COMPUTER SCIENCE

Database Management System

FD's & Normalization

Lecture_10

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TOPICS TO BE COVERED

01 Dependency preserving

02 Normal Forms

Lossless Join

① BASIC CONCEPT

$R_1 \bowtie R_2 \equiv R$

Lossless Join

If $R_1 \bowtie R_2 \supset R$

lossy join.

Lossless Join

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

OR

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

If Common Attribute either a super key of R_1

or

Super key of R_2.

Lossless Join

1. BASIC CONCEPT
2. Binary Method (Successive Approach)
3. CHASE TEST.

Q R(ABC) [A → B]

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

Sol^n

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

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

$(A)^+ = [A\underline{B}]$ Super key of R_1

Lossless Join

R(ABC) (A → B)

$R_1(AB)$ & $R_2(BC)$

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

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

$(B)^+ = (B)$ Not Super key of R_1 & R_2

Lossy Join

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

Decomposed into R_1(ABCD) and R_2(DEFG)

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

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

$\{D\}^+ = (DEFG)$ Super key of R_2

Lossless Join

CHASE TEST :

In the CHASE TEST we Create a Matrix in which Row(Tuple) Represent the Sub Relation & Column Represent ~~the~~ Attributes

- Fill all the Cells (Entries) with (any variable) 'a' in the Corresponding Attribute of Corresponding Sub Relation.

Now Fill the table (Entries) with the Help of given FD.

for $\underline{X \rightarrow y}$ (FD): If 2 Attribute value of X is Present & One y value is Present the Insert (write) the same Variable 'a' in that y.

If in $\underset{FD}{\underline{X \to Y}}$: If 2 same value of X is present & 0 value of Y is present then write some other variable (Assume b instead of a)

OR
Note If Two same value of X is Not present then that FD Not Applied

Note If we get any Table (One any Tuple) with all 'a' entries then Lossless Join Decomposition.

Note CHASE TEST will stop either we get a Tuple with all 'a' entries OR their is a No further Updation in Table then CHASE TEST Stop.

If $\underline{t_1.X = t_2 X}$ then $\underline{t_1 y = t_2 y}$
Must be same.

$X \rightarrow y$ (If 2 same value of X is Present)

$\boxed{X \rightarrow y}$

X	y
1 →	RAM
1 →	RAM

→ If One value of y ['a'] is Present the write the same value 'a'.

X	y
1 →	a
1	a

→ If '0' value of y is Present then write some other variable 'b' instead of 'a'.

X	y
1	b
1	b

Q.1

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

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

By CHASE TEST.

$X \to y$

if $t_1.X = t_2.X$ then $t_1.y = t_2.y$ must be same

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

✗ $AB \to CD$

✓ $D \to E$

✓ $E \to FG$

One Table With all 'a' Entries

Lossless

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

Decomposed into R_1(ABCE) and R_2(DEFG)

By CHASE TEST.

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

✗ AB → C

✗ C → D

✗ D → EFG

Not getting a Tuple with all 'a' entries

So Lossy Join.

Q.

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

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

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

✗ $AB \rightarrow C$

✓ $AC \rightarrow B$

✓ $AD \rightarrow E$

✓ $B \rightarrow D$

✓ $BC \rightarrow A$

✓ $E \rightarrow G$

all 'a' entries

Lossless.

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

$R_1(AD)$ $R_2(AC)$ $R_3(BCD)$ By CHASE TEST.

		A	B	C	D
(AD)	R_1	a	$\cancel{b_1}$ a	a	a
(AC)	R_2	a	$\cancel{b_1}$ a	a	
(BCD)	R_3	a	a	a	a

1) $A \to B$

$B \to C$

$CD \to A$

One Tuple with all 'a' entries

so lossless

Q.

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

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 $R_4(ECG)$

Soln :

$\underline{R_1(AB)} \cap \underline{R_2(BC)} = B$ $\quad [B]^+ = [BD]$ Not super key of R_1 & R_2

Can not Join.

$R_1(\underline{AB}) \cap R_3(ABDE) = \underline{AB}$

$(AB)^+ = [ABCDEG]$ Super key of R_1 & R_3

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

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

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

$(B)^+ = [BD]$ Not Super key of R_{134} & 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. $R(ABCDEG)$ $\{AB \to C, AC \to B, AD \to E, B \to D, BC \to A, E \to CG\}$

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 $R_4(ECG)$

Soln 2

$R_1(AB) \cap R_2(BC) = B \Rightarrow (B)^+ = (BD)$ Not Super key of R_1 & R_2 So Cannot Join.

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

$(AB)^+ = (ABCDEG)$ Super key of R_1 & R_3

$R_{13}(ABDE) \cap R_4(ECG) = (E) \Rightarrow (E)^+ = [ECG]$ Super key of R_4

$R_{134}(ABCDEG) \cap R_2(BC) = (BC) \Rightarrow (BC)^+ = (BCADEG)$ Super key of R_2 & R_{134}

$R_{1234}(ABCDEG)$ Lossless Join

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

$R_2 \cap R_4 = C$

$[C]^+ = [C]$

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

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

$R_{1234}(ABCDEG)$ Lossless Join

Q.

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

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 $R_4(ECG)$

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 $\overset{R_1}{(A, B)}$, $\overset{R_2}{(B, C)}$, $\overset{R_3}{(B, D)}$ [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

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

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

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

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

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

$(B)^+ = [BCD]$ Super key of R_3

$R_{123}(ABCD)$ 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.

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.

$R(PQSTXYZW)$ $[PQ \to X,\ P \to YX,\ Q \to Y,\ Y \to ZW]$

D_2: $R_1(PQST)$ $R_2(PTX)$ $R_3(QY)$ $R_4(YZW)$

		P	Q	S	T	X	Y	Z	W
(PQST)	R_1	a	a	a	a	a	a	a	a
(PTX)	R_2	a			a	a	a	a	a
(QY)	R_3		a				a	a	a
(YZW)	R_4						a	a	a

$P \to Y$
$P \to X$

$Y \to ZW$

Ullman

Q R(ABCDE) (B → E, CE → A)

$R_1(ABC)$ $R_2(BCD)$ $R_3(ACE)$

		A	B	C	D	E
(ABC)	R_1	a	a	a		b_1
(BCD)	R_2	a	a	a	a	b_1
(ACE)	R_3	a		a		a

Lossy

B → E

CE → A

B → E

$R(PQSTXYZW)$ $\{PQ \to X \quad P \to YX, \quad Q \to Y, \quad Y \to ZW\}$

D: $R_1(PQST)$ $R_2(PTX)$ $R_3(QY)$ $R_4(YZW)$

$R_1(PQST) \cap R_2(PTX) \Rightarrow PT$

$[PT]^+ = [\underline{PT}Y\underline{X} \ldots]$ Super key of R_2

$R_{12}(PQSTX) \cap R_3(QY) = Q$

$[Q]^+ = [\underline{Q}Y \ldots\ldots]$ Super key of R_3

$R_{123}(PQSTXY) \cap R_4(YZW) = Y$

$[Y]^+ = [YZW]$ Super key of R_4

$R_{1234}(PQSTXYZW)$ Lossless Join

$R(PQSTXYZW)$ $\{PQ \to X,\ P \to YX,\ Q \to Y,\ Y \to ZW\}$

D_2: $R_1(PQS)$ $R_2(TX)$ $R_3(QY)$ $R_4(YZW)$

$R_1(PQS) \cap R_2(TX)$ = No Common Attribute

$R_1(PQS) \cap R_3(QY) = Q$

$(Q)^+ = (QY \ldots)$ super key of R_3

$R_{13}(PQSY) \cap R_4(YZW) = Y$

$(Y)^+ = [YZW]$ super key of R_4

$R_{134}(PQSYZW) \cap R_2(TX)$: No Common Attribute

Lossy

$R_3(QY) \cap R_4(YZW) = Y$

$(Y)^+ = (YZW)$ S.K of R_4

$R_{34}(QYZW) \cap R_1(PQS) = Q$

$(Q)^+ = (QYZW)$ S.K of R_{34}

$R_{134}(PQSYZW) \cap R_2(TX)$

Lossy / (No Common Attribute)

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 Preserving Decomposition

Let R be the Relational schema with FD Set F

is Decomposed into sub Relation $R_1\ R_2\ R_3 \ldots R_m$

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.

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

Dependency Not Preserving.

Dependency Preservation

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

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

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 Preserving.

Process to check D.P

first take the closure of all individual Attribute

then Write Non Trivial in the Respective Sub Relation

then

$$\boxed{\text{If } F_1 \cup F_2 \cup F_3 \ldots \cup F_n \equiv F \quad \text{Dependency Preserving.}}$$

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

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

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

$(D)^+ = (DBEC)$

$(D)^+ = (DCB)$

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

$\Downarrow$

$D \to B$

$D \to E$

$D \to BE$

Dependency Preserved.

$(A)^+ = (ABCDE)$

$(B)^+ = (BCDE)$

$(C)^+ = (CDBE)$

$(D)^+ = (DBEC)$

$(E)^+ = (E)$

F1	F2	F3	F4
$R_1(AB)$	$R_2(BC)$	$R_3(CD)$	$R_4(DE)$
$A \to B$	$B \to C$ $C \to B$	$C \to D$ $D \to C$	$D \to E$

$(A \to B) \cup (B \to C,\ C \to B) \cup (C \to D,\ D \to C) \cup D \to E$

$A \to B,\ B \to C,\ C \to D,\ \boxed{D \to C,\ C \to B,\ D \to E}$

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]

$(B)^+ = (B)$
$(D)^+ = (D)$
$(A)^+ = (AB)$
$(C)^+ = (CD)$

(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

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

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

Dep. Preserved

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

Lossy (No Common Attribute)

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

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

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

$(A)^+ = \{ABCD\}$

$(B)^+ = \{BCD\}$

$(C)^+ = \{CDB\}$

$(D)^+ = \{DBC\}$

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

$(A \to B) \cup (B \to C,\ C \to B) \cup (B \to D,\ D \to B)$

$A \to B,\ B \to C,\ D \to B,\ \dfrac{C \to B,\ B \to D}{C \to D}$

Dep. Preserved

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

Alternate method

VIA

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

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

$\boxed{C \to D}$

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

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

So

$C \to D$ Indirectly Preserved in $C \to B$ in R_2 & $B \to D$ in R_3.

Any Doubt ?

THANK YOU!