CS & IT ENGINEERING

Database Management System

DBMS

Lecture No. 3

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Recap of Previous Lecture

Topic

ER Model

Topics to be Covered

Topic Integrity Constraints & ER Model (2 Marks)

Topic Normalization (2-4 Marks)

Topic Queries (Relational Algebra, SQL, Tuple Relational Calculus) (4 Marks)

Topic File Organization & Indexing(2-4 Marks)

Topic Transactions & Concurrency Control (2- 4 Marks)

Normalization Topics

Topic Normalization

Topic Functional dependency

Topic Armstrong rules over FD's

Topic Attribute Closure(X^+)

Topic Candidate-key: (Minimal Super-key)

Topic Important questions for GATE

Topic : Normalization

Redundancy and Anomalies in a database are removed by Normalization.

Normalized Database:

- Decomposition of a relation R into sub relation R_1, R_2, R_3….. R_n to eliminate / reduce Redundancy.

#Q.

R

Sid	Sname	DOB	Cid	Cname	Instructor	Fee
S1	A	1990	C1	DB	Korth	—
S2	A	1990	C1	DB	Korth	—
S3	B	1998	C1	DB	Korth	—
S3	B	1998	C2	Algo	Coremon	—
S3	B	1998	C3	OS	Galwin	—

Topic : Normalization

41 → august-31st

Sol: The table can be divided as follows

Sid → Sname

Sid Cid → Fee

Cid → Cname Instructor

R1 (PK: Sid)

Sid	Sname	DOB
S1	SN1	1998
S2	SN2	1997
S3	SN3	1998

R2 (FK: Sid, FK: Cid)

Sid	Cid	Fee
S1	C1	6K
S2	C1	6K
S3	C1	6K
S3	C2	8K
S3	C3	9K

R3 (PK: Cid)

Cid	Cname	Instructor
C1		
C2		
C3		

Topic : Normalization

- This is called Normalized Database and it has no redundancy.
- These decomposed tables do not have any redundancies and anomalies.

0% → Rcd → diff

Topic : Functional dependency

- Used in Normalization
- Definition: Let X , Y are some sets of attributes of a relation R, and t_1, t_2 are any tuples of R.

  Let $X \rightarrow Y$ is an FD implied (member of) in relation R. If $t_1 \cdot x = t_2 \cdot x$ then $t_1 \cdot y = t_2 \cdot y$

Topic : Functional dependency

- Example-1: Given below is a relation R

	X	Y	....
t_1	x_1	y_5	
t_2	x_1	y_5	
	x_2	y_2	
	x_3	y_2	
	x_4	y_4	
	x_2	y_2	
	x_1	y_5	

Topic : Functional dependency

- Example-1: Given below is a relation R

	X	Y	....
t_1	x_1	y_5	
t_2	x_1	y_5	
	x_2	y_2	
	x_3	y_2	
	x_4	y_4	
	x_2	y_2	
	x_1	y_5	

$X \to Y$ ~~$Y \to X$~~

Here,

$X \to Y$ holds

$Y \to X$ does not hold

Because of $y_2 \to x_2$

$y_2 \to x_3$

Topic : Functional dependency

- Example-1: Given below is a relation R

	X	Y	………
t_1	x_1	y_5	
t_2	x_1	y_5	
	x_2	y_2	
	x_3	y_2	
	x_4	y_4	
	x_2	y_2	
	x_1	y_5	

Here,
$X \rightarrow Y$ holds
$Y \rightarrow X$ does not hold
Because of $y_2 \rightarrow x_2$
$y_2 \rightarrow x_3$

As per definition, $X \rightarrow Y$ is an FD implied (member of) in relation R. If $t_1 \cdot x = t_2 \cdot x$ then $t_1 \cdot y = t_2 \cdot y$

Topic : Functional dependency

- Example-2: For the given below relation Student, Sid→ Sname holds or not?

Student

Sid	Sname	Cid
S1	A	C1
S1	A	C2
S1	A	C3
S2	B	C3
S2	B	C4
S3	B	C1
S4	C	C2
S5	D	C3

Topic : Functional dependency

- Example-2: For the given below relation Student, Sid→ Sname holds or not?

Student

Sid	Sname	Cid
S1	A	C1
S1	A	C2
S1	A	C3
S2	B	C3
S2	B	C4
S3	B	C1
S4	C	C2
S5	D	C3

Explanation:

- For a value of Sid the Sname should be same which holds for this table.
- Sid, can be different which implies to same Sname.

Topic : Functional dependency

$$Sid \rightarrow Sname$$

- If the data of Sid is same but Sname is different then the FD is not implied on a relation.

$S1 \rightarrow SN1$, $S1 \rightarrow SN1$ holds

$S1 \rightarrow SN1$, $S1 \rightarrow SN2$ does not hold

Topic : Functional dependency

- Property of FD: For $X \rightarrow YZ$ then $X \rightarrow Y$ and $X \rightarrow Z$

Topic : Functional dependency

Types of functional dependencies:

1. Trivial functional dependencies
2. Non-trivial functional dependencies
3. Semi- Non-trivial functional dependencies

Topic : Functional dependency

1. Trivial functional dependencies

   $X \rightarrow Y$ is trivial FD of R is $X \supseteq Y$

RHS ⊆ LHS

- Example-1: $Sid \rightarrow Sid$

  $Sid, Sname \rightarrow Sid, Sname$

  $Sid, Sname \rightarrow Sname$

  $Sid, Sname \rightarrow Sid$

Topic : Functional dependency

2. Non-trivial functional dependencies

   $X \to Y$ is non-trivial FD of R, if $X \cap Y = \phi$

- Example-1: $Sid \to Sname$

  $Sid\ Cid \to Sname$

Topic : Functional dependency

3. Semi- Non-trivial functional dependencies

   Semi- Non-Trivial dependency when it has combination of both trivial & non-trivial FD.

- Example-1: Sid → Sname

Topic : Functional dependency

3. Semi- Non-trivial functional dependencies

   Semi- Non-Trivial dependency when it has combination of both trivial & non-trivial FD.

- Example-1: Sid → Sname

  can be written as $\underbrace{Sid \rightarrow Sid}$ → trivial

  $\underbrace{Sid \rightarrow Sname}$ → Non –trivial

-

Topic : Functional dependency

3. Semi- Non-trivial functional dependencies

   Semi- Non-Trivial dependency when it has combination of both trivial & non-trivial FD.

- Example-1: Sid → Sname

  can be written as Sid → Sid → trivial

  Sid → Sname → Non –trivial

- Example-2: Sid Cid → Cid · Sname

Topic : Functional dependency

3. Semi- Non-trivial functional dependencies

   Semi- Non-Trivial dependency when it has combination of both trivial & non-trivial FD.

- Example-1: Sid → Sname

  can be written as Sid → Sid → trivial

  Sid → Sname → Non –trivial

- Example-2: Sid Cid → Cid · Sname

  can be written as Sid Cid → Cid → trivial

  Sid Cid → Sname → Non -trivial

Inspiring Stories : C. Mallesham

Background: **Born in a poor weaver's family in Telangana.**

Education: **Dropped out of school early, but later earned recognition from IIT Hyderabad for his invention.**

Achievements: **Invented the Laxmi Asu machine, a semi-automatic device that cut the 6-hour manual weaving process to just 1.5 hours.**

Impact: **Saved the health of thousands of women weavers.**

Topic : Armstrong rules over FD's

- Let X, Y, Z are some attributes over R.

  (i) Reflexivity: (Trivial FD)

  $X \rightarrow X$ always in R

Topic : Armstrong rules over FD's

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(i) Reflexivity: (Trivial FD)

$X \rightarrow X$ always in R

(ii) Transitivity:

If $X \rightarrow Y$ & $Y \rightarrow Z$ then $X \rightarrow Z$

Topic : Armstrong rules over FD's

- Let X, Y, Z are some attributes over R.

  (i) Reflexivity: (Trivial FD)

  $X \rightarrow X$ always in R

  (ii) Transitivity:

  If $X \rightarrow Y$ & $Y \rightarrow Z$ then $X \rightarrow Z$

  (iii) Augmentation:

  If $X \rightarrow Y$ then $XZ \rightarrow YZ$

  - Example: if Sid → Sname then SidCid→ Cid Same

Topic : Armstrong rules over FD's

(iv) Split Rue:

If $X \rightarrow YZ$ then $X \rightarrow Y$, $X \rightarrow Z$

Topic : Armstrong rules over FD's

(iv) Split Rue:

If $X \rightarrow YZ$ then $X \rightarrow Y$, $X \rightarrow Z$

(v) Merge Rule:

If $X \rightarrow Y$, $X \rightarrow Z$ then $X \rightarrow YZ$

Topic : Attribute Closure(X^+)

X^+

Attribute Closure (X^+):

X

X is some attribute set of relation R, then X^+ is set of all attributes which can be determined by X.

Topic : Attribute Closure(X^+)

Example-1: The FD's that hold for a relation R(ABCDEF) are given below {$A \rightarrow B$, $C \rightarrow D$, $AB \rightarrow E$, $BE \rightarrow C$, $EF \rightarrow G$} then what are the closure sets?

Topic : Attribute Closure(X^+)

Example-1: The FD's that hold for a relation R(ABCDEF) (G written above the F) are given below {A→B, C →D, AB→ E, BE →C, EF →G} then what are the closure sets?

Sol: Can take any properset of the attributes {A,B,C,D,E,F}

$(AF)^+$ ↑SK

Some examples of closures are

$(A)^+ = \{A, B, E, C, D\}$ then $A \rightarrow ABCDE$ $A^+ = ABECD$

$(AF)^+ = \{A, F, B, E, C, D, G\}$ then $AF \rightarrow ABCDEFG$ $(AF)^+ = AFBECDG$

$(BE)^+ = \{B, E, C, D\}$ then $BE \rightarrow BECD$ → $(BE)^+ = BECD$

Super-key:

X is some attribute set of relational schema R, X is super-key of relation R, Iff X^+ must determine all attributes of R.

Topic : Super-key

Example-1: R(ABCDEF) {AB→ C, C→D , D→E, E → F, F→B}

What are the super-keys of the Relation R ?

Topic : Super-key

Example-1: $R(ABCDEF)\ \{AB \rightarrow C,\ C \rightarrow D,\ D \rightarrow E,\ E \rightarrow F,\ F \rightarrow B\}$

What are the super-keys of the Relation R ?

Sol: Lets consider some examples

$(AB)^+ = \{ABCDEF\} \rightarrow$ Super-key

$(ABC)^+ = \{ABCDEF\} \rightarrow$ Super-key

$(BC)^+ = \{BCDEF\} \rightarrow$ Not Super-key

Topic : Candidatekey: (Minimal Superkey)

Candidate key: (Minimal Superkey) :

$X^{+} = \{ \ldots \ldots \}$

$\forall Y \subset X \quad Y^{+} = \{ \ldots \ldots \}$

X is candidate key of R iff

(i) X must be super-key of R i.e. $X^+ = \{\text{All attribute of R}\}$

(ii) No proper subset of X is super-key of R.

i.e. $\forall Y \subset X$ such that $Y+ \neq \{\text{All attribute of R}\}$.

Topic : Candidatekey: (Minimal Superkey)

Example-1: R(ABCDF) $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$, then find the candidate key of R?

Topic : Candidatekey: (Minimal Superkey)

Example-1: R(ABCDF) {AB → C, C→D , B → E}, then find the candidate key of R?

Sol: $(AB)^+ = \{ABCDE\} \rightarrow$ super-key

and $A^+ = \{A\}$

$B^+ = \{BE\}$

$\left.\begin{array}{l} A^+ = \{A\} \\ B^+ = \{BE\} \end{array}\right\}$ Not super-key

AB follows both the rules, therefore it is a candidate key.

#Q. Find all candidate key of R with n attribute given FD set.

Topic : Important questions for GATE

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#Q. This is an NP- complete problem (exponential time complexity)

Topic : Important questions for GATE

#Q. Find all candidate key of R with n attribute given FD set.

#Q. This is an NP- complete problem (exponential time complexity)

#Q. Is a big, part of finding height NF & decomposition.

Topic : Important questions for GATE

Example-1: Given a relation R(ABCD) and FD's {$AB \to C$, $C \to D$, $D \to B$}. Find all candidate keys.

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Sol: $(AB)^+ = \{ABCD\}$

$A^+ = A$, $B^+ = B$ → No proper subset is SK

Topic : Important questions for GATE

Example-1: Given a relation R(ABCD) and FD's {AB→ C, C → D, D→ B}. Find all candidate keys.

Sol: $(AB)^+ = \{ABCD\} \rightarrow$ Super-key

$A^+ = A$, $B^+ = B \rightarrow$ No proper subset is SK

AB

C → A

CB

Topic : Important questions for GATE

Example-1: Given a relation R(ABCD) and FD's {AB→ C, C → D, D→ B}. Find all candidate keys.

A, B

$A\overset{C}{B} \rightarrow$ CK

A, B → prime

$C \rightarrow B$

Sol: $(AB)^+ = \{ABCD\} \rightarrow$ Super-key

$A^+ = A$, $B^+ = B$ → No proper subset is SK

- Prime attributes are attributes that belong to CK.

If Non trivial FD X → Y with Y is prime, then R has at least 2 CK'S

Topic : Important questions for GATE

Example-1: Given a relation R(ABCD) and FD's $\{AB \rightarrow C, C \rightarrow D, D \rightarrow B\}$. Find all candidate keys.

AB $D \rightarrow B$

Sol: $(AB)^+ = \{ABCD\} \rightarrow$ Super-key

$A^+ = A, B^+ = B \rightarrow$ No proper subset is SK

- Prime attributes are attributes that belong to CK.

If Non trivial FD $X \rightarrow Y$ with Y is prime, then R has at least 2 CK'S

- Here for $D \rightarrow B$, B is prime attribute then B can be replaced with D.

$\therefore (AD)^+ = \{ABCD\}$

$A^+ = A, D = \{DB\} \rightarrow$ No proper subset is SK.

Example-1: Given a relation R(ABCD) and FD's {$AB \to C$, $C \to D$, $D \to B$}. Find all candidate keys.

Sol: $(AB)^+ = \{ABCD\} \to$ Super-key

$A^+ = A$, $B^+ = B \to$ No proper subset is SK

- Prime attributes are attributes that belong to CK.

  If Non trivial FD $X \to Y$ with Y is prime, then R has at least 2 CK'S

- Here for $D \to B$, B is prime attribute then B can be replaced with D.

  $\therefore$ $(AD)^+ = \{ABCD\} \to$ super key

  $A^+ = A$, $D = \{DB\} \to$ No proper subset is SK.

Topic : Important questions for GATE

Example-1: Given a relation R(ABCD) and FD's {AB→ C, C → D, D→ B}. Find all candidate keys.

AB

Sol Cont: Now the CKs are {AB, AD}

- Same for C → D , D is prime attribute now.

∴ $(AC)^+ = \{ABCD\}$

$A^+ = A$, $C^+ = CDB$ → No proper subset is SK.

∴ AB, AD, AC are candidate keys.

Prime attr = {A, B, C, D}

Topic : Important questions for GATE

Example-1: Given a relation R(ABCD) and FD's {AB→ C, C → D, D→ B}. Find all candidate keys.

Sol Cont: Now the CKs are {AB, AD}

- Same for C → D , D is prime attribute now.

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Topic : Important questions for GATE

Example-2: R(ABCDE) and FD's are $\{AB \rightarrow C, BC \rightarrow D\}$ then what are its candidate keys?

Topic : Important questions for GATE

Example-2: R(ABCDE) and FD's are {$AB \rightarrow C$, $BC \rightarrow D$} then what are its candidate keys?

Sol: $(AB)^+ = \{ABCD\}$

Topic : Important questions for GATE

Example-2: R(ABCDE) and FD's are $\{AB \rightarrow C, BC \rightarrow D\}$ then what are its candidate keys?

Sol: $(AB)^+ = \{ABCD\}$

None of the FD's determine E, so E should be part of CK.

Topic : Important questions for GATE

Example-2: R(ABCDE) and FD's are $\{AB \rightarrow C, BC \rightarrow D\}$ then what are its candidate keys?

Sol: $(AB)^+ = \{ABCD\}$

None of the FD's determine E, so E should be part of CK.

$\underbrace{(ABE)^+}_{SK} = \{ABCDE\}$

Proper subset of ABE
$$\left\{\begin{array}{l} A^+ = \{A\} \\ B^+ = B \\ E^+ = E \\ AB^+ = \{ABCD\} \\ AE^+ = \{AE\} \\ BE^+ = \{BE\} \end{array}\right.$$

No Super-key

Example-2: R(ABCDE) and FD's are $\{AB \rightarrow C, BC \rightarrow D\}$ then what are its candidate keys?

Sol: $(AB)^+ = \{ABCD\}$

None of the FD's determine E, so E should be part of CK.

$(ABE)^+ = \{ABCDE\} \rightarrow$ Super-key

↓

CK

Proper subset of ABE
$$\left\{\begin{array}{l} A^+ = \{A\} \\ B^+ = B \\ E^+ = E \\ AB^+ = \{ABCD\} \\ AE^+ = \{AE\} \\ BE^+ = \{BE\} \end{array}\right.$$

No Super-key

Topic : Important questions for GATE

Example-2: R(ABCDE) and FD's are {AB → C, BC → D} then what are its candidate keys?

Sol Cont. : ∴ ABE is super-key & minimal, hence it is CK.

(A, B, E)

- Now check X →Y where Y is prime attribute.
- No such case, So only CK is possible.

Topic : Important questions for GATE

Example-3: For a relation R(ABC), No non trivial FD's are given then what are candidate keys.

Sol: According to RDBMS rules, there has to be at least one CK that uniquely differentiates a row in R.

Example-3: For a relation R(ABC), No non trivial FD's are given then what are candidate keys.

Sol: According to RDBMS rules, there has to be at least one CK that uniquely differentiates a row in R.

- If No non-trivial FD's are present then the combination of all attribute in R becomes CK.

R(ABC) ✗FD

(ABC) → CK

Example-3: For a relation R(ABC), No non trivial FD's are given then what are candidate keys.

Sol: According to RDBMS rules, there has to be at least one CK that uniquely differentiates a row in R.

- If No non-trivial FD's are present then the combination of all attribute in R becomes CK.

$\therefore$ ABC is the candidate key since it is the super-key and proper subset of this key cannot determine all attribute of R.

Topic : Important questions for GATE

Example-4: For relation R(ABCDEF), then FD's are

$\{AB \rightarrow C, C \rightarrow D, CD \rightarrow BE, DE \rightarrow F, EF \rightarrow A\}$. Find all the possible CK'S?

Sol: $(AB)^+ = \{ABCDEF\}$

SK

CK

$A^+ = A$, $B^+ = B$

Example-4: For relation R(ABCDEF), then FD's are

$\{AB \rightarrow C, C \rightarrow D, CD \rightarrow BE, DE \rightarrow F, EF \rightarrow A\}$. Find all the possible CK'S?

Sol: $(AB)^+ = \{ABCDEF\}$

$A^+ = A$, $B+ = B$

$\therefore$ AB is one of the CK.

Topic : Important questions for GATE

Example-4: For relation R(ABCDEF), then FD's are

$\{AB \rightarrow C, C \rightarrow D, CD \rightarrow BE, DE \rightarrow F, EF \rightarrow A\}$. Find all the possible CK'S?

Sol: $(AB)^+ = \{ABCDEF\}$ A, B

$A^+ = A, B+ = B$

$\therefore$ AB is one of the CK.

- Checking for $X \rightarrow Y$ where Y can be subset of {AB} which are CKs

$EF \rightarrow A$, A can be replaced with EF.

$AB = (EF)B$

$= EFB$ ✓

Topic : Important questions for GATE

Example-4: For relation R(ABCDEF), then FD's are

$\{AB \rightarrow C, C \rightarrow D, CD \rightarrow BE, DE \rightarrow F, EF \rightarrow A\}$. Find all the possible CK'S?

SK

Sol Cont.: Now checking for $(BEF)^+ = \{ABCDEF\}$

Proper subset

$$\left\{\begin{array}{l} B^+ = B \\ E^+ = E \\ F^+ = F \\ BE^+ = BE \\ BF^+ = BF \\ EF^+ = EFA \end{array}\right\}$$

$\therefore$ BEF is another CK.

Example-4: For relation R(ABCDEF), then FD's are

$\{AB \rightarrow C,\ C \rightarrow D,\ CD \rightarrow BE,\ DE \rightarrow F,\ EF \rightarrow A\}$. Find all the possible CK'S?

Sol Cont.: Now CK's are {AB, BEF}

- Check for $X \rightarrow Y$ where Y can be subset of {ABEF} i.e. set of all prime attributes.

  $DE \rightarrow F$, F can be replaced with DE

  $(BDE)^+ = BDEFAC$

  $B^+ = B$, $D^+ = D$, $E^+ = E$, $(BD)^+ = BD$, $(DE)^+ = DEFA$, $(BE)^+ = BE$

  $\therefore$ BDE is another CK

SK

CK

Topic : Important questions for GATE

Example-4: For relation R(ABCDEF), then FD's are

$\{AB \rightarrow C, C \rightarrow D, CD \rightarrow BE, DE \rightarrow F, EF \rightarrow A\}$. Find all the possible CK'S?

$C^+ = CDBEFA$

Sol Cont.: Now, CKs are {AB, BEF, BDE}

- Checking for $X \rightarrow Y$ where Y is part of prime attribute set $CD \rightarrow BE$, BE can be replaced with CD.

BEF = CDF

$(CDF)^+ = \{ABCDEF\}$

SK

$C^+ = CDBEFA \rightarrow$ Super-key

$\therefore$ CDF is not CK

C is CKey

BDE = CD

$C^+ = ABCDEF$

$\therefore$ CD is not CK

Example-4: For relation R(ABCDEF), then FD's are

$\{AB \rightarrow C, C \rightarrow D, CD \rightarrow BE, DE \rightarrow F, EF \rightarrow A\}$. Find all the possible CK'S?

Sol Cont.: CKs are {AB, BEF, BDE, C}

- Check for $X \rightarrow Y$ where Y is part of {ABCDEF}

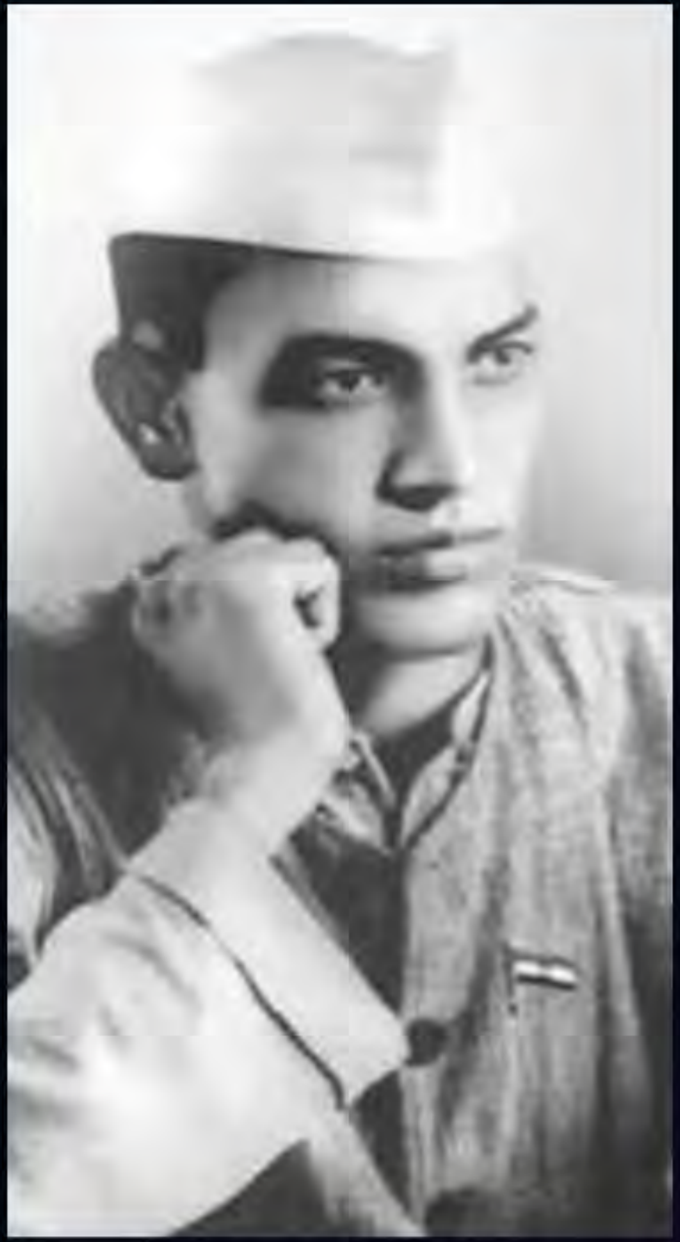
  $C \rightarrow D$, D can be replaced with C

  BDE = BCE $\rightarrow$ Not CK, because C which is proper subset is already a CK.

  $AB \rightarrow C$, C can be replaced with AB {Already a CK}.

$\therefore$ There are 4CK's present.

Inspiring Stories : Sri Dev Suman



Background: **Hill region writer-activist.**

Struggles: **Fought a harsh local monarchy backed by the Raj.**

Achievements: **Led non-violent protests; jailed and died in custody (1944).**

Impact: **Hill youth still remember him as the voice of the mountains.**

Topic : Important questions for GATE

Example-5: R(ABCDEF), FD's are $\{AB \rightarrow C, C \rightarrow DE, E \rightarrow F, F \rightarrow B\}$ then what are CK's.

Sol: $(AB)^+ = \{ABCDEF\}$

SK

$A^+ = A$, $B^+ = B$

CK

$\therefore$ AB is CK

Example-5: R(ABCDEF), FD's are $\{AB \rightarrow C, C \rightarrow DE, E \rightarrow F, F \rightarrow B\}$ then what are CK's.

Sol: $(AB)^+ = \{ABCDEF\}$ (A, B)

$A^+ = A, B^+ = B$

$\therefore$ AB is CK

- Check for $X \rightarrow Y$ where Y is subset of {AB}

  $F \rightarrow B$, B can be replaced with F.

  AB = AF

Topic : Important questions for GATE

Example-5: R(ABCDEF), FD's are {$AB \rightarrow C$, $C \rightarrow DE$, $E \rightarrow F$, $F \rightarrow B$} then what are CK's.

Sol: $(AB)^+ = \{ABCDEF\}$

$A^+ = A$, $B^+ = B$

$\therefore$ AB is CK

- Check for $X \rightarrow Y$ where Y is subset of {AB}

$F \rightarrow B$, B can be replaced with F.

$AB = AF$

$(AF)^+ = \underline{(AFBCDEF)}$ SK

$A^+ = A$

$F^+ = FB$

CK $\therefore$ AF is CK

Topic : Important questions for GATE

Example-5: R(ABCDEF), FD's are {$AB \rightarrow C$, $C \rightarrow DE$, $E \rightarrow F$, $F \rightarrow B$} then what are CK's.

Sol Cont:

The CK's now are {AB ✓, AF ✓}

- Check for $X \rightarrow Y$ where Y is part of {ABF}

  $E \rightarrow F$, F can be replaced with E.

  AF = AE

  $(AE)^+ = \{AFBCDEF\}$ SK → CK

  propersubsets closures: $A^+ = A$, ~~$E^+ = FB$~~ $E^+ = EFB$

  ∴ AE is the CK.

Example-5: R(ABCDEF), FD's are {$AB \rightarrow C$, $C \rightarrow DE$, $E \rightarrow F$, $F \rightarrow B$} then what are CK's.

Sol Cont:

CK's Now are {AB, AE, AF}

- Check for $X \rightarrow Y$ where Y is part of {ABEF}

  $C \rightarrow DE$ can be written as $C \rightarrow D$, $C \rightarrow E$

Example-5: R(ABCDEF), FD's are {$AB \rightarrow C$, $C \rightarrow DE$, $E \rightarrow F$, $F \rightarrow B$} then what are CK's.

Sol Cont:

CK's Now are {AB, AE, AF}

- Check for $X \rightarrow Y$ where Y is part of {ABEF}

$C \rightarrow DE$ can be written as $C \rightarrow D$, $C \rightarrow E$

In place of E, C can be used.

AE = AC

SK

$AC^+ = ACDEFB$

proper subsets closure:

$A^+ = A$

CK

$C^+ = CDEFB$

∴ AC is CK

∴ The CKs are AB, AF, AE, AC.

Topic : Important questions for GATE

Example-6 R(ABCDE) {A→B, B→C, C→D, D→A}. What are CK's?

Sol: $A^+ = ABCD$; None of the FDs determine E, so E should be part of CK.

Example-6 R(ABCDE) {A→B, B→C, C→D, D→A}. What are CK's?

Sol Cont: $A^+ = ABCD$; None of the FDs determine E, so E should be part of CK.

$(AE)^+ = \underline{ABCDE}$

SK

$A^+ = \underline{ABCD}$

$E^+ = \underline{E}$

CK

∴ AE is CK

Topic : Important questions for GATE

Example-6 R(ABCDE) {A→B, B→C, C→D, D→A}. What are CK's?

Sol Cont: A^+ = ABCD; None of the FDs determine E, so E should be part of CK.

$(AE)^+ = ABCDE$

$A^+ = ABCD$

$E^+ = E$

$\therefore$ AE is CK

- Checking for prime attributes {AE} on Right side.

  D → A, A can be replaced with D

Topic : Important questions for GATE

Example-6 R(ABCDE) {A→B, B→C, C→D, D→A}. What are CK's?

Sol Cont: $A^+ = ABCD$; None of the FDs determine E, so E should be part of CK.

$(AE)^+ = ABCDE$

$A^+ = ABCD$

$E^+ = E$

∴ AE is CK

- Checking for prime attributes {AE} on Right side.

D → A, A can be replaced with D

AE = DE ✓

SK ← $(DE)^+ = \{ABCDE\}$

$D^+ = \underline{ABCD}$

$E^+ = \underline{E}$

∴ DE is CK

Example-6 R(ABCDE) {A→B, B→C, C→D, D→A}. What are CK's?

Sol Cont: Now the CKs are {AE, DE}

- Checking for the prime attributes(ADE} on Right side.

  C → D, D can be replaced with C

  DE = CE

Example-6 R(ABCDE) {A→B, B→C, C→D, D→A}. What are CK's?

Sol Cont: Now the CKs are {AE, DE}

- Checking for the prime attributes(ADE} on Right side.

$C \rightarrow D$, D can be replaced with C

DE = CE

$(CE)^+ = ABCDE$, C^+ , E^+ are not super-key

$\therefore$ CE is CK

Example-6 R(ABCDE) {A→B, B→C, C→D, D→A}. What are CK's?

Sol Cont:

Now CK's are {AE, DE, CE}

- Checking for prime Attributes on Right Side.

  B→C, C can be replaced with B.

  CE = BE

Example-6 R(ABCDE) {A→B, B→C, C→D, D→A}. What are CK's?

Sol Cont:

Now CK's are {AE, DE, CE}

- Checking for prime Attributes on Right Side.

  B→C, C can be replaced with B.

  CE = BE

  $(BE)^+$ = ABCDE

  B & E are not SK

SK

∴ BE is CK.

Topic : Important questions for GATE

Example-6 R(ABCDE) {A→B, B→C, C→D, D→A}. What are CK's?

Sol Cont:

Now, CK's are {AE, DE, CE, BE}

- Checking for prime Attributes on Right Side.

  A→B, B can be replaced with A

  BE = AE already a CK.

∴ The CK's are {AE, BE, CE, DE}

Topic : Important questions for GATE

Example-7: R(ABCDEF), the FD's are $\{AB \rightarrow C,\ C \rightarrow A,\ BC \rightarrow D,\ ACD \rightarrow B,\ BE \rightarrow C,\ EC \rightarrow FA,\ CF \rightarrow BD,\ D \rightarrow E\}$

Sol: $AB^+ = \{ABCDEF\}$

SK

$A^+ = A,\ B^+ = B$

$\therefore$ AB is CK

CK

Example-7: R(ABCDEF), the FD's are {$AB \to C$, $C \to A$, $BC \to D$, $ACD \to B$, $BE \to C$, $EC \to FA$, $CF \to BD$, $D \to E$ }

Sol Cont. : $AB^+ = \{ABCDEF\}$

$A^+ = A$, $B+ = B$

$\therefore$ AB is CK

- Checking for prime attribute on Right Side

$C \to A$, A can be replaced with C.

$AB = CB$

$(CB)^+ = CB\ ADEF$

$C^+ = CA$

$\therefore$ CB is CK.

Example-7: R(ABCDEF), the FD's are {$AB \rightarrow C$, $C \rightarrow A$, $BC \rightarrow D$, $ACD \rightarrow B$, $BE \rightarrow C$, $EC \rightarrow FA$, $CF \rightarrow BD$, $D \rightarrow E$ }

Sol Cont: The CKs now are {AB, BC}

- Checking for prime attribute on Right Side

  $ACD \rightarrow B$, B can be replaced with ACD

  BC = ACD

  $(ACD)^+$ = ABCDEF

  SK

  instead of finding all closures, lets observe the FDs

  A and C cannot be in same CK, because $C \rightarrow A$

  Replace A with C in ACD, then $(CD)^+$= CDABEF

∴ CD alone can be CK

AB = ACD same for this

Example-7: R(ABCDEF), the FD's are {AB→C, C→A, BC→D, ACD→B, BE→C, EC→FA, CF→BD, D→E }

Sol Cont: Now, CK's are {AB, BC, CD}

- Checking for prime attribute on Right Side

  BC→D, D can be replaced with BC

  CD = BC, already a CK.

Topic : Important questions for GATE

Example-7: R(ABCDEF), the FD's are {$AB \rightarrow C$, $C \rightarrow A$, $BC \rightarrow D$, $ACD \rightarrow B$, $BE \rightarrow C$, $EC \rightarrow FA$, $CF \rightarrow BD$, $D \rightarrow E$ }

Sol Cont: Now, CK's are {AB, BC, CD}

- Checking for prime attribute on Right Side

  $BC \rightarrow D$, D can be replaced with BC

  CD = BC, already a CK.

  $BE \rightarrow C$, C can be replaced with BE.

  BC = BE,

  $(BE)^+ = ABCDEF$ SK

  $B^+ = B$

  $E^+ = E$

  ∴ BE is CK.

  CD = BED SK

  BE is already CK

  ∴ BED is not CK

Topic : Important questions for GATE

Example-7: R(ABCDEF), the FD's are {$AB \rightarrow C$, $C \rightarrow A$, $BC \rightarrow D$, $ACD \rightarrow B$, $BE \rightarrow C$, $EC \rightarrow FA$, $CF \rightarrow BD$, $D \rightarrow E$ }

Sol Cont: Now, the CK's are {AB, BC, CD, BE}

Example-7: R(ABCDEF), the FD's are {$AB \to C$, $C \to A$, $BC \to D$, $ACD \to B$, $BE \to C$, $EC \to FA$, $CF \to BD$, $D \to E$ }

Sol Cont: Now, the CK's are {AB, BC, CD, BE}

$D \to E$, E can be replaced with D.

BE = BD

SK ← $(BD)^+ = ABCDEF$

$B^+ = B$

$D^+ = DE$

$\therefore$ BD is CK.

Topic : Important questions for GATE

Example-7: R(ABCDEF), the FD's are {$AB \to C$, $C \to A$, $BC \to D$, $ACD \to B$, $BE \to C$, $EC \to FA$, $CF \to BD$, $D \to E$ }

Sol Cont: Now, the CK's are {AB, BC, CD, BE, BD}

- Checking for prime attribute on Right side.

  $CF \to BD$, BD can be replaced with CF.

Example-7: $R(ABCDEF)$, the FD's are $\{AB \to C,\ C \to A,\ BC \to D,\ ACD \to B,\ BE \to C,\ EC \to FA,\ CF \to BD,\ D \to E\}$

Sol Cont: Now, the CK's are {AB, BC, CD, BE, BD}

- Checking for prime attribute on Right side.

$CF \to BD$, BD can be replaced with CF.

$BD = CF$

$(CF)^+ = \underline{ABCDEF}$

SK

$C^+ = CA$

$F^+ = F$

$\therefore$ CF is CK.

Example-7: R(ABCDEF), the FD's are {AB→C, C→A, BC→D, ACD→B, BE→C, EC→FA, CF→BD, D→E }

Sol Cont: CK's are {AB, BC, CD, BE, BD, CF}

Now checking for remaining FDs that are not covered

Also check for CF → BD => CF → B, CF → D

like before problem, the proper subsets are already CK's.

Topic : Important questions for GATE

Example-7: R(ABCDEF), the FD's are {AB→C, C→A, BC→D, ACD→B, BE→C, EC→FA, CF→BD, D→E }

Sol Cont: ⇒ EC→FA then EC→ F, EC→A.

$\underbrace{F}_{\downarrow \text{ Prime}}$, $\underbrace{A}_{\downarrow \text{ Prime}}$

Topic : Important questions for GATE

Example-7: R(ABCDEF), the FD's are $\{AB \rightarrow C,\ C \rightarrow A,\ BC \rightarrow D,\ ACD \rightarrow B,\ BE \rightarrow C,\ EC \rightarrow FA,\ CF \rightarrow BD,\ D \rightarrow E\}$

Sol Cont: $\Rightarrow$ $EC \rightarrow FA$ then $EC \rightarrow F$, $EC \rightarrow A$.

Prime Prime Replacing F and A with EC

$CF = C(EC)$
$= EC$
✓ $EC^+ = ABCDEF$
$E^+ = E$
$C^+ = CA$
EC is CK.

$AB = (EC)\ B$
$= BCE$ ✗
BC, BE are already CKs.
$\therefore$ BCE cannot be a CK.

Example-7: R(ABCDEF), the FD's are {$AB \to C$, $C \to A$, $BC \to D$, $ACD \to B$, $BE \to C$, $EC \to FA$, $CF \to BD$, $D \to E$ }

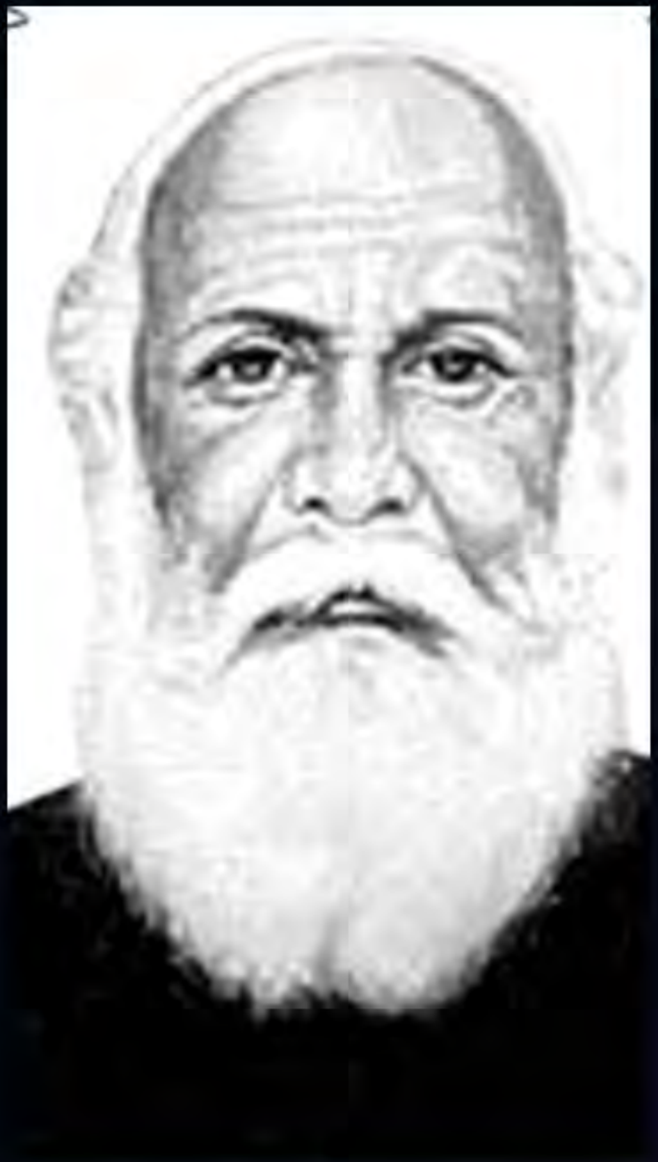
Sol Cont:

- The New CK's are {AB, BC, CD, BE, BD, CF, EC}

  $AB \to C$, None of the CK's form new CKs.

$\therefore$ 7 Candidate keys are possible.

Inspiring Stories : Baba Kanshi Ram



Background: **Poet from the hills; called "Pahari/Hill Gandhi".**

Struggles: **Used poems and speeches against British rule.**

Achievements: **Took vows of simple living; kept the freedom fire alive in Himachal.**

Impact: **Proved that words can be weapons.**

Topic: Membership Test

X

- $X \rightarrow Y$ functional dependency is a member of FD set F,

  iff X^+ must determine Y in FD set F.

Topic: Membership Test

Ex : Given FD set $\{AB \rightarrow C, C \rightarrow D, D \rightarrow E, E \rightarrow F, F \rightarrow B\}$, which of the FD's are members of given FD test

(i) $AB \rightarrow F$ (ii) $AC \rightarrow B$ (iii) $BC \rightarrow A$

Topic: Membership Test

Ex : Given FD set $\{AB \to C, C \to D, D \to E, E \to F, F \to B\}$, which of the FD's are members of given FD test

(i) $AB \to F$ (ii) $AC \to B$ (iii) $BC \to A$

Sol.: (i) $AB^+ = \{ABCDEF\}$

$AB \to F$ is a member of FD set.

Topic: Membership Test

Ex : Given FD set $\{AB \rightarrow C, C \rightarrow D, D \rightarrow E, E \rightarrow F, F \rightarrow B\}$, which of the FD's are members of given FD test

(i) $AB \rightarrow F$ (ii) $AC \rightarrow B$ (iii) $BC \rightarrow A$

Sol.: (i) $AB^+ = \{ABCDEF\}$

$AB \rightarrow F$ is a member of FD set.

(ii) $AC^+ = \{ACDEFB\}$

$AC \rightarrow B$ is a member of FD set.

Topic: Membership Test

Ex : Given FD set $\{AB \to C, C \to D, D \to E, E \to F, F \to B\}$, which of the FD's are members of given FD test

(i) $AB \to F$ (ii) $AC \to B$ (iii) $BC \to A$

X

Sol.: (i) $AB^+ = \{ABCDEF\}$

$AB \to F$ is a member of FD set.

(ii) $AC^+ = \{ACDEFB\}$

$AC \to B$ is a member of FD set.

(iii) $BC^+ = \{BCDEF\}$

$BC \to A$ is not a member of FD set. X

Topic: Equality of Two FD Sets

F & G FD sets are logically equal iff

(i) F covers G : Every FD of G set must be member of F set

and

(ii) G covers F : Every FD of F set must be member of G set.

Topic: Equality of Two FD Sets

F & G FD sets are logically equal iff

(i) F covers G : Every FD of G set must be member of F set

and

(ii) G covers F : Every FD of F set must be member of G set.

F cover G ($F \supseteq G$)

G cover F ($G \supseteq F$)

Topic: Equality of Two FD Sets

F covers G	G covers F	Conclusion
Yes	Yes	F = G
Yes	No	$F \supset G$
No	Yes	$F \subset G$
No	No	Cannot compare

#Q. $F = \{A \rightarrow B, B \rightarrow C, C \rightarrow A\}$

$G = \{A \rightarrow BC, B \rightarrow AC, BC \rightarrow A, AB \rightarrow C\}$

Which one is true?

A) $F \subset G$

B) $F \supset G$

C) $F = G$

D) None

#Q. $F = \{A \to B, B \to C, C \to A\}$

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

Which one is true?

A $F \subset G$

B $F \supset G$

C $F = G$

D None

Sol. (i) F covers G

G FD's

$A \to BC$

$B \to AC$

$BC \to A$

$AB \to C$

#Q. $F = \{A \to B, B \to C, C \to A\}$

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

Which one is true?

A $F \subset G$

B $F \supset G$

C $F = G$

D None

Sol. (i) F covers G

G FD's

$A \to BC$

$B \to AC$

$BC \to A$

$AB \to C$

F closures from F FDs

#Q. $F = \{A \to B, B \to C, C \to A\}$

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

Which one is true?

A $F \subset G$

B $F \supset G$

C $F = G$

D None

Sol. (i) F covers G

G FD's

$A \to BC$ ✓

$B \to AC$ ✓

$BC \to A$ ✓

$AB \to C$ ✓

F closures from F FDs

$\underline{A}^+ = \underline{ABC}$

$B^+ = ABC$ ✓

#Q. $F = \{A \rightarrow B, B \rightarrow C, C \rightarrow A\}$

$G = \{A \rightarrow BC, B \rightarrow AC, BC \rightarrow A, AB \rightarrow C\}$

Which one is true?

A $F \subset G$

B $F \supset G$

C $F = G$

D None

Sol. (i) F covers G

G FD's	F closures from F FDs
$A \rightarrow BC$ ✓	$A^+ = ABC$
$B \rightarrow AC$ ✓	$B^+ = ABC$
$BC \rightarrow A$ ✓	$BC^+ = BC\underline{A}$
$AB \rightarrow C$ ✓	$AB^+ = AB\underline{C}$

#Q. $F = \{A \to B, B \to C, C \to A\}$

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

Which one is true?

A $F \subset G$

B $F \supset G$

C $F = G$

D None

Sol. (i) F covers G

G FD's

$A \to BC$

$B \to AC$

$BC \to A$

$AB \to C$

$\therefore$ F covers G

F closures from F FDs

$A^+ = ABC$

$B^+ = ABC$

$BC^+ = BCA$

$AB^+ = ABC$

#Q. $F = \{A \rightarrow B, B \rightarrow C, C \rightarrow A\}$

$G = \{A \rightarrow BC, B \rightarrow AC, BC \rightarrow A, AB \rightarrow C\}$

Which one is true?

A $F \subset G$

B $F \supset G$

C $F = G$

D None

Sol Cont. (ii) G covers F

F FD's

$$\left.\begin{array}{l} A \rightarrow B \\ B \rightarrow C \\ C \rightarrow A \end{array}\right\}$$

#Q. $F = \{A \to B, B \to C, C \to A\}$

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

Which one is true?

A $F \subset G$

B $F \supset G$

C $F = G$

D None

Sol Cont. (ii) G covers F

F FD's

$A \to B$ ✓

$B \to C$ ✓

$C \to A$ ✗

G closures from G FD's

$A^+ = ABC$ ✓

$B^+ = BAC$

$C^+ = C$ ✓

#Q. $F = \{A \rightarrow B, B \rightarrow C, C \rightarrow A\}$

$G = \{A \rightarrow BC, B \rightarrow AC, BC \rightarrow A, AB \rightarrow C\}$

Which one is true?

A $F \subset G$

B $F \supset G$

C $F = G$

D None

Sol Cont. (ii) G covers F

F FD's	G closures from G FD's
$A \rightarrow B$	$A^+ = ABC$
$B \rightarrow C$	$B^+ = BAC$
$C \rightarrow A$	$C^+ = C$

$\therefore$ G doesn't covers F

#Q. $F = \{A \rightarrow B, B \rightarrow C, C \rightarrow A\}$

$G = \{A \rightarrow BC, B \rightarrow AC, BC \rightarrow A, AB \rightarrow C\}$

Which one is true?

A $F \subset G$

B $F \supset G$

C $F = G$

D None

Sol Cont. (ii) G covers F

F FD's	G closures from G FD's
$A \rightarrow B$	$A^+ = ABC$
$B \rightarrow C$	$B^+ = BAC$
$C \rightarrow A$	$C^+ = C$

$\therefore$ G doesn't covers F

Topic: Properties of Decomposition

Properties of Decomposition:

- The decomposition should be Lossless join Decomposition
- The decomposition should be Dependency Preserving decomposition

10 min break

Topic: Properties of Decomposition

Decomposition (For instances or tables given) :

- If a relation R is decomposed into sub Relation $R_1, R_2, \ldots, R_n$ there are 3 possible cases:

  (i) $R_1 \bowtie R_2 \bowtie R_3 \ldots R_n \supseteq R$

  (ii) $R_1 \bowtie R_2 \bowtie R_3 \ldots R_n = R$

  (iii) $R_1 \bowtie R_2 \bowtie R_3 \ldots R_n \supset R$

Topic: Properties of Decomposition

Decomposition (For instances or tables given) :

- If a relation R is decomposed into sub Relation $R_1, R_2, \ldots, R_n$ there are 3 possible cases:

(i) $R_1 \bowtie R_2 \bowtie R_3 \ldots R_n \supseteq R \rightarrow$ In General

(ii) $R_1 \bowtie R_2 \bowtie R_3 \ldots R_n = R \rightarrow$ Lossless join decomposition

(iii) $R_1 \bowtie R_2 \bowtie R_3 \ldots R_n \supset R \rightarrow$ Loosy join decomposition

Topic: Properties of Decomposition

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- If a relation R is decomposed into sub Relation $R_1, R_2, \ldots, R_n$ there are 3 possible cases:

  (i) $R_1 \bowtie R_2 \bowtie R_3 \ldots R_n \supseteq R \rightarrow$ In General

  (ii) $R_1 \bowtie R_2 \bowtie R_3 \ldots R_n = R \rightarrow$ Lossless join decomposition

  (iii) $R_1 \bowtie R_2 \bowtie R_3 \ldots R_n \supset R \rightarrow$ Loosy join decomposition

Topic: Properties of Decomposition

Ex : Let a Relation R is decomposed into smaller relation R_1 and R_2.

Relation R

Sid	Sname	Cid
S1	A	C1
S1	A	C2
S2	B	C2
S3	B	C3

Topic: Properties of Decomposition

Ex : Let a Relation R is decomposed into smaller relation R_1 and R_2.

Relation R

Sid	Sname	Cid
S1	A	C1
S1	A	C2
S2	B	C2
S3	B	C3

=>

Relation R_1

Sid	Sname
S1	A
S2	B
S3	B

Relation R_2

Sid	Cid
S1	C1
S1	C2
S2	C2
S3	C3

Topic: Properties of Decomposition

Explanation : $\bowtie$ → Natural join

Joining Two Relation based on Sid

R_1

Sid	Sname
S1	A
S2	B
S3	B

R_2

Sid	Cid
S1	C1
S1	C2
S2	C2
S3	C3

Here, $R_1 \bowtie R_2 = R$, this is called Lossless join decomposition.

Topic: Properties of Decomposition

Explanation : $\bowtie \rightarrow$ Natural join

Joining Two Relation based on Sid

R_1

Sid	Sname
S1	A
S2	B
S3	B

R_2

Sid	Cid
S1	C1
S1	C2
S2	C2
S3	C3

$R_1 \bowtie R_2$

Sid	Sname	Cid
S1	A	C1
S1	A	C2
S2	B	C2
S3	B	C3

Here, $R_1 \bowtie R_2 = R$, this is called Lossless join decomposition.

Topic: Properties of Decomposition

Now lets say the new R is decomposed into different relations R_1 and R_2

R

Sid	Sname	Cid
S1	A	C1
S1	A	C2
S2	B	C2
S3	B	C3

Topic: Properties of Decomposition

Now lets say the new R is decomposed into different relations R_1 and R_2

R

Sid	Sname	Cid
S1	A	C1
S1	A	C2
S2	B	C2
S3	B	C3

=>

R_1

Sid	Sname
S1	A
S2	B
S3	B

R_2

Sname	Cid
A	C1
A	C2
B	C2
B	C3

Topic: Properties of Decomposition

Now $R_1 \bowtie R_2$ on Sname

R_1

Sid	Sname
S1	A
S2	B
S3	B

R_2

Sname	Cid
A	C1
A	C2
B	C2
B	C3

Topic: Properties of Decomposition

Now $R_1 \bowtie R_2$ on Sname

R_1

Sid	Sname
S1	A
S2	B
S3	B

R_2

Sname	Cid
A	C1
A	C2
B	C2
B	C3

Sid	Sname	Cid
S1	A	C1
S1	A	C2
S2	B	C2
S2	B	C3
S3	B	C2
S3	B	C3

Spurious tuples

Now $R_1 \bowtie R_2 \supset R$, this is lossy join

Topic: Properties of Decomposition

Now $R_1 \bowtie R_2 \supset R$, this is lossy join

- If the decomposition is done and the common attribute is a Super key / Candidate key of one of the Sub-Relation then such a decomposition is guaranteed to be loss-less decomposition.

Topic: Properties of Decomposition

Now $R_1 \bowtie R_2 \supset R$, this is lossy join

- If the decomposition is done and the common attribute is a Super key / Candidate key of one of the Sub-Relation then such a decomposition is guaranteed to be loss-less decomposition.

Ex: Decomposition on Sid is lossless

Decomposition on Sname is lossy, because Sname is not a Superkey or Candidate key of any Sub-Relation.

Inspiring Stories : Paona Brajabasi

Background: Major in the Manipur army.

Struggles: Faced British invasion in the 1891 war.

Achievements: Fought at Khongjom; refused to switch sides even when offered his life; executed.

Impact: Manipur marks Patriots' Day for heroes like him.

Topic: Properties of Decomposition

Lossless join decomposition (For Relation with FD's given) :

- Let a Relation Schema R with FD set F is decomposed into Sub-Relation R_1 , R_2

  Given decomposition is lossless join iff

  (i) $R_1 \cup R_2 = R$

Topic: Properties of Decomposition

Lossless join decomposition (For Relation with FD's given) :

- Let a Relation Schema R with FD set F is decomposed into Sub-Relation R_1 , R_2

  Given decomposition is lossless join iff

  (i) $R_1 \cup R_2 = R$

  and

  (ii) $(R_1 \cap R_2) \rightarrow R_1$ or $(R_1 \cap R_2) \rightarrow R_2$

Topic: Properties of Decomposition

Lossless join decomposition (For Relation with FD's given) :

- Let a Relation Schema R with FD set F is decomposed into Sub-Relation R_1 , R_2

  Given decomposition is lossless join iff

  (i) $R_1 \cup R_2 = R$

  and

  (ii) $(R_1 \cap R_2) \rightarrow R_1$ or $(R_1 \cap R_2) \rightarrow R_2$

  $\Downarrow$ $\Downarrow$

  $R_1 \cap R_2$ is SK of R_1 $R_1 \cap R_2$ is SK of R_2

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(i) decomposition {ABC, CD} is it lossless?

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(i) decomposition {ABC, CD} is it lossless?

Sol: Here, $R_1 \cup R_2$ = ABCD EX

$\neq$ R, so lossy join

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(i) decomposition {ABC, CD} is it lossless?

Sol: Here, $R_1 \cup R_2 = ABCD$

$\neq R$, so lossy join

(ii) decomposition {ABC, DE} is it lossless?

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(i) decomposition {ABC, CD} is it lossless?

Sol: Here, $R_1 \cup R_2 = ABCD$

$\neq R$, so lossy join

(ii) decomposition {ABC, DE} is it lossless?

Sol: Here, $R_1 \cup R_2 = R$, but there is no common attribute for Natural join.

So, it is lossy

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \to C, C \to D, B \to E\}$

(iii) decomposition R_1 (ABC) , R_2 (CDE) is it lossless?

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(iii) decomposition R_1 (ABC) , R_2 (CDE) is it lossless?

Sol: $R_1 \cup R_2 = ABCDE = R$ ✓

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(iii) decomposition R_1 (ABC) , R_2 (CDE) is it lossless?

Sol: $R_1 \cup R_2 = ABCDE = R$

There is a common attribute

Now, $R_1 \cap R_2 = \underline{C}$

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(iii) decomposition R_1 (ABC) , R_2 (CDE) is it lossless?

Sol: $R_1 \cup R_2 = ABCDE = R$

There is a common attribute

Now, $R_1 \cap R_2 = C$

$C^+ = \{C, D\}$

C is not a Superkey of both the relation R_1 & R_2

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(iii) decomposition R_1 (ABC) , R_2 (CDE) is it lossless?

Sol: $R_1 \cup R_2$ = ABCDE = R

There is a common attribute

Now, $R_1 \cap R_2 = C$

$C^+ = \{C, D\}$

C is not a Superkey of both the relation R_1 & R_2

such a decomposition is also lossy.

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(iv) decomposition R_1 (ABC) , R_2 (CD), R_3 (DE), is it lossless?

Sol: $R_1 \cup R_2 \cup R_3 = ABCDE = R$

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(iv) decomposition R_1 (ABC) , R_2 (CD), R_3 (DE), is it lossless?

Sol: $R_1 \cup R_2 \cup R_3 = ABCDE = R$

There is common attribute for R_1 & R_2, the new relation has common attribute with R_3, then again merged.

R_1 (ABC) R_2 (CD)

$C^+ = CD$

Candidate key

R_{12} (ABCD)

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(iv) decomposition R_1 (ABC) , R_2 (CD), R_3 (DE), is it lossless?

Sol: $R_1 \cup R_2 \cup R_3 = ABCDE = R$

There is common attribute for R_1 & R_2, the new relation has common attribute with R_3, then again merged.

R_1 (ABC) $\quad$ R_2 (CD) $\quad$ R_3 (DE)

$C^+ = CD$ → Candidate key of R_2

R_1 (ABC) + R_2 (CD) → R_{12} (ABCD)

R_{12} (ABCD) + R_3 (DE) → R_{123} (ABCDE)

$D^+ = D$ not Sk for any of tables

So, not possible

∴ This is lossy decomposition.

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(v) R_1 (AB) R_2 (CD) R_3 (BC)

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \to C, C \to D, B \to E\}$

(v) R_1 (AB) R_2 (CD) R_3 (BC)

Sol: Lossy because E attribute is missing

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(v) R_1 (AB) R_2 (CD) R_3 (BC)

Sol: Lossy because E attribute is missing

(vi) R_1 (ABC) R_2 (CD) R_3 (BE)

Topic: Properties of Decomposition

Ex : Relation R(ABCDE) and the function dependencies are $\{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$

(v) R_1 (AB) R_2 (CD) R_3 (BC)

Sol: Lossy because E attribute is missing

$C^+ = CD$

(vi) R_1 (ABC) R_2 (CD) R_3 (BE)

Sol: R_1 & R_2 can be merged because the common attribute C is Ck of R_2.

$R_1 (ABC) \bowtie R_2 (CD) = R_{12} (ABCD)$

R_{12} (ABCD) & R_3 (BE)

Common attribute = B

$B^+ = BE$, Ck of R_3 $\therefore$ can be joined,

the new table is R_{123} (ABCDE) $\therefore$ The join is lossless.

Topic: Functional Dependencies of Decomposition

- Relational schema R with FD set F is decomposed into Sub Relation $R_1, R_2, \ldots, R_n$ with FD sets $F_1, F_2, \ldots, F_n$

  (i) If $\{F_1 \cup F_2 \ldots F_n\} \subseteq F \rightarrow$ In General

  (ii) If $\{F_1 \cup F_2 \ldots F_n\} = F$, then it is dependency preserving decomposition

  (iii) If $\{F_1 \cup F_2 \ldots F_n\} \subset F$, then it is not dependency preserving decomposition

Topic: Functional Dependencies of Decomposition

For a Relation R_1 (p q r),

find the closures of all possible attribute subsets, and non-trivial FD's from it,

ex: {p, q, r, pq, qr, rp} are possible ones and find the non-trivial ones from it,

ex: $p^+ = pqr$ then $p \rightarrow qr$ is a FD associated with p

This is used to check the FD preservation

Topic: Properties of Decomposition

Ex1: There is a Relation R (ABCDE) and its functional dependencies are $\{A \rightarrow B, B \rightarrow C, C \rightarrow D, D \rightarrow BE\}$

(i) The decomposition {AB, BC, CD, DE}, is this

dependency preserving

Sol:

R_1 (AB)

$A \rightarrow B$

Topic: Properties of Decomposition

Ex1: There is a Relation R (ABCDE) and its functional dependencies are {$A \rightarrow B$, $B \rightarrow C$, $C \rightarrow D$, $D \rightarrow BE$}

(i) The decomposition {AB, BC, CD, DE}, is this

Sol:

R_1 (AB)	R_2 (BC)
$A \rightarrow B$	$B \rightarrow C$
	$C \rightarrow B$
$A^+ = ABCDE$	(from $C \rightarrow D$, $D \rightarrow BE$)

$B^+ = BCDE$

$C^+ = CDBE$

Topic: Properties of Decomposition

Ex1: There is a Relation R (ABCDE) and its functional dependencies are $\{A \to B, B \to C, C \to D, D \to BE\}$

(i) The decomposition {AB, BC, CD, DE}, is this

Sol:

R_1 (AB)	R_2 (BC)	R_3 (CD)
$A \to B$	$B \to C$ $C \to B$ (from $C \to D$, $D \to BE$)	$C \to D$ $D \to C$ (from $D \to B$, $B \to C$)

$C^+ = CDBE$

$D^+ = DBECD$

Topic: Properties of Decomposition

Ex1: There is a Relation R (ABCDE) and its functional dependencies are {$A \rightarrow B$, $B \rightarrow C$, $C \rightarrow D$, $D \rightarrow BE$}

(i) The decomposition {AB, BC, CD, DE}, is this

Sol:

R_1 (AB)	R_2 (BC)	R_3 (CD)	R_4 (DE)
$A \rightarrow B$	$B \rightarrow C$ $C \rightarrow B$ (from $C \rightarrow D$, $D \rightarrow BE$)	$C \rightarrow D$ $D \rightarrow C$ (from $D \rightarrow B$, $B \rightarrow C$)	$D \rightarrow E$

$D^+ = DBECD$

$E^+ = E$ ✓

Topic: Properties of Decomposition

Ex1: There is a Relation R (ABCDE) and its functional dependencies are $\{A \to B, B \to C, C \to D, D \to BE\}$

(i) The decomposition {AB, BC, CD, DE}, is this

Sol:

R_1 (AB)	R_2 (BC)	R_3 (CD)	R_4 (DE)
$A \to B$	$B \to C$	$C \to D$	$D \to E$
	$C \to B$	$D \to C$	
	(from $C \to D$, $D \to BE$)	(from $D \to B$, $B \to C$)	
✓	✓	✓	✓
F_1	F_2	F_3	F_4

Topic: Properties of Decomposition

Ex1: There is a Relation R (ABCDE) and its functional dependencies are $\{A \to B, B \to C, C \to D, D \to BE\}$

(i) The decomposition {AB, BC, CD, DE}, is this

Sol: The FD's are $A \to B$, $B \to C$, $C \to D$, $D \to B$, $D \to E$ (from $D \to BE$) every FD is covered except $D \to B$ from F_1, F_2, F_3, F_4, $D^+ = DECB$

$\therefore$ $D \to B$ also holds

$\therefore$ $\{F_1 \cup F_2 \cup F_3 \cup F_4\} = F$, therefore this is dependency preserving decomposition.

Topic: Properties of Decomposition

Ex2: Relation R (ABCD), and its functional dependencies are $\{AB \rightarrow CD, D \rightarrow A\}$

Check if decomposition {ABC, BCD, AD} is dependency preserving or not?

Topic: Properties of Decomposition

Ex2: Relation R (ABCD), and its functional dependencies are $\{AB \rightarrow CD, D \rightarrow A\}$

Check if decomposition {ABC, BCD, AD} is dependency preserving or not?

Sol:

R_1 (ABC)

$A^+ = A$

$B^+ = B$

$C^+ = C$

$AB^+ = ABCD$

$\therefore$ $AB \rightarrow C$ holds from

$AB \rightarrow CD$

$AC^+ = AC$

$BC^+ = BC$

FD's that holds are

$AB \rightarrow C$

Topic: Properties of Decomposition

Ex2: Relation R (ABCD), and its functional dependencies are $\{AB \rightarrow CD, D \rightarrow A\}$

Check if decomposition {ABC, BCD, AD} is dependency preserving or not?

Sol:

R_1 (ABC)	R_2 (BCD)
$A^+ = A$	$B^+ = B$, $D^+ = DA$
$B^+ = B$	$C^+ = C$
$C^+ = C$	$BC^+ = BC$, $CD^+ = CD$
$AB^+ = ABCD$	$BD^+ = BDAC$
$\therefore AB \rightarrow C$ holds from	FD's holds are
$AB \rightarrow CD$	$BD \rightarrow C$
$AC^+ = AC$	
$BC^+ = BC$	
FD's that holds are	
$AB \rightarrow C$	

Topic: Properties of Decomposition

Ex2: Relation R (ABCD), and its functional dependencies are $\{AB \rightarrow CD, D \rightarrow A\}$

Check if decomposition {ABC, BCD, AD} is dependency preserving or not?

Sol:

R_1 (ABC)	R_2 (BCD)	R_3 (DA)
$A^+ = A$	$B^+ = B$, $D^+ = DA$	$D^+ = DA$,
$B^+ = B$	$C^+ = C$	$A^+ = A$
$C^+ = C$	$BC^+ = BC$, $CD^+ = CD$	$\therefore D \rightarrow A$ holds
$AB^+ = ABCD$	$BD^+ = BDAC$	
$\therefore AB \rightarrow C$ holds from $AB \rightarrow CD$	FD's holds are $BD \rightarrow C$	
$AC^+ = AC$		
$BC^+ = BC$		
FD's that holds are $AB \rightarrow C$		

Topic: Properties of Decomposition

Ex2: Relation R (ABCD), and its functional dependencies are $\{AB \rightarrow CD, D \rightarrow A\}$

Check if decomposition {ABC, BCD, AD} is dependency preserving or not?

Sol:

R_1 (ABC)	R_2 (BCD)	R_3 (DA)
$A^+ = A$	$B^+ = B$, $D^+ = DA$	$D^+ = DA$,
$B^+ = B$	$C^+ = C$	$A^+ = A$
$C^+ = C$	$BC^+ = BC$, $CD^+ = CD$	$\therefore D \rightarrow A$ holds
$AB^+ = ABCD$	$BD^+ = BDAC$	
$\therefore AB \rightarrow C$ holds from $AB \rightarrow CD$	FD's holds are $BD \rightarrow C$	
$AC^+ = AC$		
$BC^+ = BC$		
FD's that holds are $AB \rightarrow C$		
F_1	F_2	F_3

Topic: Properties of Decomposition

Ex2: Relation R (ABCD), and its functional dependencies are $\{AB \rightarrow CD, D \rightarrow A\}$

Check if decomposition {ABC, BCD, AD} is dependency preserving or not?

Sol: All the FD's are covered but for F_1, F_2 & F_3 $AB^+ = ABC$ whereas $AB^+ = ABCD$ for R.

$\therefore \quad (F_1 \cup F_2 \cup F_3) \subset F$

$AB \rightarrow D$ lost because of decomposition.

$\therefore$ NOT Dependency Preserving

Telegram channel

@RBRSIRPW

THANK - YOU