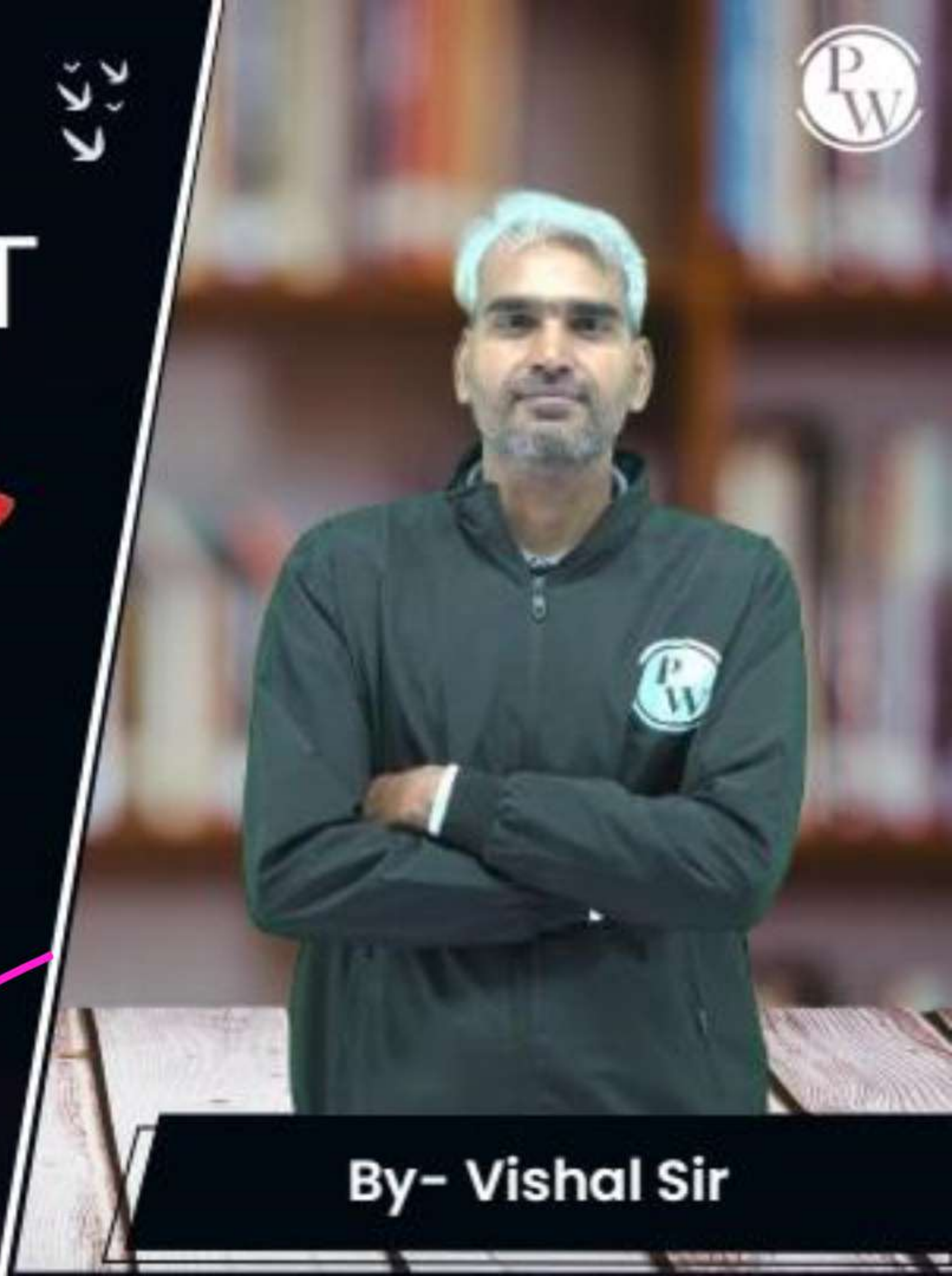
Computer Science & IT

Database Management System

Relational Model & Normal Forms

Lecture No. 10



Recap of Previous Lecture

Topic Schema refinement (Normalization)

Topic Problems because of redundancy in a relation

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Topics to be Covered

Topic Properties of decomposition

Topic Dependency preserving decomposition

Topic Lossless join decomposition

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Topic : Properties of decomposition

While decomposing a relational table into sub-relations following must be ensured

i.e., After decomposition there should not be any loss of information

- neither in terms of functional dependency
- Nor, in terms of data (tuple)

① Decomposition must be dependency preserving:

All the functional dependencies present in the original relation must be preserved even after the decomposition into sub-relations.

② Decomposition must be lossless join decomposition:-

i.e., if we perform the natural join ($\bowtie$) of all the sub-relations then we must get the exact same tuples as original relation.

Topic : Properties of decomposition

Properties of decomposition

Dependency Preserving decomposition

Let Relation R with FD set F is decomposed into sub-relations $R_1, R_2, \ldots R_N$ with FD sets $F_1, F_2, \ldots F_N$ respectively

i.e. $R(F)$ → $R_1(F_1)$, $R_2(F_2)$ . . . . . $R_N(F_N)$

In general

$$F_1 \cup F_2 \cup \ldots \cup F_N \subseteq F$$

(i) if $F_1 \cup F_2 \cup \ldots \cup F_N = F$, then dep. preserving decomposition

(ii) if $F_1 \cup F_2 \cup \ldots \cup F_N \subset F$, then not dep. preserving

(iii) $F_1 \cup F_2 \cup \ldots \cup F_N \supset F$ (Not possible)

Lossless join decomposition

Let relation R with FD set F is decomposed into sub-relations $R_1, R_2, \ldots R_N$ with FD sets $F_1, F_2, \ldots, F_N$ respectively

i.e. $R(F)$ → $R_1(F_1)$, $R_2(F_2)$ . . . . $R_N(F_N)$

in general, $R_1 \bowtie R_2 \bowtie \ldots \bowtie R_N \supseteq R$

(i) if $R_1 \bowtie R_2 \ldots \bowtie R_N = R$ then lossless Join

(ii) if $R_1 \bowtie R_2 \ldots \bowtie R_N \supset R$, then lossy join

(iii) $R_1 \bowtie R_2 \bowtie \ldots \bowtie R_N \subset R$ (Not Possible)

Topic : Dependency preserving decomposition

- Let R be the relation with FD set F, and it is decomposed into sub-relations $R_1, R_2, \ldots R_N$ with FD sets $F_1, F_2, \ldots F_N$ respectively.

In general $F_1 \cup F_2 \cup \ldots \cup F_N \subseteq F$

1. if $= F$ then dep. preserving
2. if $\subset F$ then not dep. preserving
3. $\supset F$ is not possible

Q. Let $R(A, B, C, D)$ be the relational schema with FD set $F = \{A \to B,\ B \to C,\ C \to D,\ D \to A\}$ is decomposed into Sub-relation $R_1(A, B)$, $R_2(B, C)$, and $R_3(C, D)$.

Check whether the decomposition is dependency preserving or not?

$R(A, B, C, D) \quad F = \{A \to B,\ B \to C,\ C \to D,\ D \to A\}$

$R_1(A, B)$

✓ $F_1 = ?$

$(A)^+ = \{\cancel{A}, B, C, D\} \quad \therefore A \to B$

$(B)^+ = \{\cancel{B}, C, D, A\} \quad \therefore B \to A$

trivial

Not in relation

$\therefore F_1 = \left\{ \begin{array}{l} A \to B \\ B \to A \end{array} \right\}$

$R_2(B, C)$

$F_2 = ?$

$(B)^+ = \{\cancel{B}, C, \cancel{D}, \cancel{A}\} \quad \therefore B \to C$

$(C)^+ = \{\cancel{C}, \cancel{D}, \cancel{A}, B\} \quad \therefore C \to B$

$F_2 = \left\{ \begin{array}{l} B \to C \\ C \to B \end{array} \right\}$

$R_3(C, D)$

$F_3 = ?$

$(C)^+ = \{\cancel{C}, D, \cancel{A}, \cancel{B}\} \quad \therefore C \to D$

$(D)^+ = \{\cancel{D}, \cancel{A}, \cancel{B}, C\} \quad \therefore D \to C$

$F_3 = \left\{ \begin{array}{l} C \to D \\ D \to C \end{array} \right\}$

$F_1 \cup F_2 \cup F_3 = \{ A \to B,\ B \to C,\ C \to D,\ B \to A,\ C \to B,\ D \to C \}$

$F = \{ A \to B,\ B \to C,\ C \to D,\ D \to A \}$

- We need to identify the relationship b/w F & $F_1 \cup F_2 \cup F_3$

① Check if F Covers $F_1 \cup F_2 \cup F_3$

i.e, Check if $F_1 \cup F_2 \cup F_3 \subseteq F$

We don't need to check if F Covers $F_1 \cup F_2 \cup \ldots \cup F_N$ or not

i.e, $F_1 \cup F_2 \cup F_3 \subseteq F$ will always hold true

↳ eqn ①

② Check if $F_1 \cup F_2 \cup F_3$ Covers F

FD of set F	Remark	Conclusion
$A \to B$	Directly available in $F_1 \cup F_2 \cup F_3$	$F_1 \cup F_2 \cup F_3$ Covers F. $F \subseteq F_1 \cup F_2 \cup F_3$ ↳ eqn ②
$B \to C$	directly available	
$C \to D$	directly available	
$D \to A$	$(D)^+$ w.r.t $F_1 \cup F_2 \cup F_3 = \{D, C, B, A\}$; $A \in (D)^+$, ∴ $D \to A$ is a member of $F_1 \cup F_2 \cup F_3$	

By eqn ① & eqn ② $\boxed{F_1 \cup F_2 \cup F_3 = F}$ ∴ Dep. preserving decomposition.

Q: Let $R(A,B,C,D)$ be the relational schema with FD set $F = \{AB \to CD,\ D \to A\}$, if relation R is decomposed into two sub-relations $R_1(A,D)$ & $R_2(B,C,D)$, then Check whether the decomposition is dep. preserving or not?

$$
\begin{tikzcd}
 & R(A,B,C,D) \arrow[dl] \arrow[dr] & \\
R_1(A,D) & & R_2(B,C,D)
\end{tikzcd}
$$

$R_1(A,D)$:

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

$(D)^+ = \{\cancel{D}, A\}$

$F_1 = \{D \to A\}$

$R_2(B,C,D)$:

$(B)^+ = \{\cancel{B}\}$, $(C)^+ = \{\cancel{C}\}$, $(D)^+ = \{\cancel{D}, \cancel{A}\}$

$(BC)^+ = \{\cancel{B}, \cancel{C}\}$, $(BD)^+ = \{\cancel{B}, \cancel{D}, \cancel{A}, C\}$

$(CD)^+ = \{\cancel{C}, \cancel{D}, \cancel{A}\}$

$F_2 = \{BD \to C\}$

$F_1 \cup F_2 = \{D \rightarrow A,\ BD \rightarrow C\}$

① F covers $F_1 \cup F_2$ $\therefore$ $F_1 \cup F_2 \subseteq F$ — eqⁿ ①

② Check if $F_1 \cup F_2$ covers F.

FDs of F	
$D \rightarrow A$	Directly available
$AB \rightarrow CD$	$(AB)^+$ w.r.t $F_1 \cup F_2 = \{\underbrace{A, B}\}$

↳ C & D are not present

$\therefore$ $AB \rightarrow CD$ is not a member of $F_1 \cup F_2$

i.e. $\boxed{F_1 \cup F_2 \subset F}$ Hence not dep. preserving

Q: Let $R(A, B, C, D, E, F)$ be the relation with FD set

$$F = \begin{Bmatrix} AB \rightarrow C, & AC \rightarrow B, & BC \rightarrow A, \\ B \rightarrow D, & AD \rightarrow E, & E \rightarrow F \end{Bmatrix}$$

Which of the following decomposition of R is a dependency Preserving decomposition

(i) $D_1 = \{R_1(A, B, C),\ R_2(A, C, D, F),\ R_3(A, D, F)\}$

(ii) $D_2 = \{R_1(A, B, C),\ R_2(A, B, D, E),\ R_3(E, F)\}$

$F = \{ AB \to C,\ AC \to B,\ BC \to A,\ B \to D,\ AD \to E,\ E \to F \}$

(i) $D_1 = \{ R_1(A, B, C),\quad R_2(A, C, D, F)\quad R_3(A, D, F) \}$

$F_1 = \{ AB \to C,\ AC \to B,\ BC \to A \}$

$F_2 = \{ AC \to DF,\ AD \to F,\ ACD \to F \}$

$F_3 = \{ AD \to F \}$

FDs of F: $\{$

$AB \to C$ Preserved in $F_1 \cup F_2 \cup F_3$

$AC \to B$ — " —

$BC \to A$ — " —

$B \to D$ $(B)^+$ w.r.t. $F_1 \cup F_2 \cup F_3 = \{B\}$ ∴ $B \to D$ is lost

$AD \to E$ $(AD)^+$ w.r.t. $F_1 \cup F_2 \cup F_3 = \{A, D, F\}$ → E is not present ∴ $AD \to E$ is lost

$E \to F$ $(E)^+$ w.r.t. $F_1 \cup F_2 \cup F_3 = \{E\}$ ∴ $E \to F$ is lost

lost FDs

∴ Not dependency Preserving

$$F = \{ AB \to C,\ AC \to B,\ BC \to A,\ B \to D,\ AD \to E,\ E \to F \}$$

(ii) $D_2 = \{ R_1(A,B,C),\ R_2(A,B,D,E),\ R_3(EF) \}$

$F_1 = \{ AB \to C,\ AC \to B,\ BC \to A \}$ $F_2 = \{ B \to D,\ AD \to E, \}$ $F_3 = \{ E \to F \}$

All FDs of set F are directly available in $F_1 \cup F_2 \cup F_3$

$\therefore F_1 \cup F_2 \cup F_3 = F$

Hence, "D_2" is dependency preserving decomposition

Home Work :

Read about following relational algebra operations.

1. Projection (π)
2. Selection (σ)
3. Cross Product / Cartesian Product ($\times$)
4. Natural Join

2 mins Summary

Topic Properties of decomposition

Topic Dependency preserving decomposition

Topic Lossless join decomposition

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THANK - YOU

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