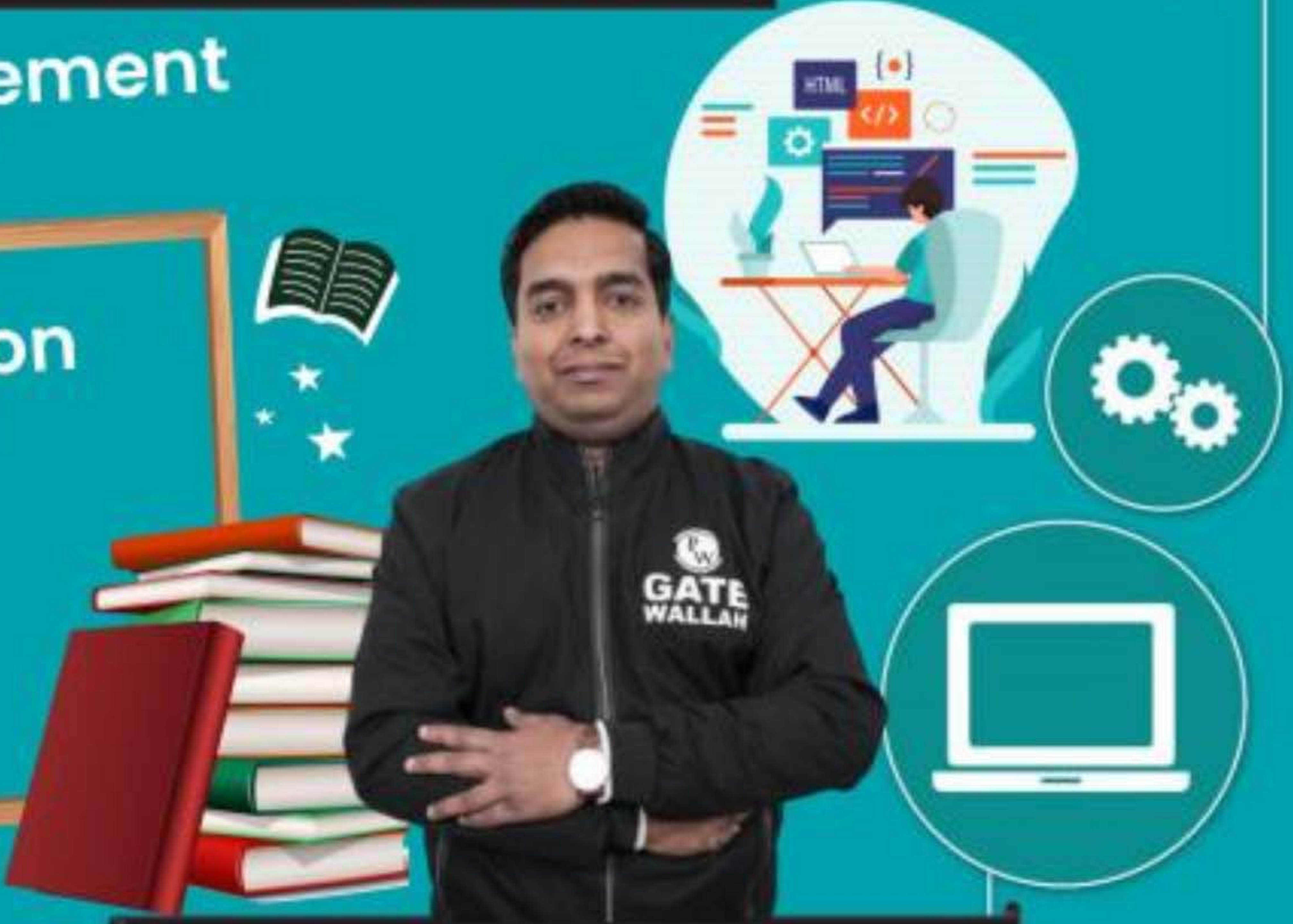
COMPUTER SCIENCE

Database Management System

FD's & Normalization

Properties of Decomposition-2

Lecture_08



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TOPICS TO BE COVERED

01 Lossy and Lossless Join

02 Dependency preserving

1. RDBMS Concept
2. FD Concept & Types.
3. Attribute closure.
4. Super key
5. Candidate key
6. finding Multi Candidate key
7. Membership set
8. Equality b/w 2 FD Set
9. Minimal Cover
10. Finding Number of Super keys.

Candidate key : minimal of super key.

$R(ABCDE)$ $\{AB \to C,\ C \to D,\ D \to E\}$

$(AB)^+ = [ABCDE]$

AB is candidate key

If $X_{\text{Attribute}} \to [\text{Prime Attribute}]$

n: # of Attributes.

Total Maximum Number of Super key $= 2^n - 1$

4 Attribute $= 2^4 - 1 = 15$

Maximum Number of Candidate key $= {}^{n}C_{\lfloor \frac{n}{2} \rfloor}$

6 Attribute

c.k

$^6C_1 = 6$

$^6C_2 = 15$

$^6C_3 = 20$

$^6C_4 = 15$

$^6C_5 = 6$

$^6C_6 = 1$

n is # of Attribute

$$^nC_{\lfloor \frac{n}{2} \rfloor} \Rightarrow {}^6C_{\lfloor \frac{6}{2} \rfloor}$$

$$\Rightarrow {}^6C_3$$

Properties of Decomposition

1. Lossless Join Decomposition

2. Dependency Preserving Decomposition

① Lossless Join Decomposition : Let R be the Relational Schema with instances r, is decomposed into sub Relations $R_1, R_2, R_3 \ldots R_m$ with instance $r_1\ r_2\ r_3 \ldots r_m$ respectively.

$\bowtie$: Natural Join

If $r_1 \bowtie r_2 \bowtie r_2 \ldots\ldots \bowtie r_m \equiv r$

Lossless Join Decomposition.

If $r_1 \bowtie r_2 \bowtie r_3 \ldots\ldots \bowtie r_m \supset r$

Lossy Join Decomposition.

Natural Join ($\bowtie$) $R \bowtie S$

Step1: CROSS PRODUCT (Cartesian Product) of R & S.

R	S
n_1 Tuple	n_2 Tuple
C_1 Attributes	C_2 Attributes

$R \times S$: $n_1 \times n_2$ Tuple, $C_1 + C_2$ Attribute

Step2: Select the tuples which Satisfy equality Condition on ALL Common Attribute of R & S. (FROM $R \times S$)

Step3: Projection of Distinct Attribute.

Q. R(ABC)

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

Decomposed into

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

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

R_1: 3 Tuples, 2 Attribute

R_2: 3 Tuples, 2 Attribute

$R_1 \times R_2$ = 3 × 3 = 9 Tuples
2 + 2 = 4 Attribute

R_1

A	B
1	5
2	5
3	8

R_2

B	C
5	5
5	8
8	8

Step 1

$R_1.B = R_2.B$

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

Step2

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

Step3: Projection of Distinct Attribute.

$R_1 \bowtie R_2$

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

Lossy Join Decomposition.

Spurious (Extra) Tuple

∴ Lossy Join.

Q. R(ABC)

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

Decomposed into

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

$\boxed{\text{Q.2 } R_1(AB) \text{ \& } R_2(AC)}$

$R_1(AB)$

A	B
1	5
2	5
3	8

3 Tuples
2 Attribute

$R_2(AC)$

A	C
1	5
2	8
3	8

3 Tuples
2 Attribute

$R_1 \times R_2 = 3 \times 3 = 9$ Tuples

$2+2 = 4$ Attributes.

$R_1.A$	$R_1.B$	$R_2.A$	$R_2.C$
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

Step 3 : Projection of Distinct Attributes.

Step 2

R_1A	R_1B	R_2A	R_2C
1	5	1	5
2	5	2	8
3	8	3	8

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

$R_1 \bowtie R_2$

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

$\boxed{\text{Lossless Join}}$ Ans

Lossless Join Decomposition

Method.

1. Binary Method (Successive Method)
2. Chase Test (Matrix Method)

Lossless Join Decomposition

Let R be the Relational Schema With FD Set F, is Decomposed into Sub Relation R_1, R_2 then

$R_1 \bowtie R_2$ 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.

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

OR

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

$R_1 \bowtie R_2$ is Lossy Join iff

① 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

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

② $R(ABCD)$

$R_1(AB)$ $R_2(CD)$

Lossy Join Because No Common Attribute

③ $R(ABCDE)$

$R_1(ABC)$ $R_2(BCD)$

Lossy Join Because Attribute 'E' Missing

Q1 $R(ABC)$ $[A \rightarrow B]$

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

Sol^n 1

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

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

$[A]^+ = [AB]$ Super key of R_1

$\boxed{\text{Lossless Join Decomposition}}$

Q2 $R(ABC)$ $[A \rightarrow B]$

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

Sol^n

$R_1(AB) \cup R_2(BC) \equiv R(ABC)$

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

$[B]^+ = [B]$ Neither super key of R_1 nor super key of R_2

$\boxed{\text{Lossy Join Decomposition}}$

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^+:
  - $\boxed{(R_1 \cap R_2)^+ \rightarrow R_1}$
  - $\boxed{(R_1 \cap R_2)^+ \rightarrow R_2}$

Q.1

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

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

Sol^n 1

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

(ii) $R_1(ABCD) \cap R_2(DEFG) \Rightarrow [D]$

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

$\boxed{\text{Lossless Join.}}$

CHASE METHOD (MATRIX)

R(ABCDEFG) (AB → CD, D → E, E → FG)

R₁(ABCD) R₂(DEFG)

$t_1.x = t_2.x$ then $t_1.y = t_2.y$ must be same

× AB → CD

✓ D → E

✓ E → FG

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

getting a Tuple with all 'a' entries so

its Lossless

Q. 2

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

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

$R_1(ABCE) \cap R_2(DEFG) = [E]$

$(E)^+ = [E]$

Lossy Join Decomposition

Q.3 $R(ABCDEG)\ \{AB \to C, AC \to B, AD \to E, B \to D, BC \to A, E \to G\}$

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

$R_1(ABC) \cap R_2(ACDE) = (AC)^+ = [ACB.DEG.]$

Super key of R_1 & R_2 also.

$R_{12}(ABCDE) \cap R_3(ADG) = (AD)^+ = [ADEG..]$

Super key of R_3.

$R_{123}(ABCDEG)$

Lossless Join

P.T.O

$R_2 \cap R_3$

or

$R_1 \cap R_3$

Q.3

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

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

OR

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

$R_1(ABC) \cap R_3(ADG) = A \Rightarrow [A]^+ = [A]$ Can not Join R_1 & R_3.

$R_2(ACDE) \cap R_3(ADG) = AD \Rightarrow [AD]^+ = [\underline{AD}E\underline{G}]$ Super key of R_3

$R_1(ABC) \cap R_{23}(ACDEG) \Rightarrow [AC] \Rightarrow [AC]^+ = [ACB.DEG]$

Super key of R_1 & R_{23} also

$R_{123}(ABCDEG)$

Lossless Join

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 $R_4(ECG)$

Sol^n 2

$R_1(AB) \cap R_2(BC) \Rightarrow B \Rightarrow (B)^+ = [BD]$ Can not Join.

$R_1(AB) \cap R_3(ABDE) = AB \Rightarrow [AB]^+ = [AB.C.D.E.G]$ super key of R_1 & R_3 also

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

$R_{134}(ABCDEG) \cap R_2(BC) \Rightarrow [BC] \Rightarrow (BC)^+ = [BC \ldots]$ super key of R_2

$R_{1234}(ABCDEG)$

lossless

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.

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

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

[redacted]

$R_1(AB) \cap R_3(ABDE) \Rightarrow (AB)^+ = (ABCDEG)$ super key of R_1 & R_3 also

$R_{13}(ABDE) \cap R_4(EG) = (E) = (E)^+ = (ECG)$ super key of R_4

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

Not a super key of R_{134} nor R_2

Lossy Join

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

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

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

Cannot Join

Lossy 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.

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

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

Lossy

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

$R_1(AB) \cap R_2(BC) = B \Rightarrow [B]^+ = [BCD]$ s.k of R_2

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

$R_{12}(ABC) \cap R_3(BD) = (B) \Rightarrow [B]^+ = [BCD]$ s.k of R_3

[MCQ: 2M]

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

lossless Join

(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

Any Doubt ?

THANK YOU!