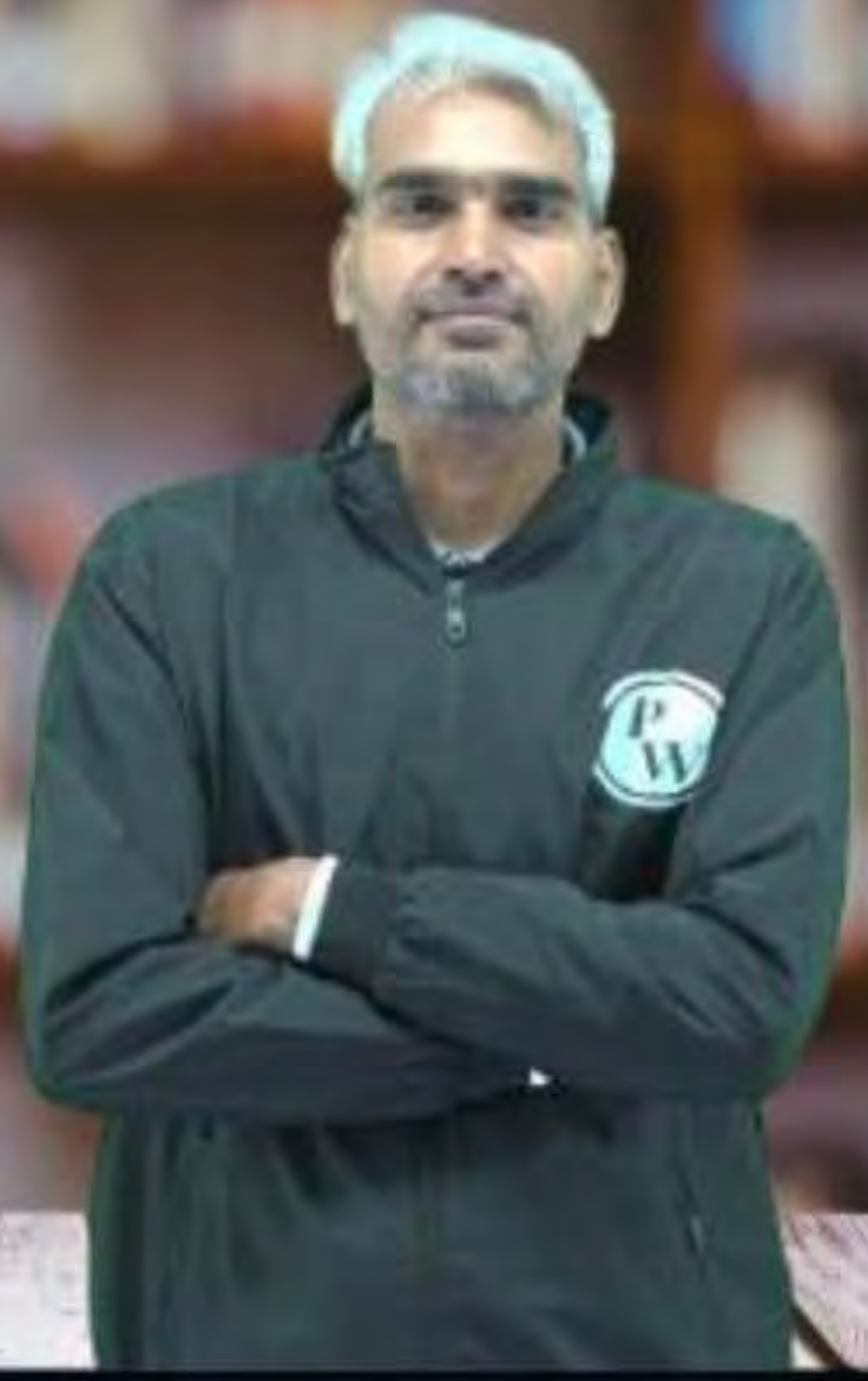
Computer Science & IT

Database Management System

Relational Model & Normal Forms

Lecture No. 08



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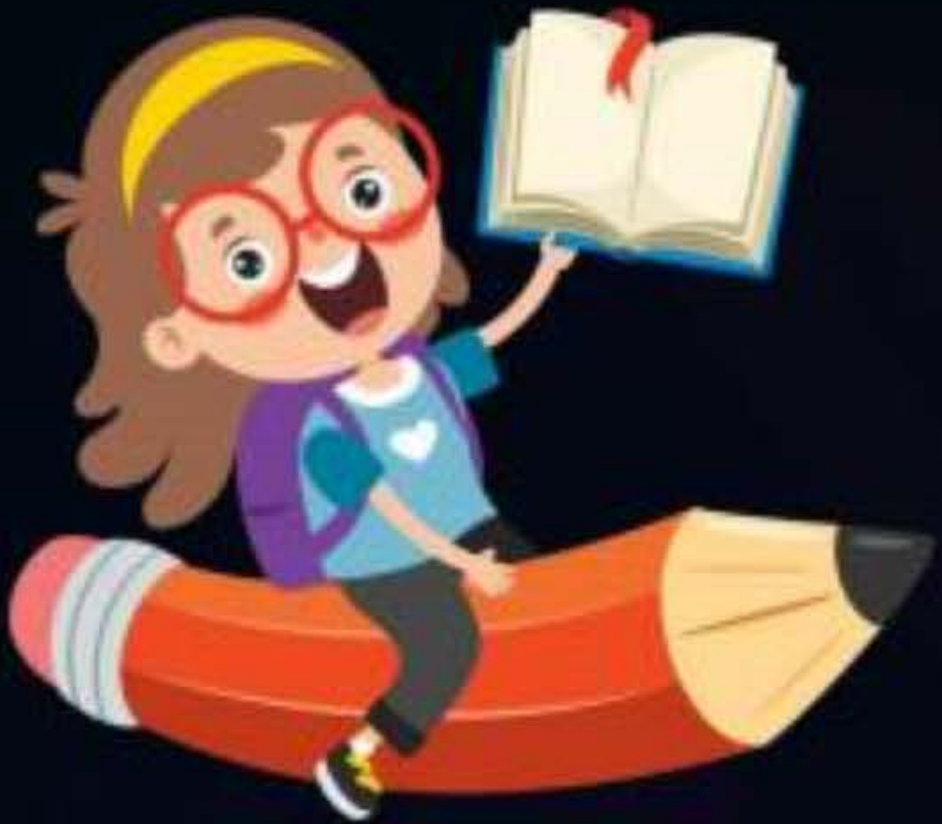
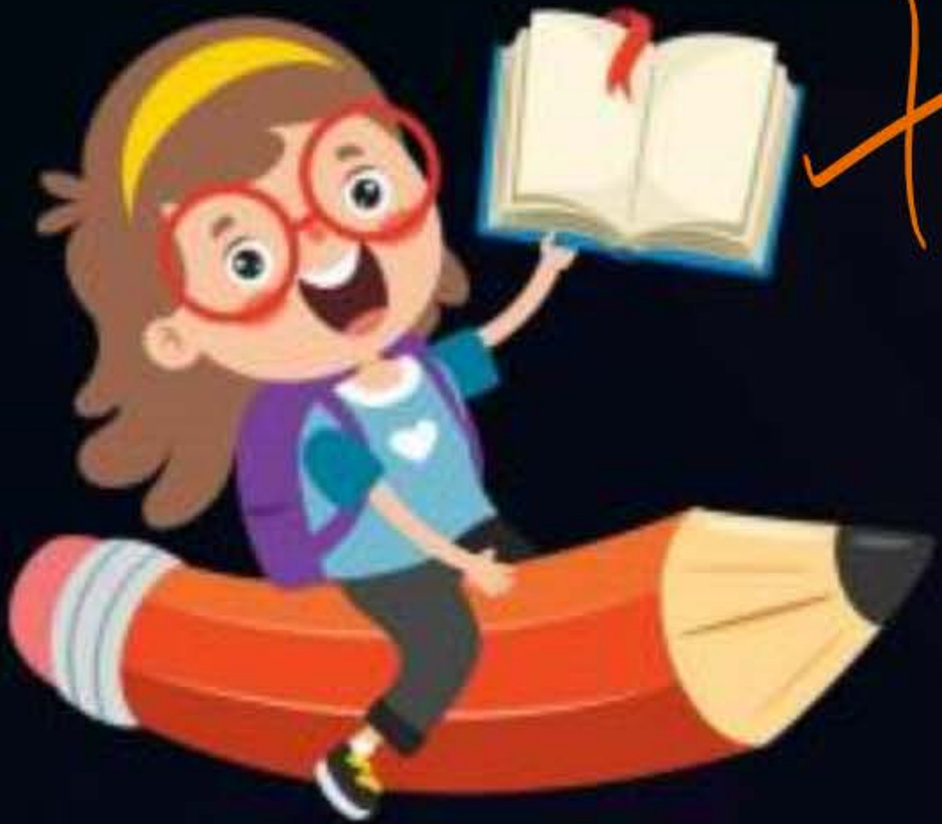
Recap of Previous Lecture



- **Topic** Identification of candidate key w.r.t. FD set
- **Topic** Membership test
- **Topic** Relation between two FD sets
- **Topic** FD set of a sub-relation

Slide

Topics to be Covered



Topic FD set of a sub-relation

Topic Minimal cover or Canonical cover

Slide

H.W.

#Q. Consider a relational schema R(A,B,C,D,E,F) with FD set

$\boxed{F = \{AB \to C,\ B \to D,\ BC \to A,\ D \to EF\}}$

Find the FD set F1 for sub-relation R1(A,B,C,D) of R(A,B,C,D,E,F).

Also find candidate keys for the sub-relation R1(A,B,C,D).

A	AB	ABC
B	AC	ABD
C	AD	ACD
D	BC	BCD
	BD	
	CD	

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

$(B)^+ = \{\cancel{B}, D, \cancel{E}, \cancel{F}\}$ $\boxed{B \to D}$

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

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

$(AB)^+ = \{\cancel{A}, \cancel{B}, C, D, \cancel{E}, \cancel{F}\}$ $\boxed{AB \to CD}$

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

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

$(BC)^+ = \{\cancel{B}, \cancel{C}, A, D, \cancel{E}, \cancel{F}\}$ $\boxed{BC \to AD}$

$(BD)^+ = \{\cancel{B}, \cancel{D}, \cancel{E}, \cancel{F}\}$

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

$ABC \to D$

$ABD \to C$

$BCD \to A$

$(ACD)^+ = \{\cancel{A}, \cancel{C}, \cancel{D}, \cancel{E}, \cancel{F}\}$

$R_1(A, B, C, D)$

FD set $F_1 = \{ B \to D,\ AB \to CD,\ BC \to AD = BC \to A,\ ABC \to D,\ ABD \to C,\ BCD \to A \}$

$(AB)^+ = \{\underbrace{A, B, C, D}_{\text{all attributes of } R_1}\}$

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

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

No proper subset is a S.K

$\therefore$ $\boxed{AB}$ is a C.K

P.A = {A, B}

$BC \to A$

$\therefore$ Replace A by BC

BC is S.K $(B)^+ = \{B, D\}$

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

$\therefore$ $\boxed{BC}$ is a C.K

P.A. = {A, B, C}

$AB \to C$

$\therefore$ Replace C by AB

"irreducible"

Topic : Minimal cover (Canonical cover)

- Minimal cover of canonical cover of FD set F is a set of functional dependencies (F_m)
  such that,
  - $F_m = F$ and
  - F_m does not contain any redundant FD, and F_m must not contain any extraneous attribute at either side of any of its FD

eg: $F = \{ \underbrace{A \rightarrow B, B \rightarrow C}, A \rightarrow C \}$

As long as $A \rightarrow B$ & $B \rightarrow C$ are present in FD set F, we don't need to mention "$A \rightarrow C$" explicitly in the FD set F.

$\therefore$ if $A \rightarrow B$ & $B \rightarrow C$ are present then $A \rightarrow C$ is a redundant FD

$\therefore$ Minimal Cover of $F = F_m = \{ A \rightarrow B, B \rightarrow C \}$

eg: Let $F = \{ A \rightarrow B, \ AB \rightarrow C \}$

In $AB \rightarrow C$

we know $A \rightarrow B$

i.e. A can determine B,

$\therefore$ if 'A' is present, then we don't need B,

Hence $AB \rightarrow C$

'B' is L.H.S. of FD is extraneous.

$\therefore$ $AB \rightarrow C$ after removal of extraneous attribute becomes "$A \rightarrow C$"

Minimal Cover of $F = F_m = \{ A \rightarrow B, \ A \rightarrow C \}$

$\alpha \longrightarrow \beta$

$\boxed{\alpha = A \cup (\alpha - A)}$

$$F = \left\{ \begin{array}{l} fd_1 \\ fd_2 \\ fd_3 \\ \alpha \longrightarrow \beta . \\ fd_4 \end{array} \right.$$

if, $A \in (\underline{\alpha - A})^+$ w.r.t. $(F - (\alpha \rightarrow \beta))$, then A is extra

<u>otherwise</u> A is not extraneous.

Topic : Testing if an Attribute is Extraneous

To check extraneous attribute in LHS of FD

Consider a set F of functional dependencies and functional dependency $\alpha \rightarrow \beta$ in F.

Set of attributes Set of attributes

To test if attribute $A \in \alpha$ is extraneous in α (i.e., Any extraneous attribute in LHS of FD)

1. compute $(\{\alpha\} - \{A\})^+$ using the dependencies in F. Except $\alpha \rightarrow \beta$
2. check if $(\{\alpha\} - A)^+$ contains A; if it does then, A is extraneous.

Otherwise A is not extraneous.

We can skip it & Check for redundant FDs

To test if attribute $B \in \beta$ is extraneous in β (i.e., Any extraneous attribute in RHS of FD)

1. compute α^+ using only the dependencies in F′, $F' = (F - \{\alpha \rightarrow \beta\}) \cup \{\alpha \rightarrow (\beta - B)\}$.
2. check that α^+ contains B; if it does then, B is extraneous

#e.g., Consider the FD set

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

In $A \to BC$

(i) Check if B is extraneous

$(A)^+$ w.r.t $\left\{ \begin{array}{l} B \to C \equiv F - (A \to BC) \\ \qquad\qquad \cup \\ A \to C \quad A \to (BC - B) \end{array} \right\} = \{A, C\}$

$B \notin (A)^+$ w.r.t $(F - (\alpha \to \beta)) \cup (\alpha \to (\beta - B))$ $\therefore$ B is not extraneous

(ii) Check if 'C' is extraneous.

$(A)^+$ w.r.t. $\left\{ \begin{array}{l} B \to C \equiv F - (A \to BC) \\ A \to B \equiv A \to (BC - C) \end{array} \right\} = \{A, B, C\}$

$C \in (A)^+ \therefore$ C is extraneous

$F = \left\{ \begin{array}{l} A \to B \\ A \to C \\ B \to C \end{array} \right\}$ ← simplified $A \to B\cancel{C}$

Check if $A \to B$ is redundant

Not redundant

Check if $A \to C$ is redundant

$(A)^+$ w.r.t $F - \{A \to C\} = \{A, B, C\}$

$\therefore$ Redundant

Topic : Procedure to obtain minimal cover of FD set

1. Simplify RHS of all FDs (i.e., split the FDs such that RHS contain exactly one attribute)
2. For all FDs find redundant (extraneous) attribute in LHS and remove them as soon as identified.
3. Eliminate all redundant FDs
4. Apply Union if needed
5. The result is minimal Cover

#e.g., Consider the following FD set

$$F = \{AC \rightarrow G$$

$$D \rightarrow EG$$

$$BC \rightarrow D$$

$$CG \rightarrow BD$$

$$ACD \rightarrow B$$

$$CE \rightarrow AG$$

$$\}$$

Find minimal cover of F.

Step-1: Simplify RHS of all FD

$F = \{ AC \to G, D \to E, D \to G, BC \to D, CG \to B, CG \to D, ACD \to B, CE \to A, CE \to G \}$

Check if A is extra: $(C)^+ = \{C\}$, $A \notin (C)^+$ ∴ Not extra

Check if C is extra: $(A)^+ = \{A\}$, $C \notin (A)^+$ ∴ Not extra

Check wrt B is extra: $(C)^+ = \{C\}$, $B \notin (C)^+$

Check wrt C is extra: $(B)^+ = \{B\}$, $C \notin (B)^+$

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

$(A)^+ = \{A\}$ 'CD' together is not extra w.r.t. A
$(AC)^+ = \{A, C, G, B, D, E\}$ $D \in (AC)^+$ ∴ D is extra if 'A & C' are present

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

$(CD)^+ = \{C, D, E, G, A\}$
$A \in (CD)^+$
∴ if we consider 'C & D' in LHS, then A will be extraneous in LHS.

FDs after removal of Extraneous attribute in LHS

~~AC → G~~ ✗
D → E
D → G
BC → D
~~CG → B~~
CG → D
AC → B
CE → A
~~CE → G~~

Identify Redundant FDs

$(AC)^+ = \{A, C, B, D, E, G\}$
∴ AC → G is Redundant
∴ Remove it.
$(D)^+ = \{D, G\}$ E not present
$(D)^+ = \{D, E\}$ G is not present
$(BC)^+ = \{B, C\}$, D not present
$(CG)^+ = \{C, G, D, E, A, B ..\}$ B is present ∴ CG → B is redundant
$(CG)^+ = \{C, G\}$ D is not present
$(AC)^+ = \{A, C\}$ B is not present
$(CE)^+ = \{C, E, G, D\}$ A is not present
$(CE)^+ = \{C, E, A, B, D, G\}$ G is present

If (AC) is present, then D is extraneous
& if (CD) is present, then A is extraneous

We choose any one of the possible options.

Our final minimal cover may vary w.r.t. our choice.

∴ More than one minimal cover are possible w.r.t. given FD set.

#e.g., Consider the following FD set

$F = \{AC \to G$

$D \to EG$

$BC \to D$

$CG \to BD$

$ACD \to B$

$CE \to AG$

$\}$

Find minimal cover of F.

Minimal Cover of F

$D \to EG$

$BC \to D$

$CG \to D$

$AC \to B$

$CE \to A$

from previous slide.

#e.g., Consider the following FD set

H.W.

$F = \{A \rightarrow BC$

$CD \rightarrow E$

$E \rightarrow C$

$D \rightarrow AEH$

$ABH \rightarrow BD$

$DH \rightarrow BC$

$\}$

Find minimal cover of F.

Topic : NOTE

Minimal cover of FD set F need not be unique, but all minimal cover are logically equivalent.

i.e., if F_{m_1} & F_{m_2} are two minimal covers of FD set F

then we know $F_{m_1} \equiv F$ & $F_{m_2} \equiv F$

$$\therefore \; F_{m_1} \equiv F_{m_2}$$

#e.g., Consider the FD set

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

Find all minimal covers of F.

2 mins Summary

Topic FD set of a sub-relation

Topic Minimal cover or Canonical cover

Slide

THANK - YOU

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