Q) Considere the relation schema R ~~with~~ = $\boxed{\text{Dt:- 10/09/24}}$

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

Find out whethere the 2nd suppose R is decompose

into Relation schema $R_1 = (A, B, C)$ $R_2 (C, D)$

$F_1 = \{AB \to C\}$, $F_2 = \{C \to D\}$ Find out whether

the decomposition is lossless or lossy.

$F^+ = \{AB \to C, C \to D, AB \to D\}$ ~~$A \to C$~~

$R_1 \cap R_2 = (C)$

$R_1 - R_2 = (A, B)$

$R_2 - R_1 = (D)$

since $C \to D$ is present in F^+ so the decomposition is loss less

Dependency - preserving Decomposition :-

Find F_1 for R_1 and F_2 for R_2

$F_1 \cup F_2$

$(F_1 \cup F_2)^+$

IF $\boxed{F^+ = (F_1 \cup F_2)^+}$ then Dependency is DPD ~~preserved~~

• IF DPD not o-

Considere a Relational schema $R = (C, S, Z)$ with FD set $F = \{CS \to Z, Z \to C\}$ ~~the~~ test fore lossless join decomposition and DPD fore decomposition.

R $R_1 (S, Z)$ and $R_2 (C, Z)$

$F_1 = \{$ R

$R_1 \cap R_2 = Z$ $Z \to S$ is not in F^+ but $Z \to C$ is in F^+ hence the decomposition is lossless

$R_1 - R_2 = S$

$R_2 - R_1 = C$

Test for dependency preservation

$R_1(S, Z)$ $F_1 = \{S \to S, Z \to Z\}$

$R_2 = (C, Z)$ $F_2 = \{Z \to C\}$

$F_1 \cup F_2 = \{Z \to C\} \neq F^+$

Decomposition ~~Dependency~~ is not Dependency preserving decomposition

Consider a relation schema $R(A, B, C, D)$ with

FD $F = \{AB \to C, C \to D\}$ R is decomposed as $R_1(A, B, C)$ and $R_2(C, D)$. Test the decomposition is dependency preserving

$R_1(A, B, C)$ $F_1 = \{AB \to C\}$ $F^+ = \{AB \to C, C \to D, AB \to D\}$

$R_2(C, D)$ $F_2 = \{C \to D\}$

$F_1 \cup F_2 = \{AB \to C, C \to D\}$

$(F_1 \cup F_2)^+ = \{AB \to C, C \to D, AB \to D\}$

As $(F_1 \cup F_2)^+ = F^+$ so it is Dependency preserving decomposition

Normal forms

1) First Normal form (1NF):-

Example

1st Normal Form

ID	Name	courses
1	A	C1, C2
2	E	C3
3	M	C2, C3

$\xrightarrow[\text{to 1NF}]{\text{conversion}}$

ID	Name	course
1	A	C1
1	A	C2
2	E	C3
3	M	C2
3	M	C3

2nd Normal form :- (2NF)

2nd NF is based on the concept of full functional dependency

$X \longrightarrow Y$

FFD means X is the combination of more than one attribute

A FD is FFD if its primary key uniquely identify the non prime attribute

Q) suppose a relation schema $R = \{A, B, C, D, E, F\}$ having FD, $F = \{AB \rightarrow C, B \rightarrow D, D \rightarrow E, A \rightarrow C, AD \rightarrow F\}$ and find out which of the FDs are partial FD and which are FFD.

For $AB \rightarrow C$

$AB \rightarrow C$ is a partial FD as $A \rightarrow C$ holds.

for $AD \rightarrow F$

$AD \rightarrow F$ is a Full FD as ~~there~~ $A \rightarrow F$ and $D \rightarrow F$ doesnot holds.

Determination of primary key

Let $R(A_1, A_2 \ldots A_n)$ be the relation schema Then X is a PK if $X \longrightarrow A_1, A_2 \ldots A_n$ holds on R.

2nd NF

A relation schema R is in 2NF if it is in 1NF and every non-prime attribute A in R is Fully FD all the PK of R.

OR

There doesnot exist any partial FD.

Q) Let R(A, B, C, D, E) and F = {BC → A, C → DE, D → E} Test whethere R is in 2NF if not converet it into 2NF.

BC^{+} A (C^{+}) = CDE

(D^{+}) = E

step1: Find out PK of R.

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

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

$D^{+} = (E)$

~~PK is BC~~ since BC is able to determine all attributes of R so BC is PK.

for BC → A

BC → A is a FFD as

preime attributes are (B, C)

Non preime a attribute are (A, D, E)

In this particualar FD set one parefial FD exist i.e, C → DE bes non-preime attributes D, E are partially dependendent on the preime attributes

It is not in 2NF as there is partial FD.

Decomposition Rule:-

If X → Y is the Parcial FD in R

Then, R is decomposed as

$X \rightarrow Y$

$R_1(X, Y)$ R_2(~~A~~ all attributes except Y)

$R_2 - Y$

Here, as per the rule $R_1(C, D, E)$, $F_1 = \{C \rightarrow DE, D \rightarrow E\}$

$R_2(A, B, C)$, $F_2 = \{BC \rightarrow A\}$

In F_1 C is the PK and no partial FD exist so R_1 is in 2NF

In F_2 BC is the PK and no partial FD exist so R_2 is in 2NF.

Dt:- 14/09/24

Q) Given a relation schema R(A, B, C, D, E) with FDs $F = \{AB \rightarrow C, B \rightarrow D, A \rightarrow E\}$.

(i) is R is in BCNF

(ii) if not decompose R into relation schemas such that they will be in BCNF.

(iii) If the decomposition lossless join decomposition.

iv) Test the decomposition to be dependency preserving.

Ans:- PK is AB

PA → A, B

N, P, A → C, D, E

(i) for $AB \rightarrow C$

AB is a super key.

for $B \rightarrow D$

B is not a super key

for $A \rightarrow E$

A is not a super key

Relation R is not in BCNF

(ii) ~~AB~~ → C if due to the FD $X \to Y$ the condition of BCNF ~~decomposition~~ R violated if

For

$B \to D$

$R_1 = (B, D)$ $R_2(A, B, C, E)$

$F_1 = \{B \to D\}$ $F_2 \{AB \to C, A \to E\}$

In R_1 B is PK

since B is the super key

$B^+ = (B, D)$

since AB is the super key

$AB^+ = (A, B, C, E)$

$AB \to C$ satisfy BCNF

$A \to E$ not satisfy BCNF

$R_3(A, E)$ $R_4(A, B, C)$

$F_3(A \to E)$ $F_4\{AB \to C\}$

R is decompose into $R_1(B, D)$, $R_3(A, E)$

and $R_4(A, B, C)$

(iii) $R_1 \cap R_2 = \{B\}$

$R_1 - R_2 = \{D\}$

since $B \to D$ is present in F^+ so the decomposition is lossless

$R_3 \cap R_4 = \{A\}$

$R_3 - R_4 = \{E\}$

since $A \to E$ is present in F^+ so the decomposition is lossless.

(iv) $F_1 \cup F_3 \cup F_4$

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

$(F_1 \cup F_3 \cup F_4)^+$

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

since $(F_1 \cup F_3 \cup F_4)^+ = F^+$

Hence the decomposition is dependency preserving.

Multivalued Dependency in DBMS:-

For a single value of an attribute 'a', mutiple values of attribut 'b' exist.

It is represent as:

$a \to\to b$

→ It is read as a multideteremines 'b'.

→ There are minimum 3 attribute in MVD.

MVD and 4NF

→ $t_3[X] = t_4[X] = t_1[X] = t_2[X]$

→ $t_3[Y] = t_1[Y]$ & $t_4[Y] = t_2[Y]$

→ $t_3[Z] = t_2[Z]$ and $t_4[Z] = t_1[Z]$

MVD is of 2 types

(i) Trivial MVD

(ii) Non-Trivial MVD

(i) Trivial MVD:-

An MVD $X \to\to Y$ in R is called a trivial MVD if the following condition hold

a) $Y \subseteq X$ OR b) $X \cup Y = R$

The rel^n schema $R(A, B)$ with FDs $F = \{A \rightarrow\rightarrow B\}$

↓

it is a trivial MVD bcs $A \cup B = R$

ii) Non-trivial MVD :-

An MVD that satisfies neither A nor B is called a non-trivial MVD

Ex:- The rel^n $R(A, B, C)$ with FDs $F = \{A \rightarrow\rightarrow B, A \rightarrow C\}$

$B \not\subset A$ and $A \cup B \neq R$

This particular FD set is non-trivial.

4NF

A rel^n schema R is in 4NF with respect to a set of dependencies F (that includes FDs and MVDs) if for every non-trivial MVD $X \rightarrow\rightarrow Y$ in F^+, X is a super key for R.

Lossless join decomposition into 4NF :-

The relation schema R_1 and R_2 form a lossless join decomposition of R iff

condition :- (i) $R_1 \cap R_2 \rightarrow\rightarrow R_1 - R_2$

OR

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

Ex:- EMP

dependent name

Ename	Pname	Dname
smith	X	john
smith	Y	Anna
smith	X	Anna
smith	Y	john

· EMP - PROJECTS

Ename	Pname
smith	X
smith	Y

EMP - DEPENDENT

Ename	Dname
smith	John
smith	Anna

Here the FD list ~~two car~~ consists of 2 MVDs i.e

Ename →→ Pname & Ename →→ Dname

check for 4NF

For Ename →→ Pname

Ename →→ Dname

Ename is not a super key ~~of LHS~~

~~Neither~~ it is not in 4NF

Here the super key is Ename, Pname & D-name

Decomposition (to make 4NF)

In EMP - PROJECTS

F_1 = { Ename →→ Pname }

it is a trivial MVD

In EMP - DEPENDENT

F2 = { Ename →→ Dname }

It is a trivial MVD

so it is in 4NF (since it is a trivial MVD no need to check for superkey)

Dt:- 17/09/24

CAR-MODEL MANUF-MONTH COLOUR

This ~~is~~ relⁿ is not in 4NF due to the presence of Non-trivial MVD and L.H.S is not a super key.

CAR-MODEL →→ MANUF-MONTH

CAR-MODEL →→ COLOUR

1st decomposed relⁿ 2nd decomposed relⁿ

These dependencies are trivial in nature,

since there is no non-trivial dependencies so by default relation is in 4NF.

Ex:-

	X	Y	Z
	Ename	Pname	Dname
t_1	smith	x	John
t_2	smith	y	Anna
t_3	Smith	x	Anna
t_4	smith	y	John

1) $t_3[X] = t_4[X] = t_1[X] = t_2[X]$

2) $t_3[Y] = t_1[Y]$ &

It is not in 4NF.

Ename is not a super key

Ename →→ Pname

Ename →→ Dname

both are non-trivial but L.H.S is not a super key.

Ename	Pname
smith	x
smith	y

Ename	dname
smith	John
smith	Anna

No non-trivial dependencies so by default it is

Inference rules for F.Ds and MVD :-

1) IR1: Reflexive Rule:-

If X → Y then Y is a subset of X then it is called reflexive rule for FDs

2) IR2: Augumentation Rule (FD):-

If X → Y then XZ → YZ

3) IR3:- Transitive Rules for FDs:-

4) IR4:- complementation Rule for MVDs:-

If $\{X \twoheadrightarrow Y\}$ $\underbrace{\text{then we can inferred}}_{F}$ $\{X \twoheadrightarrow (R-(X \cup Y))\}$

5) IR5:- Augmentation Rules for MVDs:-

If $\{X \twoheadrightarrow Y\}$ ~~then~~ and $W \supseteq Z$, then $WX \twoheadrightarrow YZ$

X, Y, Z, W are attributes sets which subset of relation schema R.

6) IR6:- Transitive Rule for MVDs:-

If $\{X \twoheadrightarrow Y, Y \twoheadrightarrow Z\}$ F $X \twoheadrightarrow (Z-Y)$

7) IR7:- Replication Rule for converting FD to MVD:-

$\{X \rightarrow Y\}$ $\cdot F$ $X \twoheadrightarrow Y$

8) IR8:- (coalescence Rule for FDs and MVDs):-

If $X \twoheadrightarrow Y$ and there exist W with the properties that a) $W \cap Y$ is ϕ b) $W \rightarrow Z$ and c) $Y \supseteq Z$ then $X \rightarrow Z$.

Ex:- Let $R(A, B, C, D)$ be the rel^n schema with FDs, $F = \{A \twoheadrightarrow B, BC \rightarrow D\}$ Test whether it is in 4NF or not if not decompose the rel^n into 4NF.

Primary key, is ABC as $(ABC)^+ = \{A, B, C, D\}$

$F^+ = \{A \twoheadrightarrow B, A \twoheadrightarrow CD, BC \rightarrow D\}$

According to Rule IR4 if $X \twoheadrightarrow Y$ then $X \twoheadrightarrow (R-(X \cup Y))$

A →→ B , A →→ CD

NON-trivial ~~depe~~ MVDs .

reln R is not in 4NF bcs both the MVDs are non-trivial but LHS are not super key

$\underline{A \to\to B}$ $\underline{A \to\to CD}$

$R_1(A, B)$ $R_2(A, C, D)$

$F_1 = \{A \to\to B\}$ $F_2 = \{A \to\to CD\}$

~~R2XA~~ Now R_1 and R_2 are 4NF Normalized bcs both the MVDs are Trivial in nature.

5NF :-

The 5NF is based on the concept of join dependency

Join dependency :-

It is denoted by JD(R_1, R_2 ... R_n) specified on reln schema R; specifies constraint on the states r of R

$\Pi_{R_1}(r), \Pi_{R_2}(r) \ldots \Pi_{R_n}(r)$

↓

Reln r decomposed into a no. of reln ~~with atributes~~ (R_1 ... R_n)

A join dependency JD(R_1, if one of the decomposed reln schema R_i = r then it is called trivial JD else it is non-trivial JD,

→ For every non-trivial JD , JD(R_1, R_2 ...

supply

sname	part-name	proj-name
Smith	Bolt	proj X
Smith	Nut	proj Y
Adamsky	Bolt	proj Y
Wallon	Nut	proj Z
Adamsky	Nail	proj X
Adamsky	Bolt	proj X
Smith	Bold	proj Y

The join dependency constraint can be stated JD (R_1, R_2, R_3)

R_1 = (sname, part-name) , R_2 = (sname, proj-name) &

R_3 (part-name, proj-name)

reln instance containing attribute of R1

$*(\Pi_{R_1}(\text{supply}), \Pi_{R_2}(\text{supply}), \Pi_{R_3}(\text{supply}))$

natural join (R_1 , R_2)

~~ensm Π.~~ $R_1 \bowtie R_2$

Sname	Part_name	Proj_name
Smith	Bolt	Proj X
Smith	~~Bol~~ Nut	proj Y
Adamsky	Bolt	Proj Y
Wallon	Nut	proj Z
Adamsky	Nail	proj X
Adamsky	Bolt	proj X
Smith	Bolt	proj Y
Smith	Nut	proj X
Adamsky	Nail	proj Y

$R_1 \bowtie R_2 \bowtie R_3$

Sname	Product_name	proj_name
smith		
smith		
Adamsky		
wallon		
Adamsky		

The dependency rel'n is in 5NF As $R_1 \bowtie R_2 \bowtie R_3$ = supply and we donot have any non-trivial join dependendency in R_1, R_2 and R_3.

Dt:- 30/09/24

MODULE – IV

Query processing

Query processing referes to the range of activities that are involved in a extracting data from a database

Basic steps in Query processing:-

The basic steps involved in processing query are:-

1) parsing and Translation.
2) optimization
3) Evaluation

1) Parsing and Translation:-