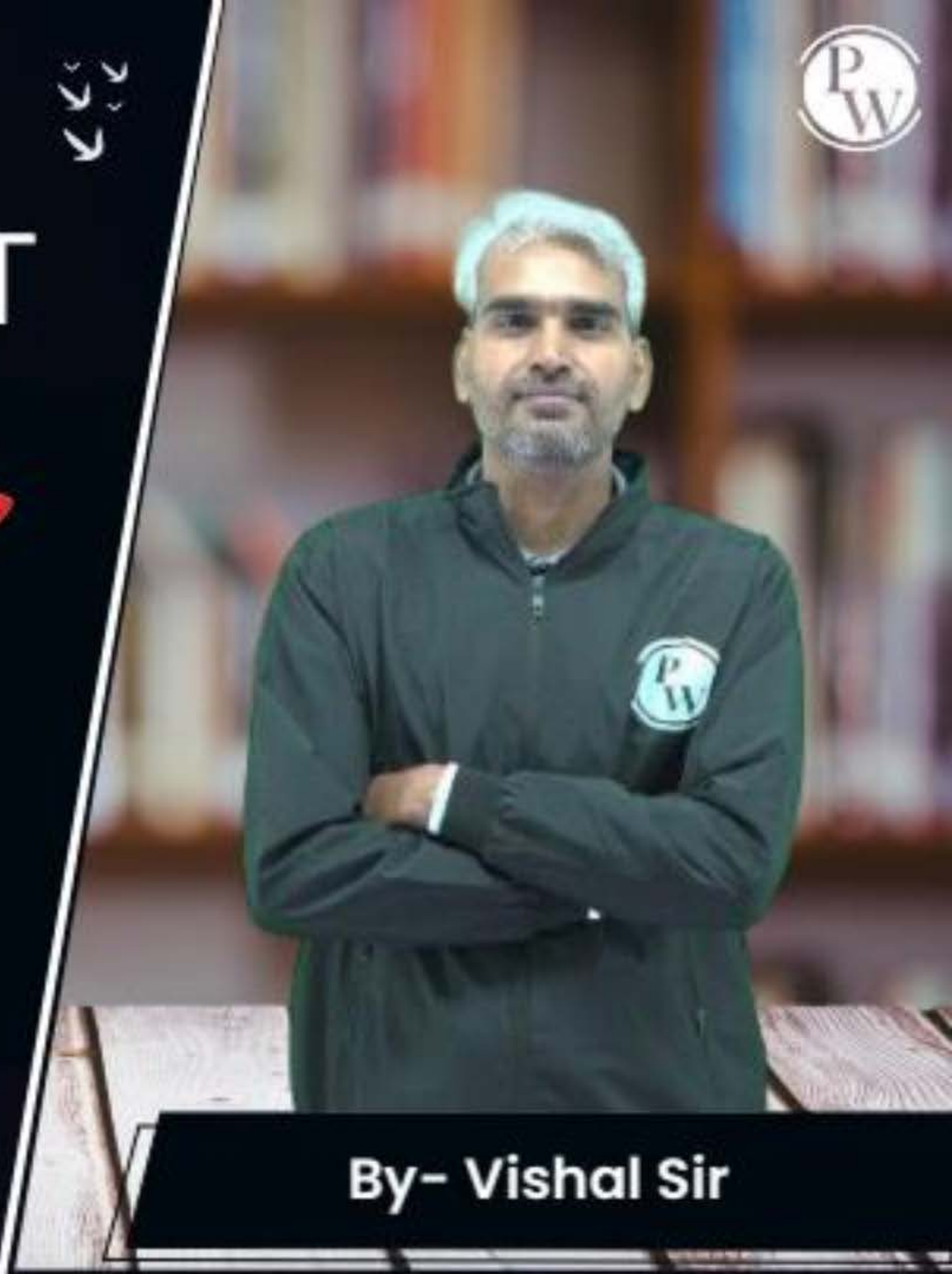
Computer Science & IT

Database Management System

Relational Model & Normal Forms

Lecture No. 06



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Recap of Previous Lecture

- Topic: Identification of candidate keys in a relation
- Topic: Membership test
- Topic: Relationship between two FD sets
- Topic: FD set of a sub-relation

Topics to be Covered

- Topic — FD set of a subrelation
- Topic — Minimal cover (Canonical cover)
- Topic — Number of superkeys in a relation

FD set of a Sub-relation

- Let R be the relation with FD set F, and R_1 is any sub-relation of R.
  Concept of membership test can be used to identify the FDs of sub-relation
- Let R(A, B, C, D, E) is a relation, then R_1(A, B, E) can be called a subrelation of relation R

Q:. Let $R(A, B, C, D, E)$ is a relation with FD set F:

F $\{A \rightarrow B,\ AB \rightarrow C,\ D \rightarrow AC,\ D \rightarrow E\}$

And let $R_1(A, B, E)$ is a sub-relation of relation $R(A, B, C, D, E)$

Find the Candidate keys of sub-relation $R_1(A, B, E)$

Soluⁿ. To find the candidate keys of any relation we need the set of functional dependencies w.r.t. that relation

i. First we need to identify the FDs that exists in sub-relation $R_1(A, B, E)$

Q:. Let $R(A,B,C,D,E)$ is a relation with FD set F.

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

and let $R_1(A,B,E)$ is a sub-relation of relation $R(A,B,C,D,E)$

We need to find FD set F_1 w.r.t. sub-relation R_1
i.e. we need identify the relationship b/w A, B & E

$(A)^+$ wrt $F = \{A, B, C\}$

i.e. $A \to A$ (trivial) B (Not in relation R_1) C $\therefore$ $A \to B$

$(B)^+$ wrt $F = \{B\}$ $\therefore$ No useful FD

$(E)^+$ wrt $F = \{E\}$ $\therefore$ No useful FD

$(AB)^+$ wrt $F = \{A, B, C\}$ $\therefore$ No useful FD

$(AE)^+$ wrt $F = \{A, E, B, C\}$ $\therefore$ $AE \to B$

$(BE)^+$ wrt $F = \{B, E\}$ $\therefore$ No useful FD

Hence FD set F_1 w.r.t sub relation $R_1(A,B,E)$ is

$$F_1 = \{A \to B,\ AE \to B\}$$

$\therefore$ Ck of R_1 is (AE)

H.W.

Q:. Let $R(A,B,C,D,E,F)$ is a relation with FD set F.

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

and let $R_1(A,B,C,D)$ is a sub-relation of relation $R(A,B,C,D,E,F)$

Find the Candidate keys of sub-relation $R_1(A,B,C,D)$

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

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

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

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

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

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

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

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

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

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

$(ABC)^+ = \{A,B,C,D,E,F\}$ $ABC \to D$

$(ABD)^+ = \{A,B,C,D,E,F\}$ $ABD \to C$

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

$(BCD)^+ = \{B,C,D,A,E,F\}$ $BCD \to A$

FD set F_1 of $R_1(ABCD)$ is

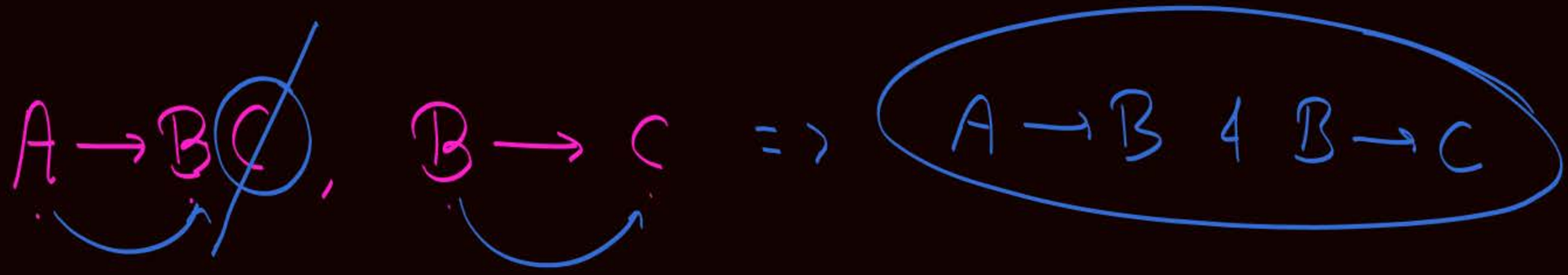
$F_1 = \{B \to D,\ AB \to CD,\ BC \to AD\}$

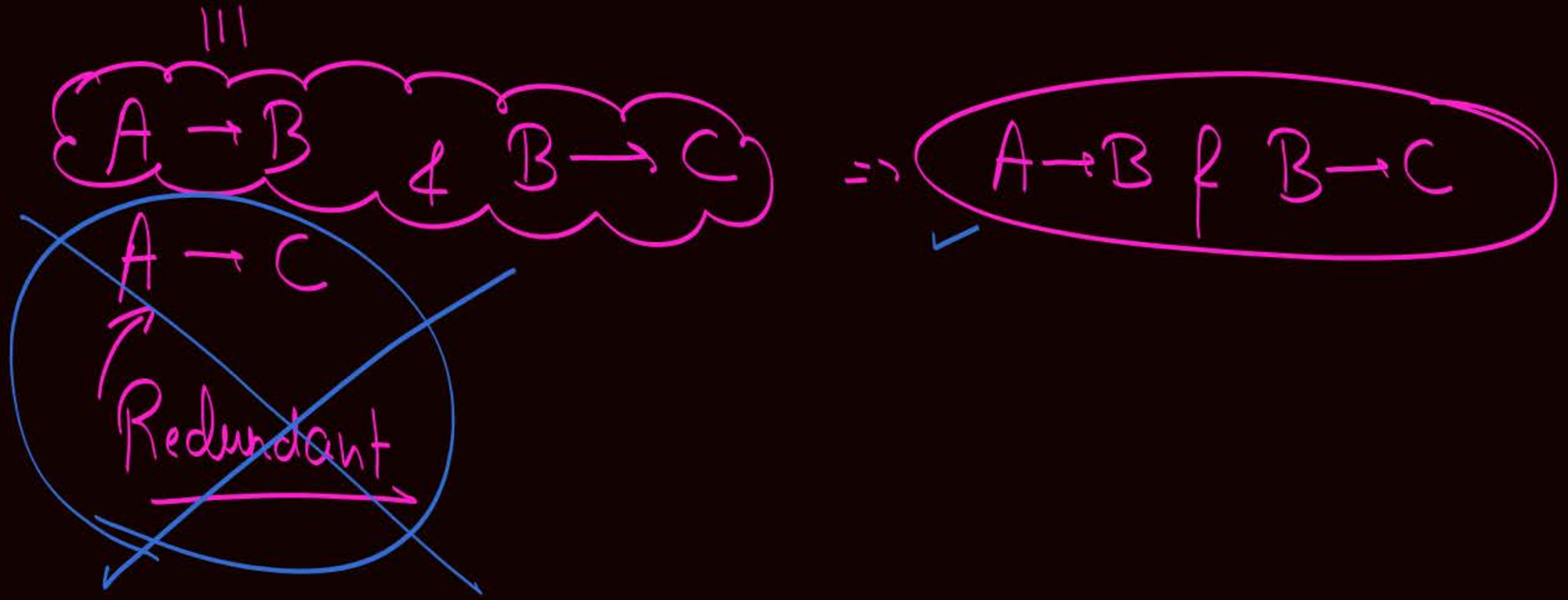
$\therefore$ CKs are AB, BC

Topic : Minimal cover (Canonical cover)

Irreducible set of functional dependencies

- Minimal cover or 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


A → B C
B → C
=>
A → B & B → C


III
A → B
&
B → C
=>
A → B & B → C
A → C
Redundant

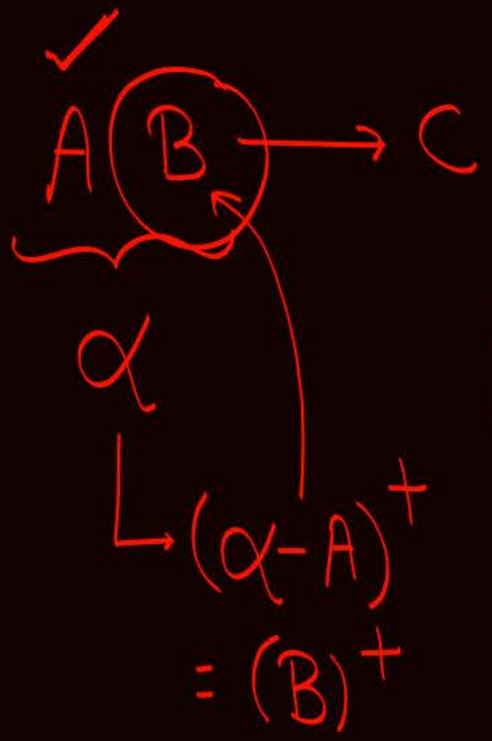
Topic : Procedure to obtain minimal cover of FD set

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.
3. Eliminate all redundant FDs
4. Apply Union if needed (it is not mandatory)
5. The result is minimal Cover

As soon as any extraneous attribute is identified in the LHS, remove it and check for other extraneous attributes

As soon as any redundant FD is identified, remove it from the set & check for other redundant FDs

$A \rightarrow B$



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

$B \in (A)^+ \therefore$ B is extraneous w.r.t. A

$AB \rightarrow C$

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

$A \notin (B)^+ \therefore$ A is extraneous w.r.t. B

Topic : Testing if an Attribute is Extraneous in LHS

α is a set of attributes that contain two or more attributes

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

After simplification $|\beta| = 1$

let 'A' is an attribute belonging to set 'α'

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', where $F' = (F - \{\alpha \rightarrow \beta\})$
2. check if $(\{\alpha\} - A)^+$ contains A; if it does then, A is extraneous.

all FDs of set F except $\alpha \rightarrow \beta$

& if $A \notin (\alpha - A)^+$ then A is not Extraneous

#e.g., Consider the FD set

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

Find minimal Cover of F

$F: \{AB \to C,\ B \to A,\ A \to B\}$ "Step-1" Simplify w.r.t. R.H.S. $\{AB \to C,\ B \to A,\ A \to B\}$

Single attribute in LHS can never be extraneous

Step-2 Check for Extraneous attribute in $AB \to C$

① Check if 'A' is extraneous when B is present

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

$A \in (B)^+ \therefore$ A is extra when B is Present

∴ Remove it

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

FD set after removing A

Step-2 Check for extraneous attribute in $AB \to C$

② Check if 'B' is extraneous when 'A' is present

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

$B \in (A)^+ \therefore$ B is extra when A is present

∴ Remove it

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

FD set after removing B

Topic : Testing if any FD is redundant

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

To test if $\alpha \rightarrow \beta$ is redundant

1. compute α^+ using only the dependencies in F', where F' = (F – {$\alpha \rightarrow \beta$})
2. check that α^+ contains β; if it does then, $\alpha \rightarrow \beta$ is redundant

All FD except $\alpha \rightarrow \beta$

otherwise $\alpha \rightarrow \beta$ is required

#e.g., Consider the FD set

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

Find minimal Cover of F

$F: \{AB \to C,\ B \to A,\ A \to B\}$ "Step-1" Simplify w.r.t. R.H.S. $\{AB \to C,\ B \to A,\ A \to B\}$

Single attribute in LHS can never be extraneous

Step-2 Check for Extraneous attribute in $AB \to C$

① Check if 'A' is extraneous when B is present

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

$A \in (B)^+ \therefore$ A is extra when B is Present

∴ Remove it

$\{B \to C,\ B \to A,\ A \to B\}$ Step-3 remove redundant FDs $\{B \to C,\ B \to A,\ A \to B\}$ Required FDs

FD set after removing A

Step-4 = Union $\{B \to AC,\ A \to B\}$

② Check if 'B' is extraneous when 'A' is present

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

$B \in (A)^+ \therefore$ B is extra when A is present

∴ Remove it

$\{A \to C,\ A \to A,\ A \to B\}$ Step-3 Remove redundant FDs $\{A \to C,\ B \to A,\ A \to B\}$ Required FDs

FD set after removing B

Step-4 = Union $\{A \to BC,\ B \to A\}$

Both are Minimal Cover of FD set F

Topic : NOTE

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

If Fm_1 & Fm_2 are two different minimal Covers of FD set F, then $\boxed{Fm_1 = Fm_2} = F$

#e.g., Consider the FD set

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

Find all minimal Cover of F

$$F = \left\{ \begin{matrix} A \to BC \\ B \to C \end{matrix} \right\} \xrightarrow[\text{w.r.t. RHS}]{\text{Step-1 Simplify}} \left\{ \begin{matrix} A \to B \\ A \to C \\ B \to C \end{matrix} \right\}$$

Step-2 Eliminate Extraneous attribute from LHS

$$\left\{ \begin{matrix} A \to B \\ A \to C \\ B \to C \end{matrix} \right\}$$

Redundant ∴ remove

Step-3 Eliminate redundant FDs

$$\left\{ \begin{matrix} A \to B \\ B \to C \end{matrix} \right\}$$

$$\left\{ \begin{matrix} A \to B \\ \\ B \to C \end{matrix} \right\}$$

it is the only Minimal Cover of FD set F.

Q. Find minimal Cover of

$$F = \{ A \to C,\ AC \to D,\ E \to AD,\ E \to H \}$$

Step-1 →

$$\{ A \to C,\ AC \to D,\ E \to A,\ E \to D,\ E \to H \}$$

Step-2 →

$$\{ A \to C,\ A \to D,\ E \to A,\ E \to D,\ E \to H \}$$

Step 3 →

$$\{ A \to C,\ A \to D,\ E \to A,\ E \to H \}$$

⇓ Union

$$\{ A \to C.D,\ E \to AH \}$$

How:

#e.g., Consider the following FD set

F ={A →BC

CD→E

E→C

D→AEH

ABH→BD

DH→BC

}

Find minimal cover of F.

	Simplify RHS.	Eliminate Extra attribute from LHS.	Eliminate Redundant FD	Union
$A \rightarrow BC$				
$CD \rightarrow E$				
$E \rightarrow C$				
$D \rightarrow AEH$				
$ABH \rightarrow BD$				
$DH \rightarrow BC$				

#Q. The following functional dependencies hold true for the relational schema

R{V, W, X, Y, Z}

[V→W; VW→X; Y→VX; Y→Z]

Which of the following is irreducible equivalent for this set of functional dependencies?

(A)

V→ W
V→ X
Y→ V
Y→ Z

(B)

V→ W
W→ X
Y→ V
Y→ Z

(C)

V→ W
V→ X
Y→ V
Y→ X
Y→ Z

(D)

V→ W
W→ X
Y→ V
Y→ X
Y→ Z

Number of Super keys

Q: Let $R(A, B, C, D, E)$ is a relation with no non-trivial functional dependency {i.e. $F = \{\}$ (Empty)} then what will be the Candidate key of relⁿ R.

Solun No FD in the FD set,
Hence all attributes are essential attributes

∴ C.k will be formed by Combining all attributes of the relation.

* In this case, we have only one Candidate key and Only one Super key (it C.k itself)

H.W Q:- Consider the relational schema $R(A_1, A_2, A_3, \ldots\ldots, A_n)$
Find the number of superkeys possible in relation R.

(i) When "A_1" is the only candidate key of relation R.

H.W

Q:- Consider the relational schema $R(A_1, A_2, A_3, \ldots\ldots, A_n)$

Find the number of superkeys possible in relation R.

(ii) When (A_1A_2) is the only candidate key of relation R.

Q:- Consider the relational schema $R(A_1, A_2, A_3, \ldots\ldots, A_n)$

H.W

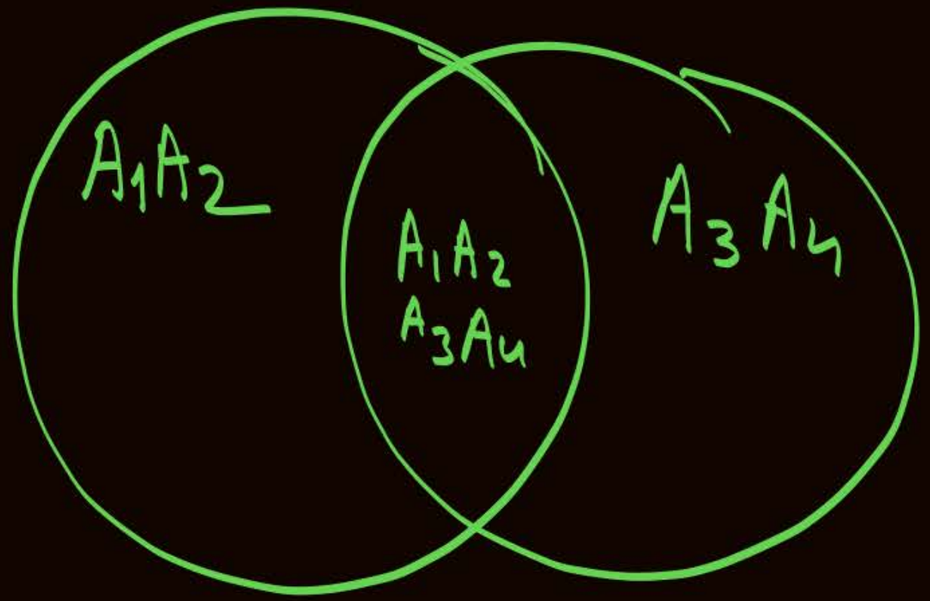
Find the number of superkeys possible in relation R.

(iii) When "A_1" & "A_2" are the only two candidate keys of relation R.

Q:- Consider the relational schema $R(A_1, A_2, A_3, \ldots\ldots, A_n)$

HW. Find the number of superkeys possible in relation R.

(iv) When (A_1A_2) and (A_3A_4) are two candidate keys of relation R.

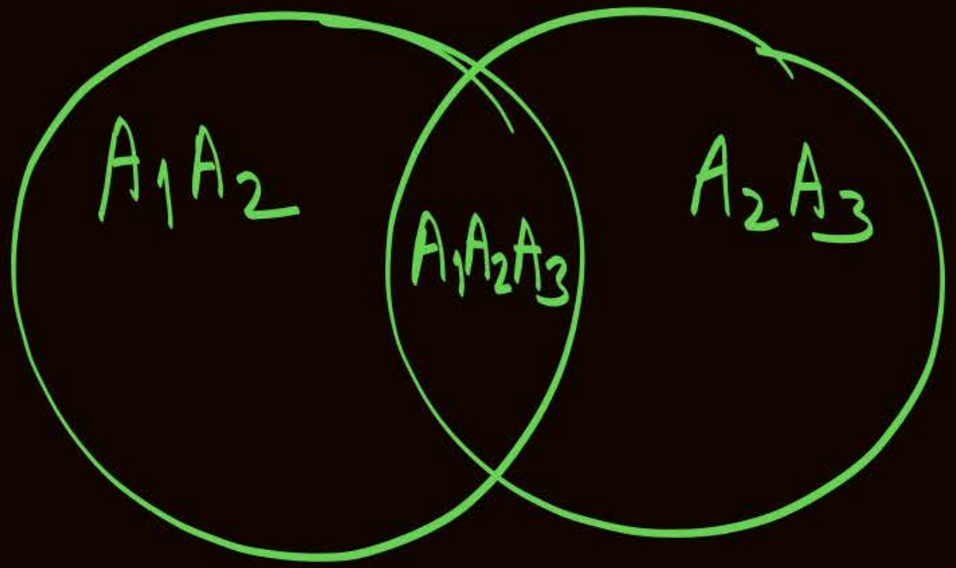


H.W.

Q:- Consider the relational schema $R(A_1, A_2, A_3, \ldots\ldots, A_n)$

Find the number of superkeys possible in relation R.

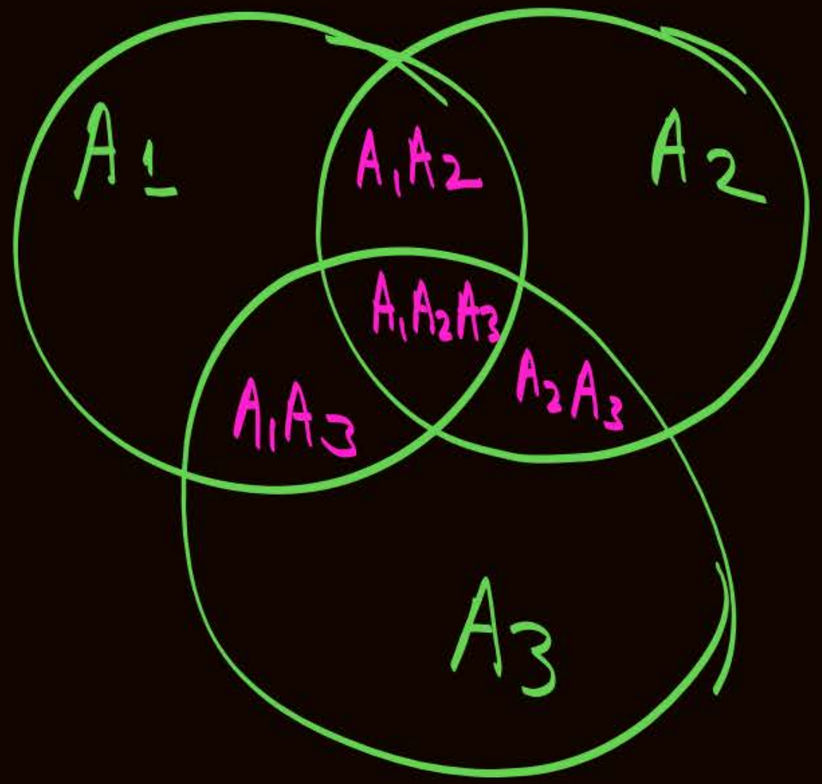
(V) When (A_1A_2) & (A_2A_3) are only two candidate keys of relation R.



H.W.

Q:- Consider the relational schema $R(A_1, A_2, A_3, \ldots\ldots, A_n)$ find the number of superkeys possible in relation R.

(vi) When (A_1), (A_2) and (A_3) are three candidate keys of relation R.



H.W.

Q:- Consider the relational schema $R(A_1, A_2, A_3, \ldots\ldots, A_n)$
Find the number of superkeys possible in relation R.
When each attribute of relation R itself is a Candidate Key

2 mins Summary

Topic FD set of a subrelation

Topic Minimal cover (Canonical cover)

Topic Number of superkeys in a relation

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THANK - YOU

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