

COMPUTER SCIENCE

Database Management System

FD's & Normalization

Lecture_10



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A graphic of a construction barrier with orange and white diagonal stripes and two yellow bollards at the top.

**TOPICS
TO BE
COVERED**

01

Lossless Join Decomposition

02

Dependency Preserving

Number of Super keys

A, BC, -



① Venn Diagram

② Other Approach

③ every $(n-1)$ attribute is C.K
 $(n-2)$ attribute

⋮

then find
of Super key ?

R(ABCDE)

Check Subkey ?

Lossless Join

If $R_1 \bowtie R_2 = R$

Lossless Join.

If $R_1 \bowtie R_2 > R$

Lossy Join

$$(R_1 \wedge R_2)^+ \rightarrow R_1$$

or

$$(R_1 \wedge R_2)^+ \rightarrow R_2.$$

Q.1

R(ABC)

A	B	C
1	5	5
2	5	8
3	8	8

Decomposed into

Q.1 R₁(AB) & R₂(BC)~~Lossy JOIN~~

A	B	C
1	5	5
2	5	8
2	5	8
3	8	8

$$R_1(AB) \bowtie R_2(BC) =$$

~~Lossy JOIN~~Spurious (Extra)
Table

~~Q.1~~

R(ABC)

$A \rightarrow B$

$A \rightarrow C$

A	B	C
1	5	5
2	5	8
3	8	8

$\cancel{B \rightarrow A}$
 $\cancel{B \rightarrow C}$

Decomposed into

Q.1 R₁(AB) & R₂(BC)

R₁(AB) R₂(BC)

(i) R₁(AB) \cup R₂(BC) = R(ABC)

(ii) R₁(AB) \cap R₂(BC) = [B]

[B]⁺ = [B] Not a Superkey of R₁

⊗

Not a Superkey of R₂

Lossy Join

Q.2

 $R(ABC)$

A	B	C
1	5	5
2	5	8
3	8	8

Decomposed into

Q.2 $R_1(AB) \& R_2(AC)$

A	B
1	5
2	5
3	8

A	C
1	5
2	8
3	8

$$R_1 \bowtie R_2 =$$

$$R_1(A) = R_2(A)$$

$R_1.A$	$R_1.B$	$R_2.A$	$R_2.C$
1	5	1	5
1	5	3	8
2	5	1	5
2	5	2	8
2	5	3	8
3	8	1	5
3	8	2	8
3	8	3	8

P
W

$R_1(AB) \bowtie R_2(AC)$

\Rightarrow

	A	BC
1	5	5
2	5	8
3	8	8

$\equiv R$

Lossless Join

Q.2

R(ABC)

 $A \rightarrow BC$ $A \rightarrow B$ $A \rightarrow C$ $B \rightarrow A$ $B \rightarrow C$

A	B	C
1	5	5
2	5	8
3	8	8

Decomposed into

Q.2 R₁(AB) & R₂(AC)

A	B
1	5
2	5
3	8

A	C
1	5
2	8
3	8

R₁(AB) & R₂(AC)(i) R₁(AB) ∪ R₂(AC) = R(ABC)(ii) R₁(AB) ∩ R₂(AC) = A $[A]^+ = [ABC]$ Super key of R₁ & R₂ BothLossless Join

Lossless Join Decomposition

① ~~BASIC Concept~~

② ~~Binary Method~~

③ CHASE TEST

Lossless Join Decomposition

Let R be the Relational Schema with FD set F is decomposed into subRelation R_1 & R_2

$R_1 \bowtie R_2$ is lossless

iff ① $R_1 \cup R_2 = R$

~~② If Common Attribute of R_1 & R_2~~
either o super key of R_1 $[R_1 \cap R_2]^+ \rightarrow R_1$
or
super key of R_2 $[R_1 \cap R_2]^+ \rightarrow R_2$

$R_1 \bowtie R_2$ is a Lossy Join.

- (i) If Common Attribute of R_1 & R_2
Neither o Super key of R_1
nor
Super key of R_2 .

(ii)

$R(ABCD)$

$R_1(AB)$

$R_2(CD)$

} lossy JOIN.

(iii)

$R(ABCDEF\bar{G}H)$

$R_1(ABCD)$

$R_2(B\bar{C}D\bar{G})$

Lossy. R_2 E, F Missing & H

Lossless - Join Decomposition

- For the case of $R = (R_1, R_2)$, we require that for all possible relations r on schema R

$$r = \pi_{R_1}(r) \bowtie \pi_{R_2}(r)$$

- A decomposition of R into R_1 and R_2 is lossless join if at least one of the following dependencies is in F^+ :

- ❖ $(\underline{R_1 \cap R_2})^+ \rightarrow \underline{R_1}$
- ❖ $(\underline{R_1 \cap R_2})^+ \rightarrow \underline{R_2}$

Q.1

$R(ABCDEFG) \{AB \rightarrow CD, D \rightarrow E, E \rightarrow FG\}$

P
W

Decomposed into $R_1(ABCD)$ and $R_2(DEFG)$

Solⁿ 1

$$R_1(ABCD) \cup R_2(DEFG) = R(ABCDEFG)$$

$$R_1(ABCD) \cap R_2(DEFG) = \emptyset$$

$[D]^+ = [DEFG]$ Super key of R_2 .

Here Common Attribute is Super key of R_2 .

Lossless.

CHASE TEST

In CHASE TEST we create a Matrix in which Column Represent the attribute & Table (Row) Represent the Sub Relations.

- Fill all the cells (Entries) / value with any variable (Assume \underline{a}) in Corresponding Attributes of Respective Sub Relation.
- Now Fill the Table Entries with the Help of Given FD's.

if In $X \rightarrow y$ if 2 'X' Value [Same 2 Value of X] is Present & One y Value ' \underline{a} ' is Present then Write ' \underline{a} ' in another y.

$X \rightarrow Y$

If $t_1.x = t_2.x$ then $t_1.y = t_2.y$ Must be same.

if 2 same value of x is present but 'o' y value is there then

insert any other Variable (Assume 'b') instead of 'a'.

if NO Two Same value of x then that FD Not applied on that moments.

Note

If we get Any one Tuple with all 'a' entries then Lossless JOIN.

Note

CHASE TEST Will Stop, if either we get any one tuple with all 'b' variable Entries (lossless) OR there is No further updation in Table

$x \rightarrow y$

If $t_1.x = t_2.x$ then $t_1.y = t_2.y$ Must be same.

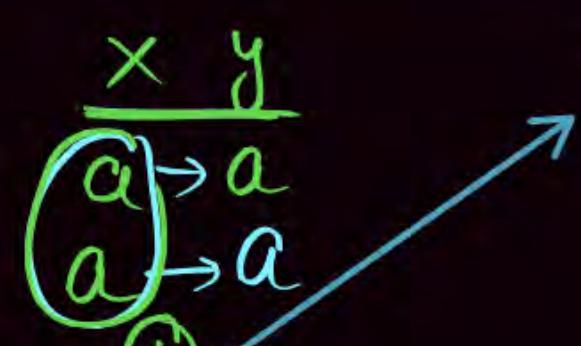
If $x \rightarrow y$

x	y
a	

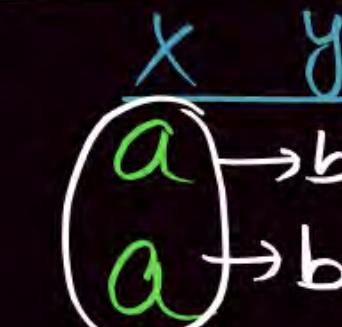
then ED
is NOT
applied

If 2 same value
at 'x'

(If x value is Repeat)



If any one y value is present then
insert the same y (a) value.



If '0' y value is present then Insert
some other Variable (Assume 'b') instead of 'a'.

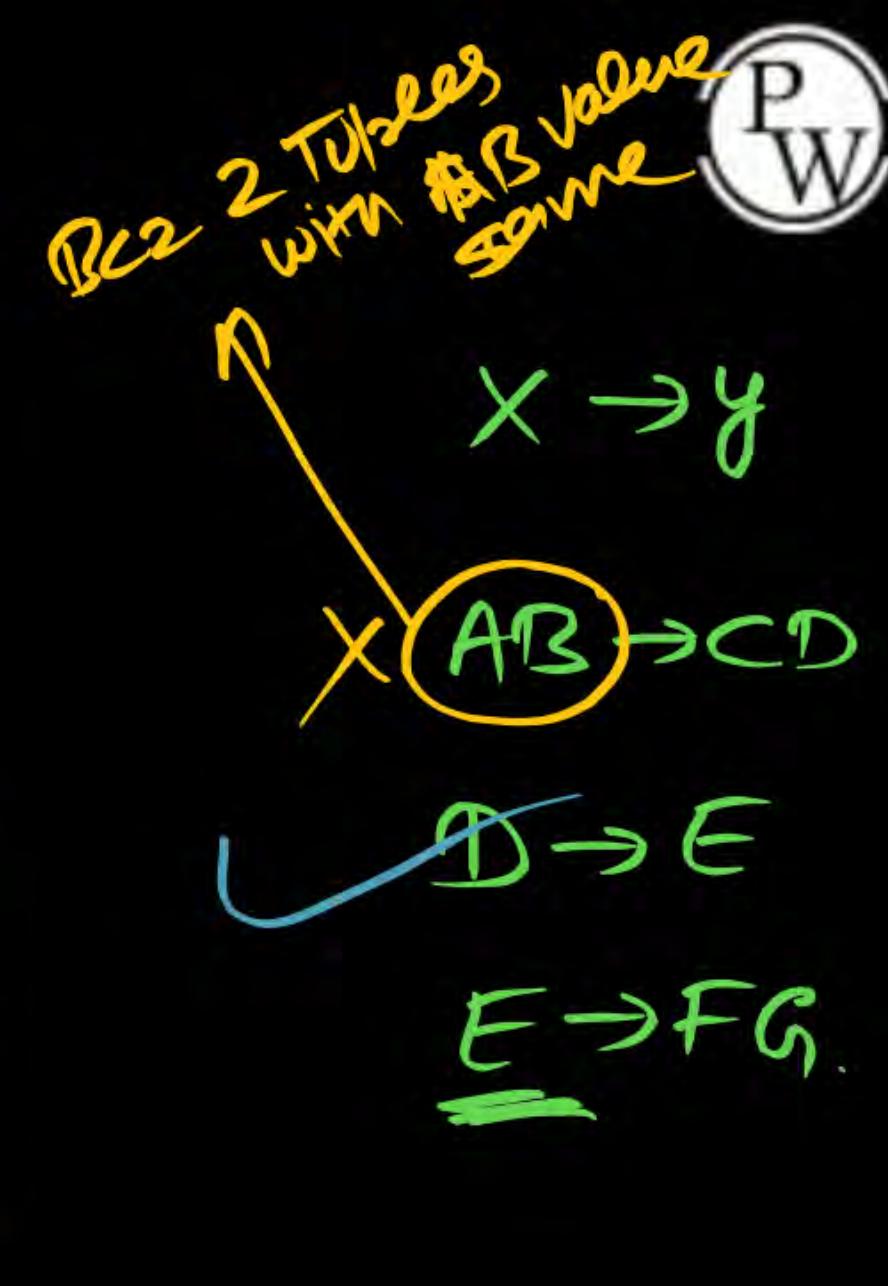
Q.1

$R(ABCDEF)$ { $AB \rightarrow CD$, $D \rightarrow E$, $E \rightarrow FG$ }

Decomposed into $R_1(ABCD)$ and $R_2(DEF)$

By CHASE TEST.

	A	B	C	D	E	F	G
$R_1(ABCD)$	a	a	a	a	a	a	a
$R_2(DEF)$				a	a	a	a



getting a tuple with all 'a' entries
so lossless

Q.2.

 $R(ABCDEFG) \{AB \rightarrow C, C \rightarrow D, D \rightarrow EFG\}$ Decomposed into $R_1(ABCE)$ and $R_2(DEFG)$

$$R_1(ABCE) \cup R_2(DEFG) = ABCDEFG$$

$$R_1(ABCE) \cap R_2(DEFG) = \{E\}$$

$$\{E\}^+ = \{E\}$$
 Not a super key of R_1
()*

Not a super key of R_2 Lossy Join

Q) $R(ABCDEFG)$ [$AB \rightarrow C$, $C \rightarrow D$, $D \rightarrow EFG$]

$R_1(ABCDE)$ $R_2(BEFG)$

$R_1(ABCDEF) \wedge R_2(BEFG) \Rightarrow \underline{[BE]}$

$(BE)^+ = BE$ Not a Super key of R_1
 $(BE)^+ = BE$ Not S.K of R_2 .

lossy Join.

Q R(ABCDEF) [AB → C, C → D, D → EFG]

R₁(ABC) (DEF)

R₁(ABC) ∩ R₂(DEF) = No Common Attribute.

Lossy Join

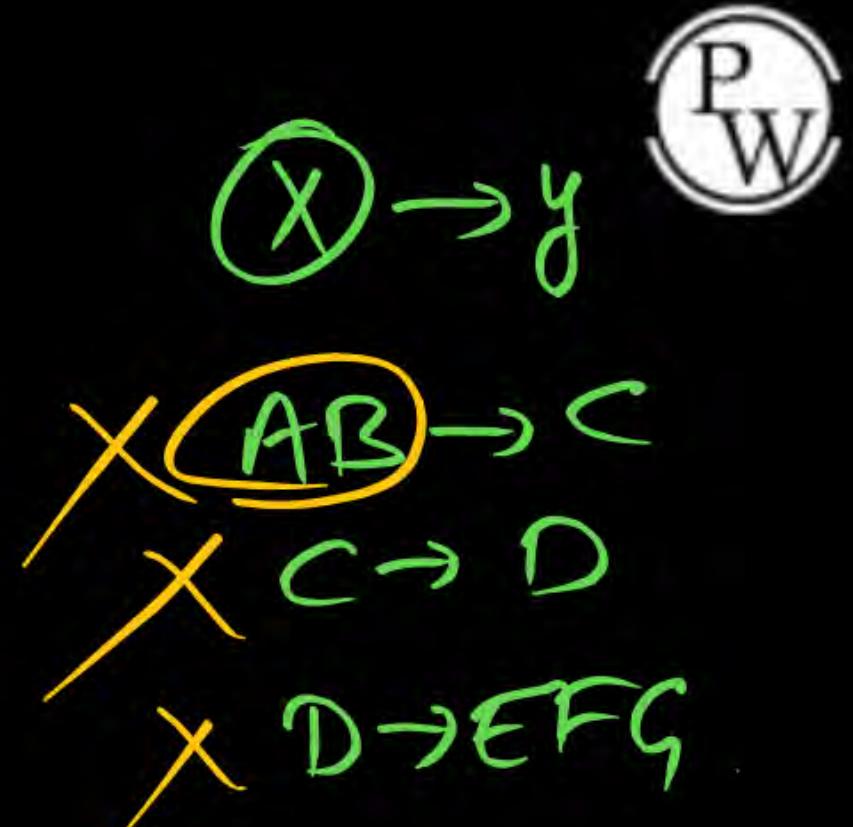
Q.2.

$R(ABCDEFG) \{AB \rightarrow C, C \rightarrow D, D \rightarrow EFG\}$

Decomposed into $R_1(ABCE)$ and $R_2(DEFG)$

By CHASE TEST.

	A	B	C	D	E	F	G
$R_1(ABCE)$	a	a	a		a		
$R_2(DEFG)$				a	a	a	a



Not getting a tuple with all 'a' entries.

Lossy Join

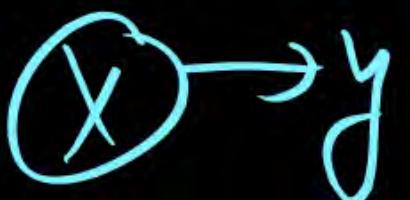
Q.

$R(\underline{ABCDE} \text{ } G)$ { $AB \rightarrow C$, $AC \rightarrow B$, $AD \rightarrow E$, $B \rightarrow D$, $BC \rightarrow A$, $E \rightarrow G$ }

Decomposed into $R_1(\underline{ABC})$ $R_2(\underline{ACDE})$ and $R_3(\underline{ADG})$

seln

	A	B	C	D	E	G
$R_1(ABC)$	a	a	a	a	a	a
$R_2(ACDE)$	a	a	a	a	a	
$R_3(ADG)$	a			a	a	a



$\times AB \rightarrow C$

$\checkmark AC \rightarrow B$

$\checkmark AD \rightarrow E$

$\checkmark B \rightarrow D$

$BC \rightarrow A$

$E \rightarrow G$

Q.

$R(\underline{ABCDE} \underline{G}) \{AB \rightarrow C, AC \rightarrow B, AD \rightarrow E, B \rightarrow D, BC \rightarrow A, E \rightarrow G\}$

P
W

Decomposed into $R_1(\underline{ABC})$ $R_2(\underline{ACDE})$ and $R_3(\underline{ADG})$

Soln

$$\underline{R_1(ABC)} \wedge R_2(ACDE) = AC$$

$$(AC)^+ = [ACB, \dots] \text{ Super key of } R_1.$$

$$R_{12}(ABC\bar{D}\bar{E}) \wedge R_3(\underline{ADG}) = AD$$

$$(AD)^+ = [\underline{ADEG}] \text{ Super key of } R_3.$$

$\underline{R_{123}(ABC\bar{D}\bar{E}\bar{G})}$ Lossless Join

$R_1(ABC)$ $R_2(ACDE)$ $R_3(ADG)$ $R_{12}(ABCDE)$ $R_3(ADG)$ $R_{123}(ABCDEFG)$ 

Q.

$R(ABCDEG) \{AB \rightarrow C, AC \rightarrow B, AD \rightarrow E, B \rightarrow D, BC \rightarrow A, E \rightarrow CG\}$

P
W

1. Decomposed into $R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ and $R_4(EG)$
2. Decomposed into $R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ and $R_4(ECG)$

① $R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ $R_4(EG)$

$$\underline{R_1(AB)} \cap R_2(BC) = [B]$$

$(B)^+ = [BD]$ Not a Superkey of R_1 & Not R_2

$$R_1(AB) \cap R_3(ABDE) = [AB]$$

$(AB)^+ = [AB \dots]$ Superkey R_L

So Join $R_{13}(ABDE)$

Q.

$R(ABCDE \text{ } G) \{AB \rightarrow C, AC \rightarrow B, AD \rightarrow E, B \rightarrow D, BC \rightarrow A, E \rightarrow CG\}$

P
W

1 Decomposed into $R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ and $R_4(EG)$

2. Decomposed into $R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ and $R_4(ECG)$

$R_{13}(ABDE)$

$R_2(BC)$

$R_4(EG)$

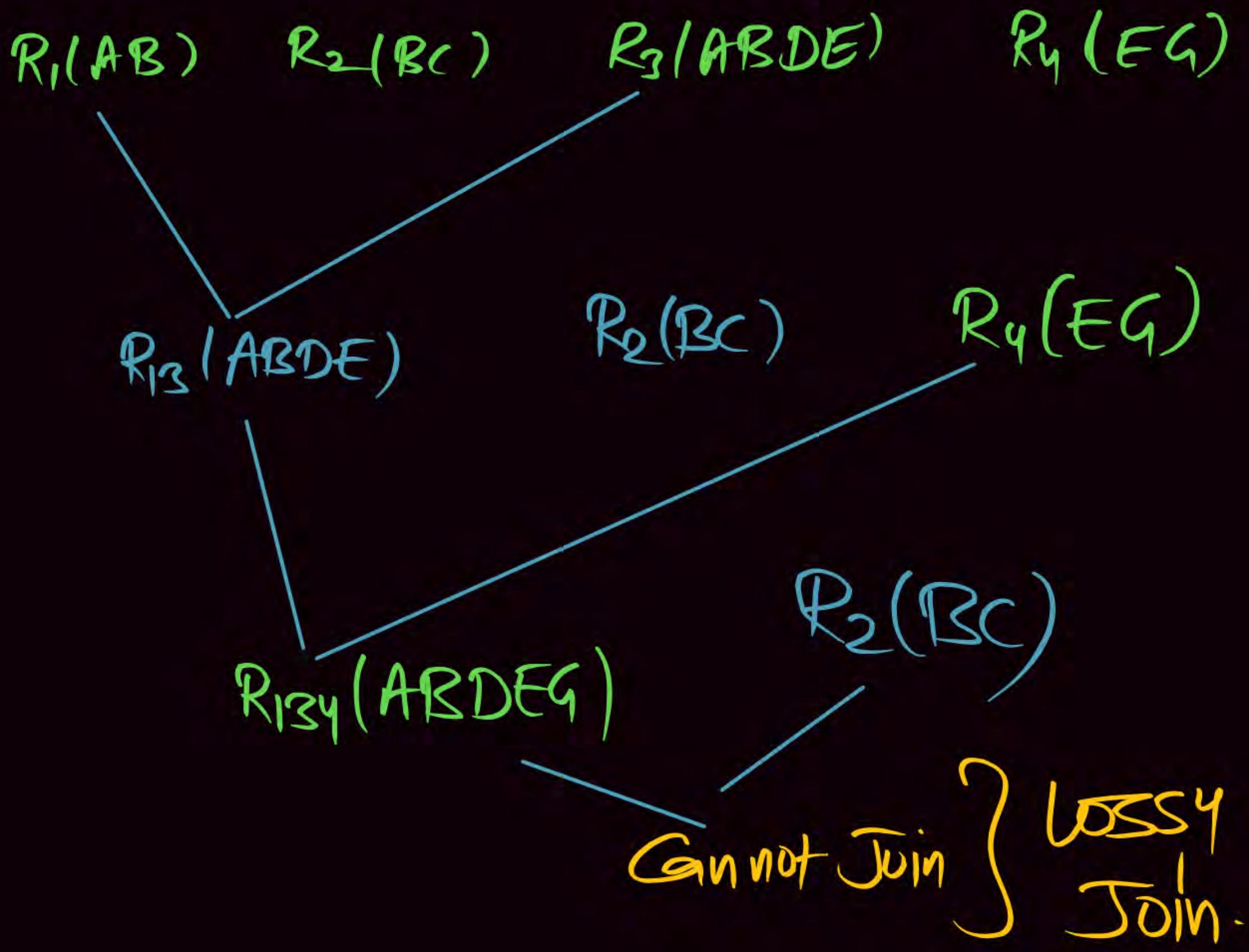
$$R_{13}(ABDE) \wedge R_4(EG) = [E]$$

$$(E)^+ = [ECG] \quad \text{Super key of } R_4.$$

$R_{134}(ABDEG)$ \wedge $R_2(BC)$ = [B]

(B) $^+ = [BD]$ Not a Super key of R_{134} & Not SK of R_2

Lossy Join



⑧ $R(ABCD)$ [$A \rightarrow B$, $B \rightarrow C$, $CD \rightarrow A$]

$R_1(AD)$ $R_2(AC)$ $R_3(BCD)$

Q.

$R(ABCDE \rightarrow G) \{AB \rightarrow C, AC \rightarrow B, AD \rightarrow E, B \rightarrow D, BC \rightarrow A, E \rightarrow CG\}$

P
W

1. Decomposed into $R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ and $R_4(EG)$

2. Decomposed into $R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ and $R_4(ECG)$

	A	B	C	D	E	G
$R_1(AB)$	a	a	b			
$R_2(BC)$		a	a			
$R_3(ABDE)$	a	a	b	a	a	
$R_4(ECG)$			a		a	a

$AB \rightarrow C$

$AC \rightarrow B$

$AD \rightarrow E$

$B \rightarrow D$

$BC \rightarrow A$

$E \rightarrow CG$

Q.

$R(ABCDEG)$ { $AB \rightarrow C$, $AC \rightarrow B$, $AD \rightarrow E$, $B \rightarrow D$, $BC \rightarrow A$, $E \rightarrow CG$ }

P
W

1. Decomposed into $R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ and $R_4(EG)$
2. Decomposed into $R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ and $R_4(ECG)$

$R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ $R_4(ECG)$

$$R_1(AB) \cap R_2(BC) = B$$

$$\underline{(B)^+ - [BD]} \quad \text{Not a Super key of } R_1 \text{ & } R_2.$$

$$R_1(AB) \cap R_3(ABDE) = (AB)$$

$$(AB)^+ = [AB, \dots] \text{ Subkey of } R_1$$

$R_{13}(ABDE)$

Q.

$R(ABCDE \text{ } G) \{AB \rightarrow C, AC \rightarrow B, AD \rightarrow E, B \rightarrow D, BC \rightarrow A, E \rightarrow CG\}$

P
W

1. Decomposed into $R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ and $R_4(\underline{EG})$

2. Decomposed into $R_1(AB)$ $R_2(BC)$ $R_3(ABDE)$ and $R_4(ECG)$

$R_{13}(ABDE)$

$R_2(BC)$

$R_4(ECG)$

$R_{13}(ABDE) \cap R_4(ECG) \Rightarrow (E)$

$(E)^t = [ECGA]$ Subkey of R_4 .

$R_{134}(ABCDEF) \cap R_2(BC) = [BC]$

$(BC)^t = [BC \dots]$ Subkey of R_2

$R_{1234}(AB(CDEG))$ Wesless

$$R_1(AB) \quad R_2(BC) \quad R_3(ABDE) \quad R_4(ECG)$$
$$R_{13}(ABDE)$$
$$R_2(BC)$$
$$R_4(ECG)$$
$$R_{134}(ABCDEG)$$
$$R_2(BC)$$
$$R_{1234}(ABCDEFG)$$
 Lossless Join.

Q.

Consider the relation R (P, Q, S, T, X, Y, Z, W) with the following functional dependencies.

 P
W

$$PQ \rightarrow X; P \rightarrow YX; Q \rightarrow Y; Y \rightarrow ZW$$

Consider the decomposition of the relation R into the constituent relations according to the following two decomposition schemes.

$$D_1: R = [(P, Q, S, T); (P, T, X); (Q, Y); (Y, Z, W)]$$

$$D_2: R = [(P, Q, S); (T, X); (Q, Y); (Y, Z, W)]$$

Which one of the following options is correct?

[MCQ: 2021: 2M]

- A** D_1 is a lossless decomposition, but D_2 is a lossy decomposition.
- B** D_1 is a lossy decomposition, but D_2 is a lossless decomposition.
- C** Both D_1 and D_2 are lossless decomposition.
- D** Both D_1 and D_2 are lossy decomposition.

Dependency Preservation

- Let F_i be the set of dependencies F that include only attributes in R_i .
 - ❖ A decomposition is dependency preserving,

if $(F_1 \cup F_2 \cup \dots \cup F_n) = F$

Let $R(A, B, C, D, E)$ be a relational schema with the following function dependencies:

$A \rightarrow B$, $B \rightarrow C$, $C \rightarrow D$ and $D \rightarrow BE$.

Decomposed into $R_1(AB)$ $R_2(BC)$ $R_3(CD)$ and $R_4(DE)$

Q.

$R(ABCDEFG) \{AB \rightarrow C, AC \rightarrow B, AD \rightarrow E, B \rightarrow D, BC \rightarrow A, E \rightarrow G\}$

Decomposed into $R_1(ABC)$ $R_2(ACDE)$ and $R_3(ADG)$

P
W

Q.

Consider a schema $R(A, B, C, D)$ and functional dependencies

$A \rightarrow B$ and $C \rightarrow D$. Then the decomposition of R into $R_1(AB)$ and $R_2(CD)$ is

[MCQ: 2M]

- A** Dependency preserving and lossless join
- B** Lossless join but not dependency preserving
- C** Dependency preserving but not lossless join
- D** Not dependency preserving and not lossless join

P
W

Q.

Let $R(A, B, C, D)$ be a relational schema with the following function dependencies:

$A \rightarrow B$, $B \rightarrow C$, $C \rightarrow D$ and $D \rightarrow B$.

The decomposition of R into (A, B) , (B, C) , (B, D)

[MCQ: 2M]

- A** Gives a lossless join, and is dependency preserving
- B** Gives a lossless join, but is not dependency preserving
- C** Does not give a lossless join, but is dependency preserving
- D** Does not give a lossless join and is not dependency preserving

Q.1

$R(ABCD) \{A \rightarrow B, B \rightarrow C, CD \rightarrow A\}$

:ULLMAN BOOK

Decomposed into $R_1(AD)$, $R_2(AC)$ and $R_2(BCD)$

By CHASE TEST.

P
W

Q.2

$R(ABCDEFG) \{AB \rightarrow CD, D \rightarrow E, E \rightarrow FG\}$

Decomposed into $R_1(ABCD)$ and $R_2(DEFG)$

By CHASE TEST.

P
W

Closure of FD Set $[F]^+$

Set of all possible FD's which can be derived from given FD set is called closure of FD set. $[F]^+$

$[F]^+$ Closure of FD

R(AB)

ϕ	$A \rightarrow \phi$	$B \rightarrow \phi$	$AB \rightarrow \phi$
A	$A \rightarrow A$	$B \rightarrow A$	$AB \rightarrow A$
B	$A \rightarrow B$	$B \rightarrow B$	$AB \rightarrow B$
AB	$A \rightarrow AB$	$B \rightarrow AB$	$AB \rightarrow AB$

R(ABC)

ϕ	$A \rightarrow \phi$	$B \rightarrow \phi$
A	$A \rightarrow A$	$B \rightarrow A$
B	$A \rightarrow B$	$B \rightarrow B$
C	$A \rightarrow C$	$B \rightarrow C$
AB	$A \rightarrow AB$	$B \rightarrow AB$
BC	$A \rightarrow BC$	$B \rightarrow AC$
AC	$A \rightarrow AC$	$B \rightarrow BC$
ABC	$A \rightarrow ABC$	$B \rightarrow ABC$

R(ABC) [A → B, B → C] $[F]^+ = 43$ Ans.

Φ 0 attribute = $\phi \rightarrow \phi$

A 1 Attribute = $[A]^+ = [ABC] = 2^3$

B $[B]^+ = [BC] = 2^2$

C $[C]^+ = [C] = 2^1$

AB 2 Attribute = $[AB]^+ = [ABC] = 2^3$

BC $[BC]^+ = [BC] = 2^2$

AC $[AC]^+ = [ABC] = 2^3$

ABC 3 Attribute = $[ABC]^+ = [ABC] = 2^3$

$$[A]^+ = \left[\begin{array}{l} A \rightarrow \phi, A \rightarrow A, A \rightarrow B, A \rightarrow C \\ A \rightarrow AB, A \rightarrow BC, A \rightarrow AC, A \rightarrow ABC \end{array} \right]$$

$$[B]^+ = [B \rightarrow \phi, B \rightarrow B, B \rightarrow C, B \rightarrow BC]$$

$$[C]^+ = [C \rightarrow \phi, C \rightarrow C]$$

$$[AB]^+ = \left[\begin{array}{l} AB \rightarrow \phi, AB \rightarrow A, AB \rightarrow B, AB \rightarrow C \\ AB \rightarrow AB, AB \rightarrow BC, AB \rightarrow AC, AB \rightarrow ABC \end{array} \right]$$

$$[BC]^+ = [BC \rightarrow \phi, BC \rightarrow B, BC \rightarrow C, BC \rightarrow BC]$$

$$[AC]^+ = \left[\begin{array}{l} AC \rightarrow \phi, AC \rightarrow A, AC \rightarrow B, AC \rightarrow C \\ AC \rightarrow AB, AC \rightarrow BC, AC \rightarrow AC, AC \rightarrow ABC \end{array} \right]$$

$$[ABC]^+ = \left[\begin{array}{l} ABC \rightarrow \phi, ABC \rightarrow A, ABC \rightarrow B, ABC \rightarrow C \\ ABC \rightarrow AB, ABC \rightarrow BC, ABC \rightarrow AC, ABC \rightarrow ABC \end{array} \right]$$

R(AB) [A → B]

Φ 0 attribute = 1

A 1 Attribute = $[A]^+ [AB] = 2^2$

B $[B]^+ = [B] = 2^1$

AB 2 Attribute = $[AB]^+ = [AB] = 2^2$

1	
4	(A → Φ, A → A, A → B, A → AB)
2	(B → Φ, B → B)
4	(AB → Φ, AB → A) (AB → B, AB → AB)

11 Ans.



Any Doubt ?

**THANK
YOU!**

