COMPUTER SCIENCE

Database Management System

FD's & Normalization

Lecture_10

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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 Super key ?

Lossless Join

$$\boxed{\begin{array}{l}\text{If } R_1 \bowtie R_2 \equiv R \\ \quad \text{Lossless Join.}\end{array}}$$

$$\boxed{\begin{array}{l}\text{If } R_1 \bowtie R_2 \supset R \\ \quad \text{Lossy Join}\end{array}}$$

$$[R_1 \cap R_2]^+ \longrightarrow R_1$$

OR

$$[R_1 \cap R_2]^+ \longrightarrow R_2 .$$

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 JOIN

$R_1(AB) \bowtie R_2(BC) \equiv$ Lossy JOIN

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

Spurious (Extra) Tuple

Q.1 R(ABC)

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

$A \to B$

$A \to C$

$\cancel{B \to A}$

$\cancel{B \to C}$

Decomposed into

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

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

(i) $R_1(AB) \cup R_2(BC) = R(ABC)$

(ii) $R_1(AB) \cap R_2(BC) = [B]$

$[B]^+ = [B]$ Not a super key of R_1

or

Not a super key of R_2

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

$R_1 \bowtie R_2 =$

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

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

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

$\Rightarrow$

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

$\equiv R$

Lossless Join

Q.2 R(ABC)

$A \to BC$

$A \to B$

$A \to C$

$\times B \to A$

$\times B \to C$

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

$R_1(AB)$ & $R_2(AC)$

(i) $R_1(AB) \cup R_2(AC) \equiv R(ABC)$

(ii) $R_1(AB) \cap R_2(AC) = A$

$(A)^+ = [ABC]$

Super key of R_1 & R_2 Both

Lossless 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 Sub Relation R_1 & R_2

$R_1 \bowtie R_2$ is Lossless

iff ① $R_1 \cup R_2 \equiv R$

② If Common Attribute of R_1 & R_2 either a super key of R_1 OR super key of R_2

$[R_1 \cap R_2]^+ \rightarrow R_1$

OR

$[R_1 \cap R_2]^+ \rightarrow R_2$

$R_1 \bowtie R_2$ is a Lossy Join.

(i) If Common Attribute of R_1 & R_2

Neither a Super key of R_1

nor

Super key of R_2.

$$[R_1 \cap R_2]^+ \not\rightarrow R_1$$

OR

$$[R_1 \cap R_2]^+ \not\rightarrow R_2$$

(ii) R(ABCD)

R_1(AB) R_2(CD) } LOSSY JOIN.

(3) R(ABCDEFGH)

R_1(ABCD) R_2(BCDG)

Lossy ∵ E, F & H Missing

Lossless – Join Decomposition

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

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

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

Q.1 $R(ABCDEFG)\ \{AB \rightarrow CD,\ D \rightarrow E,\ E \rightarrow FG\}$

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

Soln 1 $R_1(ABCD) \cup R_2(DEFG) \equiv R(ABCDEFG)$

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

$[D]^+ = [DEFG]$ 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 & Tuple (Row) Represent the sub Relations.

- Fill all the cells (Entries) / value with any variable (Assume '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 'a' is Present the write 'a' in another y.

$X \rightarrow Y$

$\boxed{\text{If } t_1.X = t_2.X \text{ then } t_1.Y = t_2.Y \text{ Must be Same.}}$

if 2 same value of X is Present but 'a' 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 'a' variable Entries (Lossless) or there is No further Updation in Table

$X \to y$

$\boxed{\text{If } t_1.X = t_2.X \text{ then } t_1.y = t_2.y \text{ Must be Same.}}$

if $X \to y$

X	y
a	

then FD is Not applied

X	y
a	a
a	a

① If any one y value is Present then insert the same y (a) value.

$X \longrightarrow y$

If 2 same value of 'X' (If X value is Repeat)

② If '0' y value is Present then Insert some other Variable (Assume 'b') instead of 'a'.

X	y
a	b
a	b

Q.1

R(ABCDEFG) {AB → CD, D → E, E → FG}

Decomposed into R_1(ABCD) and R_2(DEFG)

By CHASE TEST.

	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

so Lossless

Bcz 2 Tuples with AB value same

$X \rightarrow Y$

$AB \rightarrow CD$

$D \rightarrow E$

$E \rightarrow FG$

Q.2. R(ABCDEFG) {AB → C, C → D, D → 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

or

not a super key of R_2

Lossy Join

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

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

$R_1(ABCDE) \cap R_2(BEFG) \Rightarrow [BE]$

$(BE)^+ = (BE]$ Not a Super Key of R_1

Not S.K of R_2.

$(B)^+ =$

$(E)^+ =$

Lossy Join.

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

$R(ABC)\quad (DEFG)$

$R_1(ABC) \cap R_2(DEFG)$ = No Common Attribute.

<u>Lossy Join</u>

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

Decomposed into R_1(ABCE) and R_2(DEFG)

By CHASE TEST.

$X \rightarrow y$

~~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 a tuple with all 'a' entries.

Lossy Join

Q. R(ABCDE 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)

Sol^n

X → y

	A	B	C	D	E	G
R1(ABC)	a	a	a	a	a	a
R2(ACDE)	a	a	a	a	a	a
R3(ADG)	a			a	a	a

× AB → C

✓ AC → B

✓ AD → E

✓ B → D

BC → A

E → G

Q. R(ABCDE 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)

Sol^n

$R_1(ABC) \cap R_2(ACDE) = AC$

$(AC)^+ = [ACB.......]$ Super key of R_1.

$R_{12}(ABCDE) \cap R_3(ADG) = AD$

$(AD)^+ = [ADEG]$ Super key of R_3.

$R_{123}(ABCDEG)$ Lossless Join

$R_1(ABC)$ $R_2(ACDE)$ $R_3(ADG)$

$R_{12}(ABCDE)$ $R_3(ADG)$

$R_{123}(ABCDEG)$ Lossless Ans

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

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 $R_4(ECG)$

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

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

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

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

$(AB)^+ = [AB\ldots\ldots]$ super key R_1

So Join $R_{13}(ABDE$

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

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 $R_4(ECG)$

$R_{13}(ABDE)$ $R_2(BC)$ $R_4(EG)$

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

$(E)^+ = [ECG]$ Super key of R_4.

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

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

Lossy Join

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

$R_{13}(ABDE)$ $R_2(BC)$ $R_4(EG)$

$R_{134}(ABDEG)$ $R_2(BC)$

Can not Join } LOSSY Join.

Q $R(ABCD)$ $[A \to B,\ B \to C,\ CD \to A]$

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

Q.

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

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 $R_4(ECG)$

	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

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

Q.

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

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 $R_4(ECG)$

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

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

$(B)^+ = (BD)$ Not a super key of R_1 & R_2.

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

$(AB)^+ = (AB\ldots\ldots)$ super key of R_1

$R_{13}(ABDE)$

Q. R(ABCDE 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 $R_4(ECG)$

$R_{13}(ABDE)$ $R_2(BC)$ $R_4(ECG)$

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

$(E)^+ = [ECG]$ Super key of R_4.

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

$(BC)^+ = (BC \ldots]$ Super key of R_2

$R_{1234}(ABCDEG)$ Lossless

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

$R_{13}(ABDE)$ $R_2(BC)$ $R_4(ECG)$

$R_{134}(ABCDEG)$ $R_2(BC)$

$R_{1234}(ABCDEG)$ Lossless Join.

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.

Dependency Preservation

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

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

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

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

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

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.

Q.2 $R(ABCDEFG)\ \{AB \to CD,\ D \to E,\ E \to FG\}$

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

By CHASE TEST.

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) $[A \to B, B \to C]$ $[F]^{+} = 43$ Ans.

ϕ	0 attribute =	$\phi \to \phi$
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) $[A \rightarrow B]$

ϕ 0 attribute = 1

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

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

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

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

11 Ans.

Any Doubt ?

THANK YOU!