COMPUTER SCIENCE

Database Management System

FD's & Normalization

Lecture_11

Vijay Agarwal sir

TOPICS TO BE COVERED

01 Lossless Join Decomposition

02 Dependency Preserving

Lossless Join Decomposition

Lossless Join : If Common Attribute of R_1 & R_2 either a Super key of R_1

OR

Super key of R_2

$$\boxed{R_1 \cup R_2 \cup R_3 \ldots \cup R_n = R}$$

CHASE TEST

11^{th} Aug YouTube.

R_1( )	–	–	–		
R_2( )			–	–	–

Q.1 R(ABC)

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

Decomposed into

Q.1 $R_1(AB)$ & $R_2(BC)$

Lossy

Q.2 R(ABC)

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

Decomposed into

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

Lossless.

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^+:
  - $R_1 \cap R_2 \rightarrow R_1$
  - $R_1 \cap R_2 \rightarrow R_2$

$\underline{X \rightarrow y}$

$$\boxed{\text{If } t1.X = t2.X \text{ then } t1.y = t2.y \text{ must be same.}}$$

Q.1 R(ABCDEFG) {AB → CD, D → E, E → FG}

Decomposed into R_1(ABCD) and R_2(DEFG)

By CHASE TEST.

AB → CD

~~D~~ → E

E → FG

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

getting a Tuple with all a entries

Lossless Join

Q.2. R(ABCDEFG) {AB → C, C → D, D → EFG}

Decomposed into R_1(ABCE) and R_2(DEFG)

By CHASE TEST.

~~AB→C~~

~~C→D~~

~~D→EFG~~

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

Not getting any one Tuple with all 'a' entries

Lossy Join

Q.3

R(ABCDE~~F~~G) {AB → C, AC → B, AD → E, B → D, BC → A, E → G}

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

$AB \to C$
~~$AC \to B$~~
~~$AD \to E$~~
~~$B \to D$~~
$BC \to A$
$E \to G$

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

getting a tuple with all 'a' entries.

Lossless

If

$t_1.x = t_2.x$ then $t_1.y = t_2.y$ Must be Same.

$x \to y$

x	y
a	a
a	a

x	y
a	b_1
a	b_1

Q.1 R(ABCDE~~F~~G) {AB → C, AC → B, AD → E, B → D, BC → A, E → CG}

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)

AB→C
AC→B
AD→E
B→D
BC→A
E→CG
E→C
E→G

	A	B	C	D	E	G
R_1(AB)	a	a	b_1	a		
R_2(BC)	...	a	a	a		
R_3(ABDE)	a	a	b_1	a	a	a
R_4(EG)			b_1		a	a

Not getting all 'a' entries wallah Tuple
Lossy Join.

Q2

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

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 $R_4(ECG)$

$AB \rightarrow C$

$AC \rightarrow B$

$AD \rightarrow E$

$B \rightarrow D$

$BC \rightarrow A$

$E \rightarrow CG$

$E \rightarrow C$

$E \rightarrow G$

	A	B	C	D	E	G
$R_1(AB)$	a	a	b_1	a		
$R_2(BC)$		a	a	a		
$R_3(ABDE)$	a	a	$\cancel{b_1}$ a	a	a	a
$R_4(ECG)$			a		a	a

getting a tuple with all 'a' entries

so lossless

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

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

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.

Decomposition

① Lossless Join

① Basic Concept

② Binary Method

③ CHASE TEST

② Dependency Preserving

Dependency Preserving Decomposition:

Let R be the Relational Schema with FD Set F is Decomposed into Sub Relations $R_1\ R_2\ R_3 \ldots R_n$ with FD Set $F_1\ F_2\ F_3 \ldots F_n$ Respectively.

If $F_1 \cup F_2 \cup F_3 \ldots \cup F_n \equiv F$

Dependency Preserving Decomposition

If $F_1 \cup F_2 \cup F_3 \ldots \cup F_n \subset F$

Dependency Not Preserved.

Dependency Preservation

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

$$\boxed{\text{if } (F_1 \cup F_2 \cup \ldots \cup F_n) = F}$$

Dependency Preserved.

first take the closure of the Attributes then Write ALL Non Trivial FD in the Respective Sub Relation.

$x \cap y = \phi$ & $x \rightarrow y$ Must Satisfy FD Defination

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 $D \rightarrow BE$. ✓ Dep. Preserved

$A \rightarrow B$
$B \rightarrow C$
$C \rightarrow D$
$D \rightarrow BE$ ✓

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

$(A)^+ = (ABCDE)$
$(B)^+ = (BCDE)$
$(C)^+ = (CDBE)$
$(D)^+ = (DBEC)$
$(E)^+ = (E)$

$R_1(AB)$	$R_2(BC)$	$R_3(CD)$	$R_4(DE)$
$A \rightarrow B$ ✓	$B \rightarrow C$	$C \rightarrow D$	$D \rightarrow E$
	$C \rightarrow B$	$D \rightarrow C$	

$A \rightarrow B,\ B \rightarrow C,\ C \rightarrow B,\ C \rightarrow D,\ D \rightarrow C,\ D \rightarrow E$

$A \rightarrow B,\ B \rightarrow C,\ C \rightarrow D\ \ D \rightarrow E\ \ D \rightarrow C,\ C \rightarrow B\ \ D \rightarrow B$

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

$R_1(AB) \cap R_2(CD)$

Lossy. (not lossless)

[MCQ: 2M]

$(A)^+ = (AB)$

$(B)^+ = (B)$

$(C)^+ = (CD)$

$(D)^+ = (D)$

(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

$R_1(AB)$	$R_2(CD)$
$A \rightarrow B$	$C \rightarrow D$

$(A \rightarrow B) \cup (C \rightarrow D)$

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

Dep. Preserved.

$\boxed{\text{Ans (C)}}$

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~~

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

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

Lossless JOIN ?

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

$(B)^+ = [BCD]$ Super key of R_2.

$R_{12}(ABC) \cap R_3(BD) = B$

$(B)^+ = [BDC]$ super key of R_3

$R_{123}(ABCD)$ Lossless Join

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

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

Dependency Preserving

$[A]^+ = [ABCD]$

$[B]^+ = [BCD]$

$[C]^+ = [CDB]$

$[D]^+ = [DBC]$

$R_1(AB)$	$R_2(BC)$	$R_3(BD)$
$A \to B$	$B \to C$	$B \to D$
	$C \to B$	$D \to B$

$A \to B,\ B \to C,\ C \to B,\ B \to D,\ D \to B.$

$\to C \to D$

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

Dependency Preserving

R(ABCD) {A→B, B→C, C→D, D→B}

R₁(AB) R₂(BC) R₃(BD)

Other Approach

$R_1(AB)$	$R_2(BC)$	$R_3(BD)$
$A \to B$	$B \to C$	$D \to B$

<u>Dependency Preserving</u>

via

$C \to D$

$C \to B$ & $B \to D$

$[C]^+ = [CDB]$ $[B]^+ = [BCD]$

FD $C \to D$, indirectly $C \to B$ Preserve in R_2

& $B \to D$ Preserved in R_3

So $C \to D$ Preserved.

<u>Dep Preserved.</u>

R(   )

$A \to E$

$R_1 \quad R_2 \quad R_3 \quad R_4$

Attribute closure $[X]^+$: Set of ALL possible Attribute which is logically determined by attribute X is called Attribute closure of X. $[X]^+$.

Closure of FD Set $[F]^+$: Set of All possible FD's which is determined by given FD Set is called Closure of FD Set.

Closure of FD Set $[F]^+$

Case ① → When NO FD Set is given in Question then find $[F]^+$

Case ② → When FD Set is given in Question then Find $[F]^+$

CASE I : When FD Set is Not given in Question then Find $[F]^+$ . .

CASE (I) When No FD Set is given then Find $[F]^+$

eg. R (AB) then Find $[F]^+$

n: # of component

ϕ

A

B

AB

n=4

$\phi \to \phi$

$\phi \to A$

$\phi \to B$

$\phi \to AB$

$A \to \phi$	$B \to \phi$	$AB \to \phi$
$A \to A$	$B \to A$	$AB \to A$
$A \to B$	$B \to B$	$AB \to B$
$A \to AB$	$B \to AB$	$AB \to AB$

$[F]^+ = 13$

$(n-1) * n + 1$

$3*4+1$

$= 13$

$[F]^+ = 13$ Ans

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) $\phi \to \phi$

ϕ	$A \to \phi$	$B \to \phi$	$AB \to \phi$
A	$A \to A$	$B \to A$	$AB \to A$
B	$A \to B$	$B \to B$	$AB \to B$
AB	$A \to AB$	$B \to AB$	$AB \to AB$

$[F]^+ = 13$ Ans

R(ABC) then Find $(F)^+$?

- ϕ
- A
- B
- C
- AB
- BC $\equiv$ CB
- AC
- ABC

$(n-1) * n + 1$

$\Rightarrow (8-1) * 8 + 1$

$\Rightarrow 7 \times 8 + 1$

$= 57$ Ans

R(ABC)

$\phi \to \phi$ + $56+1 = 57$

ϕ	$A \to \phi$	$B \to \phi$	$C \to \phi$	$AB \to \phi$	$BC \to \phi$	$AC \to \phi$	$ABC \to \phi$
A	$A \to A$	$B \to A$	$C \to A$	$AB \to A$	$BC \to A$	$AC \to A$	$ABC \to A$
B	$A \to B$	$B \to B$	$C \to B$	$AB \to B$	$BC \to B$	$AC \to B$	$ABC \to B$
C	$A \to C$	$B \to C$	$C \to C$	$AB \to C$	$BC \to C$	$AC \to C$	$ABC \to C$
AB	$A \to AB$	$B \to AB$	$C \to AB$	$AB \to AB$	$BC \to AB$	$AC \to AB$	$ABC \to AB$
BC	$A \to BC$	$B \to AC$	$C \to AC$	$AB \to BC$	$BC \to BC$	$AC \to BC$	$ABC \to BC$
AC	$A \to AC$	$B \to BC$	$C \to BC$	$AB \to AC$	$BC \to AC$	$AC \to AC$	$ABC \to AC$
ABC	$A \to ABC$	$B \to ABC$	$C \to ABC$	$AB \to ABC$	$BC \to ABC$	$AC \to ABC$	$ABC \to ABC$
	8	8	8	8	8	8	8

Case II : When FD Set is given in the Question then Find $[F]^+$.

$\boxed{R(AB) \quad [A \rightarrow B]}$ then find $(F)^+$?

2^n (n : # attribute in closure)

ϕ

A

B

AB

0 Attribute : $\phi \rightarrow \phi$ $\longrightarrow$ 1

1 Attribute $[A]^+ = [AB] \Rightarrow 2^2$ — 4 $[A \rightarrow \phi,\ A \rightarrow A,\ A \rightarrow B,\ A \rightarrow AB]$

$(B)^+ = [B] = 2^1$ — 2 $[B \rightarrow \phi,\ B \rightarrow B]$

2 Attribute $(AB)^+ = (AB) = 2^2$ — 4 $[AB \rightarrow \phi,\ AB \rightarrow A,\ AB \rightarrow B,\ AB \rightarrow AB]$

11 Ans

$\boxed{(F)^+ = 11}$ Ans

$R(ABC)$ $[A \to B,\ B \to C]$ then find $(F)^+ = ?$

$(F)^+$

ϕ, A, B, C, AB, BC, AC, ABC

0 Attribute $\Rightarrow \phi \to \phi$ $= 1$

1 Attribute:

$(A)^+ = (ABC) \Rightarrow 2^3 = 8$ $[A \to \phi,\ A \to A,\ A \to B,\ A \to C,\ A \to AB,\ A \to BC,\ A \to AC,\ A \to ABC]$

$(B)^+ = (BC) = 2^2 = 4$ $[B \to \phi,\ B \to B,\ B \to C,\ B \to BC]$

$(C)^+ = (C) = 2^1 = 2$ $[C \to \phi,\ C \to C]$

2 Attribute

$(AB)^+ = (ABC) = 2^3 = 8$ $[AB \to \phi,\ AB \to A,\ AB \to B,\ AB \to C,\ AB \to AB,\ AB \to BC,\ AB \to AC,\ AB \to ABC]$

$(BC)^+ = (BC) = 2^2 = 4$ $[BC \to \phi,\ BC \to B,\ BC \to C,\ BC \to BC]$

$(AC)^+ = (ABC) = 2^3 = 8$ $[AC \to \phi,\ AC \to A,\ AC \to B,\ AC \to C,\ AC \to AB,\ AC \to AC,\ AC \to BC,\ AC \to ABC]$

3 Attribute

$(ABC)^+ = (ABC) = 2^3 = 8$ $[ABC \to \phi,\ ABC \to A,\ ABC \to B,\ ABC \to C,\ ABC \to AB,\ ABC \to BC,\ ABC \to AC,\ ABC \to ABC]$

Total $= 43$

$\boxed{(F)^+ = 43}$ Ans

$R(ABC)\ [A \rightarrow B, B \rightarrow C]$ $\boxed{[F]^{+} = 43 \text{ Ans.}}$ Ans

ϕ	0 attribute =	$\phi \rightarrow \phi$
A	1Attribute =	$[A]^{+} = [ABC] = 2^3$
B		$[B]^{+} = [BC] = 2^2$
C		$[C]^{+} = [C] = 2^1$
AB	2Attribute =	$[AB]^{+} = [ABC] = 2^3$
BC		$[BC]^{+} = [BC] = 2^2$
AC		$[AC]^{+} = [ABC] = 2^3$
ABC	3 Attribute=	$[ABC]^{+} = [ABC] = 2^3$

$$[A]^+ = \begin{bmatrix} A \to \phi, A \to A, A \to B, A \to C \\ A \to AB, A \to BC, A \to AC, A \to ABC \end{bmatrix}$$

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

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

$$[AB]^+ = \begin{bmatrix} AB \to \phi, AB \to A, AB \to B, AB \to C \\ AB \to AB, AB \to BC, AB \to AC, AB \to ABC \end{bmatrix}$$

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

$$[AC]^+ = \begin{bmatrix} AC \to \phi, AC \to A, AC \to B, AC \to C \\ AC \to AB, AC \to BC, AC \to AC, AC \to ABC \end{bmatrix}$$

$$[ABC]^+ = \begin{bmatrix} ABC \to \phi, ABC \to A, ABC \to B, ABC \to C \\ ABC \to AB, ABC \to BC, ABC \to AC, ABC \to ABC \end{bmatrix}$$

R(AB) $[A \to B]$

ϕ 0 attribute = 1

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

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

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

$$\boxed{\begin{array}{l} 1 \\ 4 \\ 2 \\ 4 \end{array}} \begin{array}{l} \\ (A\to\phi,\ A\to A,\ A\to B,\ A\to AB) \\ (B\to\phi,\ B\to B) \\ \begin{pmatrix} AB\to\phi, AB\to A \\ AB\to B, AB\to AB \end{pmatrix} \end{array}$$

11 Ans.

Any Doubt ?

THANK YOU!