COMPUTER SCIENCE

Database Management System

FD's & Normalization

Lecture_07

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TOPICS TO BE COVERED

01 Minimal Cover

02 Closure of FD Set

Membership set

Equality between 2 FD Set

F: [ ] G: [ ]

F Cover G : True ✓

G Cover F : True ✓

$\boxed{F \equiv G}$

$\boxed{AB \to C,\ A \to C}$

Minimal Cover.

R.F.D

Redundant Attribute

$\boxed{F \equiv G\ ?}$

Step 1 Split the FD such that R.H.S Contain Single Attribute

Step 2: find the Redundant Attribute from L.H.S. & Delete them

Step 3: Elimination of R.F.D.

$AB \to C$

$(A)^+ = (\ldots B)$ B extra

$(B)^+ = (\ldots A)$ A extra

(a) cc with Enjoying Concept

(b) CC

(c) C

(d) Doubt

Canonical Cover

- Sets of functional dependencies may have redundant dependencies that can be inferred from the others
  - For example: $A \rightarrow C$ is redundant in: $\{A \rightarrow B, B \rightarrow C, A \rightarrow C\}$

Procedure to find minimal set

Step (1)

Split the FD such that RHS contain single Attribute.

Ex. $A \rightarrow BC$, $\Rightarrow$ $A \rightarrow B$ and $A \rightarrow C$

Step (2)

Find the redundant attribute on L.H.S and delete them.

Ex. $AB \rightarrow C$,

A – Can be deleted $[B]^+=[A]$ B^+ Contains 'A'

OR

B can be delete if A^+ contain 'B' $[A]^+=[...B]$

Step

(3)

Find the redundant FD and delete them from the set

Ex. $\{A \rightarrow B,\ B \rightarrow C,\ A \rightarrow C\}$

$\{A \rightarrow B,\ B \rightarrow C\}$

Example 4:

$$[A \rightarrow BC,\ CD \rightarrow E,\ E \rightarrow C,\ D \rightarrow AEH,\ ABH \rightarrow BD,\ DH \rightarrow BC]$$

Ans $A \rightarrow B$, $A \rightarrow C$, $D \rightarrow A$, $D \rightarrow E$, $D \rightarrow H$, $E \rightarrow C$, $AH \rightarrow D$

OR

$A \rightarrow BC$ $\quad D \rightarrow AEH$

$E \rightarrow C$, $AH \rightarrow D$.

Example 4:

$[A \to BC,\ CD \to E,\ E \to C,\ D \to AEH,\ ABH \to BD,\ DH \to BC]$

Step 1 (RHS)

$A \to B,\ A \to C,\ CD \to E,\ E \to C,\ D \to A,\ D \to E,\ D \to H,\ ABH \to B,$
$ABH \to D,\ DH \to B,\ DH \to C.$

Step 2 (L.H.S) Extra Attribute

$\cancel{C}D \to E$

$(D)^+ = [DAEHBC]$ C is extra.

$(C)^+ = [C]$

$D\cancel{H} \to B$

$(H)^+ = [H]$

$(D)^+ = [DHE\ldots]$ H is extra.

$A\cancel{B}H \to D$ B is extra.

$[AB]^+ = [ABC]$

$[BH]^+ = [BH]$

$[AH]^+ = [AHB\ldots]$

$AH \to D$

$(H)^+ = [H]$ A is Not extra

$(A)^+ = [ABC]$ H is Not extra.

Example 4:

$[A \to BC,\ CD \to E,\ E \to C,\ D \to AEH,\ ABH \to BD,\ DH \to BC]$

$\cancel{ABH \to B}$

Step 3: (1) $A \to B$, (2) $A \to C$ (3) $D \to E$, (4) $E \to C$, (5) $D \to A$. (6) $D \to H$

(7) $\cancel{AH \to B}$ (8) $AH \to D$ (9) $\cancel{D \to B}$ (10) $\cancel{D \to C}$.

$(AH)^+ = (AHBC)$

$(D)^+ = (DECAB)$

$A \to B$ $A \to C$ $D \to E$, $D \to A$, $D \to H$, $E \to C$, $AH \to D$

OR

$A \to BC$, $D \to AEH$, $E \to C$ $AH \to D$.

Ans

Q.

Given the following two statements:

S1: Every table with two single-valued attributes is in 1NF, 2NF, 3NF and BCNF.

S2: $AB \rightarrow C, D \rightarrow E, E \rightarrow C$ is a minimal cover for the set of functional dependencies $AB \rightarrow C, D \rightarrow E, AB \rightarrow E, E \rightarrow C$.

Which one of the following is CORRECT? [MCQ: 2014: 2M]

(A) S1 is TRUE and S2 is FALSE.

(B) Both S1 and S2 are TRUE.

(C) S1 is FALSE and S2 is TRUE.

(D) Both S1 and S2 are FALSE.

Testing

F: {AB → C   D → E , AB → E , E → C}

G: {AB → C   D → E , E → C}

$\boxed{F \equiv G ?}$

① F Cover G

True

② G Cover F

✓ AB → C

✓ D → E

✗ AB → E $(AB)^+ = \{ABC\}$

✓ E → C

$\boxed{\text{False}}$

Not minimal cover.

Alternate Approach

Find Minimal Cover.

$F: \{AB \to C,\ D \to E,\ AB \to E,\ E \to C\}$

$G: \{AB \to C,\ D \to E,\ E \to C\}$

Step1: $AB \to C,\ D \to E,\ AB \to E,\ E \to C$

Step2 $AB \to C$ $AB \to E$

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

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

No extra.

Step3 ① $\cancel{AB \to C}$ ② $D \to E$ ③ $AB \to E$ ④ $E \to C$

$\{AB\}^+ = \{ABEC\}$ $(D)^+ = \{D\}$ $(AB)^+ = \{AB\}$ $(E)^+ = \{E\}$

Minimal Cover.

$\boxed{\{D \to E,\ AB \to E,\ E \to C\}}$

Ans

Test

F: {AB → C, D → E, AB → E, E → C}

Minimal Cover {D → E, AB → E, E → C}

F Cover G

✓ D → E

✓ AB → E

✓ E → C

True

G Cover F

✓ AB → C $(AB)^+ = \{ABEC\}$

✓ D → E

✓ AB → E

✓ E → C

True

$\boxed{F \equiv G}$ So above is minimal cover

Q.

The following functional dependencies hold true for the relational schema R{V, W, X, Y, Z}:

$$V \rightarrow W$$
$$VW \rightarrow X$$
$$Y \rightarrow VX$$
$$Y \rightarrow Z$$

Which of the following is irreducible equivalent for this set of functional dependencies? [MCQ:2017]

(A) $V \rightarrow W$, $V \rightarrow X$, $Y \rightarrow V$, $Y \rightarrow Z$

(B) $V \rightarrow W$, $W \rightarrow X$, $Y \rightarrow V$, $Y \rightarrow Z$

(C) $V \rightarrow W$, $V \rightarrow X$, $Y \rightarrow V$, $Y \rightarrow X$, $Y \rightarrow Z$

(D) $V \rightarrow W$, $W \rightarrow X$, $Y \rightarrow V$, $Y \rightarrow X$, $Y \rightarrow Z$

Q.

[MSQ]

Consider the following FD Set:
$\{P \to QR, Q \to PR, R \to PQ\}$ which of the following is/are the minimal cover for the above FD set?

(1) $P \to Q$, (2) $P \to R$ (3) $Q \to P$ (4) $Q \to R$ (5) $R \to P$ (6) $R \to Q$

(A) $P \to Q, Q \to R, R \to P$

(B) $P \to R, Q \to R, R \to PQ$

(C) $Q \to P, P \to R, R \to Q$

(D) $P \to QR, Q \to P, R \to P$

Note: Minimal Cover may or may Not be Unique.

$\boxed{F \equiv G \, ?}$

[Home Work]

I $P \to QR$, $Q \to PR$, $R \to PQ$

Step 1

1 $\cancel{P \to Q}$ 2 $P \to R$ 3 $\cancel{Q \to P}$ 4 $Q \to R$ 5 $R \to P$ 6 $R \to Q$

$(P)^+ = [PRQ]$ $(P)^+ = [P]$ $(Q)^+ = [QRP]$ $(Q)^+ = (Q)$ $(R)^+ = (RQ]$ $(R)^+ = (RP)$

$P \to R$ $Q \to R$ $R \to P$ $R \to Q$

$\boxed{P \to R \quad Q \to R \quad R \to PQ}$ option (b).

$P \to QR, \quad Q \to PR, \quad R \to PQ$

II

Step 1

2 $P \to Q$ 1 $\cancel{P \to R}$ 3 $\cancel{Q \to P}$ 4 $Q \to R$ 5 $R \to P$ 6 $\cancel{R \to Q}$

$(P)^+ = (P)$ $(P)^+ = [PQR]$ $(Q)^+ = (QRP)$ $(Q)^+ = (Q)$ $(R)^+ = [RQ]$ $(R)^+ = (RPQ)$

$$\boxed{P \to Q, \ Q \to R, \ R \to P}$$ option (a)

$P \to QR, \quad Q \to PR, \quad R \to PQ$

III

Step 1

3 $\cancel{P \to Q}$ 4 $P \to R$ 5 $Q \to P$ 6 $\cancel{Q \to R}$ 1 $\cancel{R \to P}$ 2 $R \to Q$.

$(P)^+ = (PRQ)$ $(P)^+ = (P)$ $(Q)^+ = (QR)$ $(Q)^+ = (QPR)$ $(R)^+ = (PQP)$ $(R)^+ = (R)$

$\boxed{P \to R \quad Q \to P \quad R \to Q}$ option (C).

$P \to QR, \quad Q \to PR, \quad R \to PQ$

IV

Step 1

5 $P \to Q$ 6 $P \to R$ 2 $Q \to P$ 1 $\cancel{Q \to R}$ 4 $R \to P$ 3 $\cancel{R \to Q}$

$(P)^+ = (PR)$ $(P)^+ = (PQ)$ $(Q)^+ = (Q)$ $(Q)^+ = (QPR)$ $(R)^+ = (R)$ $(R)^+ = (RPQ)$

$$\boxed{\begin{array}{l} P \to Q \quad P \to R \quad Q \to P \quad R \to P. \\ \\ P \to QR, \quad Q \to P, \quad R \to P. \end{array}}$$

Option (d)

Attribute closure : $[X]^+$: Set of ALL Possible Attributes which is Logically Determined by Attribute X. $[X]^+$

closure of FD set : $[F]^+$: Set of ALL Possible FD's which Can be logically (Derived) Determined is Called closure of FD set.

Closure of FD set :

① When FD Set is Not given then Find $(F)^+$

② When FD Set is given then Find $(F)^+$.

(I) When FD Set is Not Given.

(Q) R(AB) Find $[F]^+$

ϕ
A
B
AB

n: Total # component.

$\phi \rightarrow \phi$

$\times$ $\boxed{\begin{array}{l} \phi \rightarrow A \\ \phi \rightarrow B \\ \phi \rightarrow AB \end{array}}$

$A \rightarrow \phi$
$A \rightarrow A$
$A \rightarrow B$
$A \rightarrow AB$

$B \rightarrow \phi$
$B \rightarrow A$
$B \rightarrow B$
$B \rightarrow AB$

$AB \rightarrow \phi$
$AB \rightarrow A$
$AB \rightarrow B$
$AB \rightarrow AB$

$(n-1)*n+1$

$3 \times 4 + 1 = 13$ Ans

$[F]^+ = 13$ Ans

(I) When FD Set is Not Given.

(Q) R(ABC), Find $[F]^+$

ϕ
A
B
C
AB
BC
AC
ABC

$\phi \to \phi$

$(n-1) * n + L$

$7 \times 8 + 1$

$\boxed{[F]^+ = 57}$ Ans

I When FD Set is Not Given.

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

eg R(AB)

ϕ	$\phi \to \phi$ $A \to \phi$	$B \to \phi$	$AB \to \phi$
A	$A \to A$	$B \to A$	$AB \to A$
B	$A \to B$	$B \to B$	$AB \to B$
AB	$A \to AB$	$B \to AB$	$AB \to AB$

13

$R(\underline{ABC})$ then find $[F]^+$

ϕ

A

B

C

AB

BC

AC

ABC

$7 \times 8 + 1$

$[F]^+ = 57$ $\underline{\text{Ans}}$

R(ABC)

ϕ	$A \to \phi$	$B \to \phi$
A	$A \to A$	$B \to A$
B	$A \to B$	$B \to B$
C	$A \to C$	$B \to C$
AB	$A \to AB$	$B \to AB$
BC	$A \to BC$	$B \to AC$
AC	$A \to AC$	$B \to BC$
ABC	$A \to ABC$	$B \to ABC$

$(n-1) * n + 1$

$7 \times 8 + 1$

$\boxed{(F)^+ = 57}$

$R(ABC)$ Find $(F)^+$

ϕ, A, B, C, AB, BC, AC, ABC

$\phi \to \phi$

$A \to \phi$	$B \to \phi$	$C \to \phi$	$AB \to \phi$	$BC \to \phi$	$AC \to \phi$	$ABC \to \phi$
$A \to A$	$B \to A$	$C \to A$	$AB \to A$	$BC \to A$	$AC \to A$	$ABC \to A$
$A \to B$	$B \to B$	$C \to B$	$AB \to B$	$BC \to B$	$AC \to B$	$ABC \to B$
$A \to C$	$B \to C$	$C \to C$	$AB \to C$	$BC \to C$	$AC \to C$	$ABC \to C$
$A \to AB$	$B \to AB$	$C \to AB$	$AB \to AB$	$BC \to AB$	$AC \to AB$	$ABC \to AB$
$A \to BC$	$B \to BC$	$C \to BC$	$AB \to BC$	$BC \to BC$	$AC \to BC$	$ABC \to BC$
$A \to AC$	$B \to AC$	$C \to AC$	$AB \to AC$	$BC \to AC$	$AC \to AC$	$ABC \to AC$
$A \to ABC$	$B \to ABC$	$C \to ABC$	$AB \to ABC$	$BC \to ABC$	$AC \to ABC$	$ABC \to ABC$

$(F)^+ = 57$ Ans

II^{nd} Part

(II) When FD Set is given then Find $(F)^+$.

When FD set is given then Find $[F]^+$

Q $\boxed{R(AB) \quad [A \to B]}$ then Find $[F]^+$

FD's $\to 2^n$ (n : # Attribute in closure of given Attribute)

ϕ	0 Attribute	$\phi \to \phi$		1	1
A	1 Attribute	$(A)^+ = [AB]$	$\Rightarrow 2^2$	4	$[A \to \phi,\ A \to A,\ A \to B,\ A \to AB]$
B		$(B)^+ = [B]$	$\Rightarrow 2^1$	2	$[B \to \phi,\ B \to B]$
AB	2 Attribute	$(AB)^+ = [AB]$	$= 2^2$	4	$[AB \to \phi,\ AB \to A,\ AB \to B,\ AB \to AB]$

$(F)^+ = 11$ Ans

Note

When FD Set Not given R(AB)

$3 \times 4 + 1$

$= 13$

Q $R(ABC)$ $[A \to B,\ B \to C]$ then Find $(F)^+$?

ϕ	0 Attribute	$\phi \to \phi$	1	1
A	1 Attribute	$(A)^+ = (ABC)$	2^3	8
B		$(B)^+ = (BC)$	2^2	4
C		$(C)^+ = (C)$	2^1	2
AB	2 Attribute	$(AB)^+ = (ABC)$	2^3	8
BC		$(BC)^+ = (BC)$	2^2	4
AC		$(AC)^+ = (ABC)$	2^3	8
ABC	3 Attribute	$(ABC)^+ = (ABC)$	2^3	8

$(F)^+ = 43$

$R(ABC)$ $[A \rightarrow B, B \rightarrow C]$ $[F]^+ = $ 43 Ans.

ϕ	0 attribute =	$\phi \rightarrow \phi$
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=	$[ABC]^+ = [ABC] = 2^3$

L

8 $[A]^+ = \begin{bmatrix} A\to\phi, A\to A, A\to B, A\to C \\ A\to AB, A\to BC, A\to AC, A\to ABC \end{bmatrix}$

4 $[B]^+ = [B\to\phi, B\to B, B\to C, B\to BC]$

2 $[C]^+ = [C\to\phi, C\to C]$

8 $[AB]^+ = \begin{bmatrix} AB\to\phi, AB\to A, AB\to B, AB\to C \\ AB\to AB, AB\to BC, AB\to AC, AB\to ABC \end{bmatrix}$

4 $[BC]^+ = [BC\to\phi, BC\to B, BC\to C, BC\to BC]$

8 $[AC]^+ = \begin{bmatrix} AC\to\phi, AC\to A, AC\to B, AC\to C \\ AC\to AB, AC\to BC, AC\to AC, AC\to ABC \end{bmatrix}$

8 $[ABC]^+ = \begin{bmatrix} ABC\to\phi, ABC\to A, ABC\to B, ABC\to C \\ ABC\to AB, ABC\to BC, ABC\to AC, ABC\to ABC \end{bmatrix}$

43

R(AB) $[A \to B]$

ϕ 0 attribute = 1

A 1 Attribute = $[A]^+ [AB] = 2^2$

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

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

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

11 Ans.

$R(AB)$ $[A \to B,\ B \to A]$

ϕ 0 Attribute $\Rightarrow$ $\phi \to \phi$ 1 1

A 1 Attribute $(A)^+ = (AB) = 2^2 = 4$

B $(B)^+ = (AB) = 2^2 = 4$

AB

2 Attribute $(AB)^+ = (AB) = 2^2 = 4$

13 Ans

THANK YOU!