ = A, B, C, D$

CK = AC

R is in 1NF.

2

(A, B) R_1

(C, D) R_2

(AC) R_3

Q. R (ABC)

F: { A $\rightarrow$ B, B $\rightarrow$ C }

$A^+ = A, B, C$

"C.K = A"

$B^+ = B, C$

$\therefore$ $B \to C$ is't in PD

Because $A \to B$
$B \to C$

indirectly $A \to C$

$\therefore$ No Partial dependency.

$\therefore$ R is in 2NF and also in 1NF.

> A relation that contains a Key with only one attribute is always in 2NF.

$\boxed{\text{3NF}}$

3NF is based on the concept of Transitive dependencies and which is not allowed in 3NF.

$$\begin{tikzcd}
\text{Key} \arrow[r] \arrow[rr, bend left, dashed] & \text{Non-Key} \arrow[r, bend left, "TD"] & \text{Non-Key}
\end{tikzcd}$$

TD: NonKey $\to$ Non-Key

Ex:- CK: A

$$\begin{tikzcd}
A \arrow[r] \arrow[rr, bend left, dashed] & B \arrow[r, bend left, "TD"] & D
\end{tikzcd}$$

$$2NF \xrightarrow{\text{Remove TD}} 3NF$$

Ex:- ① Professor (<u>SSN</u>, Name, Seniority, Salary)

FD: SSN $\to$ Name, Seniority

TD: Seniority $\to$ Salary

CK: <u>SSN</u>

professor is in 2NF, but not in 3NF.

3NF

Prof

<u>SSN</u>	Name	Seniority (F.K)

F.K Prof-sal

<u>Seniority</u>	Salary

Q:- R(ABC) F: {A→B, $\underbrace{B \to C}_{TD}$}

CK = A

R is in 2NF

3NF → (BC) R_1, (AB) R_2

Algorithm:- Lossless join and dependency preserving decomposition into 3NF.

Step1:- find minimal set G for F.

Step2:- For each functional dependency of the form X→Y create a seperate relation that contains both X and Y attributes.

(assurance for dependency Preservance).

Step3:- If no decomposition relation contains key of R, then create a seperate relation contains key of R. (lossless)

Step4:- Remove redundant relations if any. (3NF)

Q. decompose the following relations into 3NF.

Sol:- R(ABCD) F: {AB→C, A→B, B→D}

① G:→ find

AB→C, A→B, B→D → A→C, A→B, B→D → A→BC, $\underbrace{B \to D}_{TD}$

∴ CK: A

R is in 2NF

② R_1 (ABC) R_2 (BD)

② R (ABCDE) F: { AB → C, B → D, D → E }

find minimal set

AB → C

B → D — PFD

D → E   CK = "AB"

TD

"R" is in 1NF.

R_1 (ABC) R_2 (BD) R_3 (DE)

③ R (ABCD) F: { A → B, C → D }

A → B $A^+ = A, B$

C → D $C^+ = C, D$

$AC^+ = A, C, B, D$

CK = "AC"

So, A → B (PFD)

C → D (PFD)

R_1 (AB) R_2 (CD)

is "AC" is present in either of them? No.

So, R_1 (AB) R_2 (CD) R_3 (AC)

There is no redundancy. Hence it is in 3NF.

39/P

③ AB → C ✓   CK = "AB"

A → DE (PD)

B → F (PD)

F → GH

D → IJ

R_1 (ABC) R_2 (ADE) R_3 (BF) R_4 (FGH) R_5 (DIJ)

④ AC → F $AC^+ = A, C, F, B, E, D$

A → B (PD) $A^+ = A, B, E$

B → E $B^+ = B, E,$

C → D (PD) $C^+ = C, D$

CK = "AC"

3NF R1 (ACF)   R2 (AB)   R3 (BE)   R4 (CD)

(5)

A → FC	A → F (PD)
C → D	A → C (PD)
B → E	C → D
	B → E (PD)

$AB^+ = A, F, C, E, D$

∴ CK = AB

R1 (AFC)   R2 (CD)   R3 (BE)   R4 (AB)

Q. What is the NF for the following Relation.

R (ABC)   F: {AB → C, C → A}

AB → C $AB^+ = A, B, C$

C → A   ∴ CK = AB, CB

No partial dependency. So, it is in 2NF

No Transitive dependency. So, it is in 3NF.

definition:- A relation schema R is in 3NF, if whenever a non-trivial functional dependency of the form X → A holds, then either X is superkey and A is Prime Attribute.

If all the attributes in a relation must be prime attributes, then that relation is in 3NF.

BCNF (Boyce-codd NF):-

It is a modification of 3NF and removes the problem of prime transitivity.

definition:- A relation schema R is in BCNF if whenever a non-trivial functional dependency of the form $X \rightarrow A$ holds, then X is a super key of R.

Q. R(ABC) F: $\{\underset{SK}{\underline{AB}} \rightarrow C, \underset{SK}{\underline{C}} \rightarrow AB\}$

CK: AB, C

R is in BCNF also in 3NF

② R(ABC) F: $\{\underset{SK}{\underline{AB}} \rightarrow C, C \rightarrow \underset{PA}{\underline{A}}\}$

CK: AB, CB

R is in 3NF but not in BCNF

BCNF → R_1 (CA), R_2 (BC)

Lost:- (AB → C)

Note:-

1. The dependency Preserving decomposition into BCNF may not be possible always.
2. Every relation in BCNF is also in 3NF but need not vice-versa.
3. A Relation with two attributes is always in BCNF.

proof:-

F_1: $\underset{SK}{\underline{A}} \rightarrow B$	CK: A	BCNF
F_2: $\underset{SK}{\underline{B}} \rightarrow A$	CK: B	
F_3: $A \rightarrow B$, $\underset{SK}{\underline{B}} \rightarrow A$	CK: A, B	

Un-Normalized Relation

↓ Remove multivalued & composite Attributes

1NF (Only Atomic Values)

↓ Remove Partial Functional Dependency

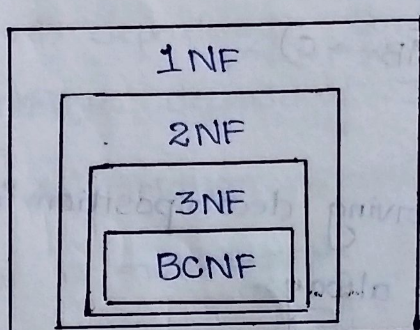
2NF (Only FFD)

↓ Remove Transitive Dependency

3NF $(\underset{\text{S.K (or) P.A}}{X \longrightarrow A})$

↓ Remove Prime Transitivity

BCNF $(\underset{\text{S.K}}{\underline{X} \longrightarrow A})$



39/P

(6) 1) $\underbrace{C \rightarrow D, C \rightarrow A}_{\text{TD}}, B \rightarrow C$ (Non-Key → Non-Key)

CK = B → 2NF

2) CK = BD 1NF

3) CK = ABC, DBC 3NF

4) $A \rightarrow B$, $\underbrace{BC \rightarrow D}_{\text{TD}}$, $A \rightarrow C$ 2NF

CK = A

5) $AB \rightarrow C$, $AB \rightarrow D$, $C \rightarrow A$, $D \rightarrow B$

CK = AB, CB, AD, CD

all are prime Attributes → 3NF

39/P

(7) $R_1(ABC)$ $R_2(CBD)$

C.K = A, B, C, D (BCNF) $\longrightarrow$ BCNF

The decomposition of BCNF turn into BCNF not into lower NF.

(8)

Y (PR)	Z (QRS)	
R → P	QR → S	D.P
	S → Q	Lossless
BCNF	CK: QR, SR	
	3NF (All are prime Attributes).	

(9) Ci → F, L PFD

Oi → D, C, Z PFD

CK: (Ci, Oi)

1NF but not in 2NF

(14) (VNSETYP)

VNSE → T

VN → Y

VNSE → P

21.10.19

Relational Algebra:-

It is a procedural language, in which each query describes the step by step procedure for computing the desired result. i.e., the relational algebra expression represents Query Evaluation Plan.

1. Selection Operator:- (σ)

It is used to select "Rows".