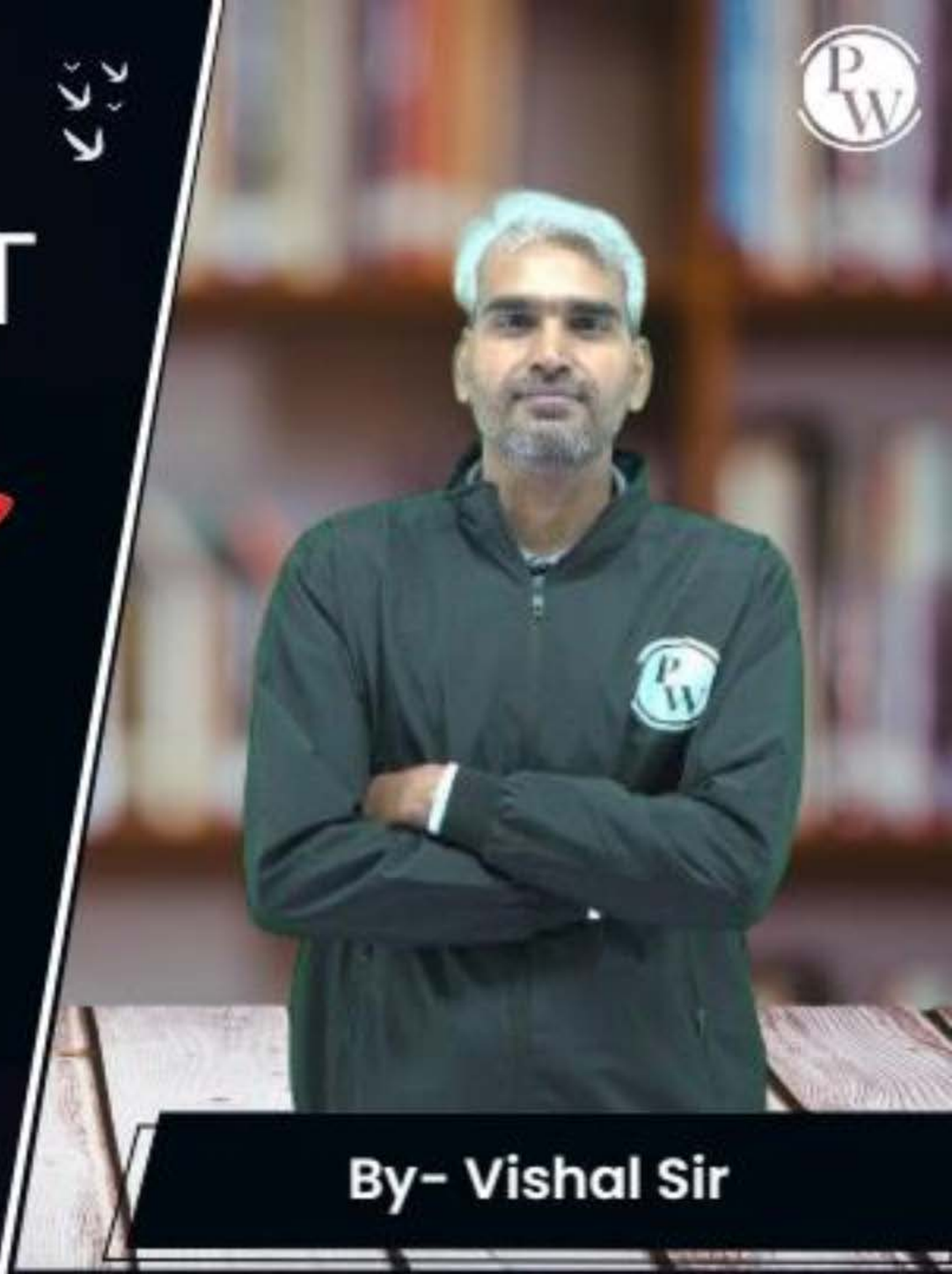
Computer Science & IT

Database Management System

Relational Model & Normal Forms

Lecture No. 12



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Recap of Previous Lecture

- **Topic** Decomposition of relation up to BCNF
- **Topic** Multi-valued dependency and 4NF

Topics to be Covered

- Topic: Properties of multi-valued dependency
- Topic: 4NF

Multi-valued dependency

eg:

Non-trivial FDs that can be defined w.r.t. three attributes

Sid	Cid	Mob_No
S_1	C_1	M_1
S_1	C_1	M_2
S_1	C_2	M_1
S_1	C_2	M_2
S_2	C_2	M_2

- Sid $\not\rightarrow$ Cid
- Sid $\not\rightarrow$ Mob_NO
- Cid $\not\rightarrow$ Sid
- Cid $\not\rightarrow$ Mob_NO
- Mob_NO $\not\rightarrow$ Sid
- Mob_NO $\not\rightarrow$ Cid
- Sid, Cid $\not\rightarrow$ Mob_NO
- Sid, Mob_NO $\not\rightarrow$ Cid
- Cid, Mob_NO $\not\rightarrow$ Sid

None of this non-trivial FDs Exist in the relation

∴ Relation is in BCNF

But redundancy is still present in the relation

Topic : Multivalued dependency

"X multi valued determines Y" is denoted by $X \twoheadrightarrow Y$

- If there exist two or more independent attributes which are dependent on some other set of attributes then multi-valued dependency will(may) exist in the relation

★ Formal definition of MVD :

Let R is a relation, and X and Y are two sets of attributes from relation R { Let us define Z = Attributes of R − 'X U Y'

i.e., Z is the set of remaining attributes

If there exist '4' tuples $t_1, t_2, t_3, t_4 \in R$

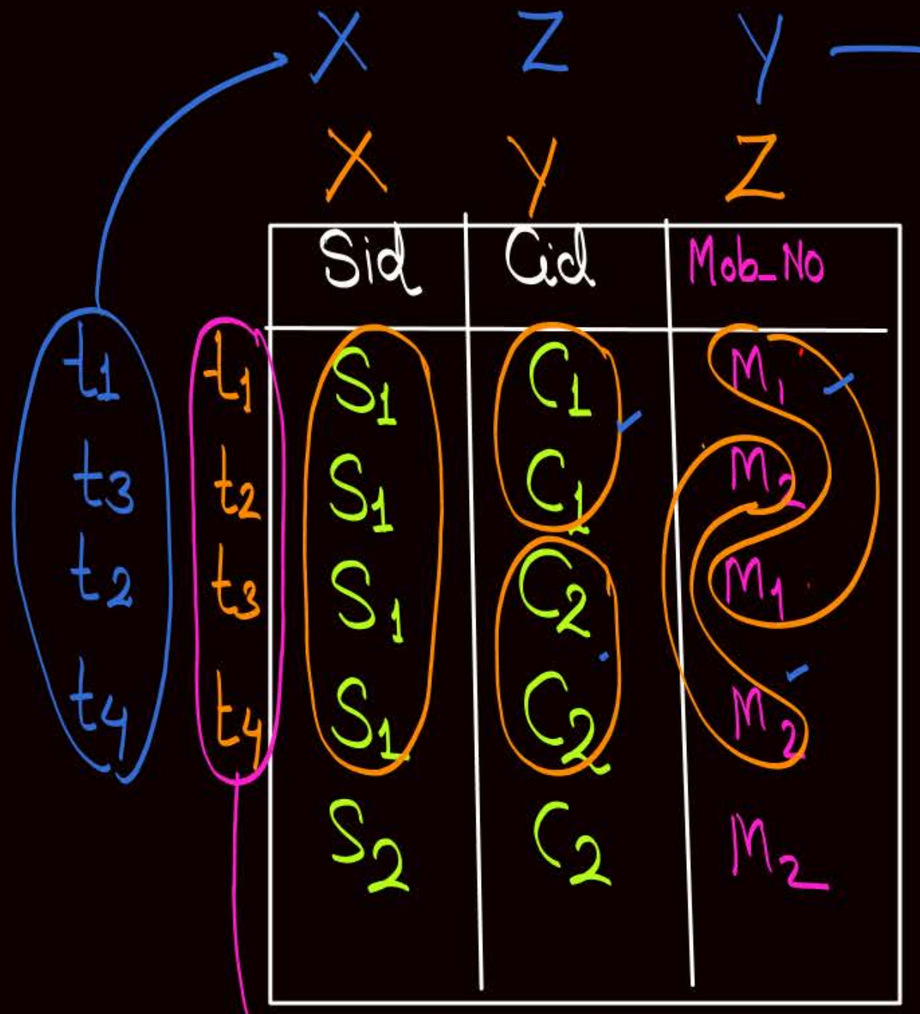
s.t.

$$\begin{cases} t_1.X = t_2.X = t_3.X = t_4.X \\ \text{and } t_1.Y = t_2.Y \text{ and } t_3.Y = t_4.Y \\ \text{and } t_1.Z = t_3.Z \text{ and } t_2.Z = t_4.Z \end{cases}$$

← "if" cond is true then "then" condition is definitely true.

But if "if" Cond^n is false, then also "then" Cond^n may be true

then Multi-valued dependency $X \rightarrow\rightarrow Y$ exist in R



w.r.t this numbering of tuples
✓ Sid →→ Mob_no will also exist in relation R.

w.r.t this numbering of tuples
✓ Sid →→ Cid exist in the relation

* Another definition w.r.t. MVD :-

Whenever we swap the values of attribute set Y in two tuples {let t_1 & t_2} which agree on the value of attribute set X {i.e., $t_1.X = t_2.X$} and if the resulting tuple was already a member of the relation, then $X \rightarrow\rightarrow Y$ exists in the relation.

Sid	Cid	Mob_No
S_1	C_1	M_1
S_1	C_1	M_2
S_1	C_2	M_1
S_1	C_2	M_2
S_2	C_2	M_2

Same Cid

∴ Swap Mob_No

Q: Check whether Cid →→ Mob_No. exist in the relation or not

$\Rightarrow$ S_1 C_2 M_2

$\Longrightarrow$ S_2 C_2 M_1

it was not present in original relation

⇓

Hence, Cid →→ Mob_no. does not exist in the relation

Topic : Properties of Multivalued dependency

(1) **Complementation Rule :-** Let R be the relational schema and X & Y be some set of attributes over relation R.

If $X \twoheadrightarrow Y$ exist in relation R.

then $X \twoheadrightarrow (\text{Attributes of } R - (X \cup Y))$ also exist in relation R

$R(A_1, A_2, A_3, A_4, A_5, A_6)$

let $X = \{A_1, A_3\}$

$Y = \{A_2, A_5\}$

} Attributes of $R - (X \cup Y) = \{A_4, A_6\}$

Complementation Rule :-

if $X \twoheadrightarrow Y$

i.e. if $\{A_1, A_3\} \twoheadrightarrow \{A_2, A_5\}$

then $\{A_1, A_3\} \twoheadrightarrow \{A_4, A_6\}$

Topic : Properties of Multivalued dependency

② Trivial MVD :-

- Let $X \rightarrow\rightarrow Y$ exist in relation R,

$X \rightarrow\rightarrow Y$ is called a trivial MVD

if $\boxed{X \supseteq Y}$

or

$\boxed{X \cup Y = R}$ { i.e; Attributes of X ∪ Attributes of Y = Attributes of R }

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

$\{A_1\}$ $\{A_2, A_3\}$ $\{A_2, A_3\}$ $\{A_3, A_4\}$

$\equiv$ $\boxed{A_1 \longrightarrow \{A_3, A_4\}}$ Splitting $\therefore$ $A_1 \rightarrow \{A_3\}$

$A_1 \rightarrow \{A_4\}$

Topic : Properties of Multivalued dependency

(3) Splitting

Multi-valued dependencies are not allowed to split.

i.e. if $X \rightarrow\rightarrow YW$ exist in relation, then, { $X \rightarrow\rightarrow Y$ and $X \rightarrow\rightarrow W$ need not hold true.

R

eg:

X	Y	W
X_1	Y_1	W_1
X_1	Y_2	W_2

$X \rightarrow\rightarrow YW$ hold true, and it is trivial but neither $X \rightarrow\rightarrow Y$ holds true nor $X \rightarrow\rightarrow W$ holds true

But FDs are allowed to split.

i.e. if $X \rightarrow YW$, then $X \rightarrow Y$ & $X \rightarrow W$

Topic : Properties of Multivalued dependency

(4) Transitivity :-

If $X \rightarrow\rightarrow Y$ and $Y \rightarrow\rightarrow W$ exists in relation R

then $X \rightarrow\rightarrow (W - Y)$ will also exist in the relation.

By Transitivity of MVD

If $X \rightarrow\!\!\rightarrow Y$ and $Y \rightarrow\!\!\rightarrow Z$, then $X \rightarrow\!\!\rightarrow Z - Y$

$\therefore$ if $\{A_1\} \rightarrow\!\!\rightarrow \{A_2, A_3\}$ & $\{A_2, A_3\} \rightarrow\!\!\rightarrow \{A_3 A_4\}$

then $A_1 \rightarrow\!\!\rightarrow \{A_3, A_4\} - \{A_2, A_3\}$

i.e. $A_1 \rightarrow\!\!\rightarrow A_4$

Topic : Properties of Multivalued dependency

⑤ **Union**: If $X \rightarrow\rightarrow Y$ and $X \rightarrow\rightarrow W$ holds in relation R, then, $X \rightarrow\rightarrow YW$ will also hold true in relation R.

By Transitivity of MVD

If $X \twoheadrightarrow Y$ and $Y \twoheadrightarrow Z$ then $X \twoheadrightarrow Z - Y$

$\therefore$ if $\{A_1\} \twoheadrightarrow \{A_2, A_3\}$ & $\{A_2, A_3\} \twoheadrightarrow \{A_3 A_4\}$

then $A_1 \twoheadrightarrow \{A_3, A_4\} - \{A_2, A_3\}$

i.e. $A_1 \twoheadrightarrow A_4$

$\{A_1\} \twoheadrightarrow \{A_2, A_3\}$ & $\{A_1\} \twoheadrightarrow \{A_4\}$

By Union $\{A_1\} \twoheadrightarrow \{A_2, A_3, A_4\}$

Topic : Properties of Multivalued dependency

(6) Augmentation :

If $X \rightarrow\rightarrow Y$ exist in the relation R, and α, β are two set of attributes from relation R, such that $\alpha \supseteq \beta$.

then $X\alpha \rightarrow\rightarrow Y\beta$ will also hold true in relation R.

Topic : Properties of Multivalued dependency

(7) Replication :-

- Every Functional dependency is also a M.V.D.
  { Every MVD need not be a Functional dependency }

i.e., if $X \rightarrow Y$ exist in R, then $X \rightarrow\rightarrow Y$ will also exist in R

& if $X \rightarrow\rightarrow Y$ exist in R, then $X \rightarrow Y$ need not exist in R.

Topic : Fourth normal form (4NF)

- For a relation R to be in 4 NF:
  - ① Relation R must be in BCNF;-
  - and ② Every non-trivial MVD $X \twoheadrightarrow Y$.
    must be with X as a Super key of the relation

{ i.e. Every non-trivial FD $X \rightarrow Y$ must be with X as a Super Key }

Candidate Keys and Superkeys are always identified usin Functional dependencies.

FDs are key dependencies,

Whereas, MVDs are data dependency.

R

Sid	Cid	Mob_No
S_1	C_1	M_1
S_1	C_1	M_2
S_1	C_2	M_1
S_1	C_2	M_2
S_2	C_2	M_2

No non-trivial FD exists in the relation,
∴ Relation is in BCNF,
and Candidate key of the relation is = {Sid, Cid, Mob_No.}

Following Non-trivia MVDs exists in the relation

(i) Sid $\rightarrow\!\!\rightarrow$ Cid
Not a SK

(ii) Sid $\rightarrow\!\!\rightarrow$ Mob_NO.
Not a SK

Non-trivial MVDs of type $X \rightarrow\!\!\rightarrow Y$ exists in the relation, such that 'X' is not a superkey
∴ Relation is not in 4NF.

* If the relation is in BCNF, but not in 4NF, then for 4NF decompose the relation w.r.t. Every non-trivial MVD $X \rightarrow\rightarrow Y$, in which X is not a S.k.

Sid	Cid	Mob_No
S_1	C_1	M_1
S_1	C_1	M_2
S_1	C_2	M_1
S_1	C_2	M_2
S_2	C_2	M_2

No non-trivial FD exists in the relation,
∴ Relation is in BCNF,
and Candidate key of the relation is = (Sid, Cid, Mob_No.)

Following Non-trivia MVDs exists in the relation

(i) Sid →→ Cid
Not a SK

(ii) Sid →→ Mob_NO
Not a SK.

← Not in 4NF

↓

For 4NF, decompose w.r.t. non-trivial MVDs in which LHS is not a S.K.

Sid →→ Cid

Sid →→ Mob.no

Sid	Cid
S_1	C_1
S_1	C_2
S_2	C_2

No. non-trivial FD
∴ Relation is in BCNF
and C.K = (Sid, Cid)

MVD "Sid →→ Cid" exists in relation s.t. Sid is not a Super key, but it is trivial MVD

No non-trivial MVD
∴ Relation is in 4NF

Sid	Mob_no.
S_1	M_1
S_1	M_2
S_2	M_2

No. non-trivial FD
∴ Relation is in BCNF
and C.K = (Sid, Mob_no.)

MVD "Sid →→ Mob_No" exists in relation s.t. Sid is not a Super key, but it is trivial MVD

No non-trivial MVD
∴ Relation is in 4NF

2 mins Summary

Topic Properties of multi-valued dependency

Topic 4NF

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THANK - YOU

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