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DBMS Assignment - 2

Que.1 Consider the relation shown in the following table. List all the functional dependencies that this relation instances satisfy.

X	Y	Z
x_1	y_1	z_1
x_2	y_1	z_2
x_1	y_2	z_2
x_2	y_1	z_2

The functional dependencies are $XY \rightarrow Z$, $XZ \rightarrow Y$, $YZ \rightarrow X$ since in all these FDs if the value at left side is same then the value at right side is also same.

Que.2 Given the following set S of functional dependencies:

$M \rightarrow O$ (F1)

$NP \rightarrow M$ (F2)

$O \rightarrow N$ (F3)

Check and prove if the following dependencies can be deduced from S. If not, give counter-example with 5 tuples or less.

A) $OP \rightarrow M$

F3) $O \rightarrow N$

Applying Augmentation rule:

$OP \rightarrow NP$ —— (F4)

F2) $NP \rightarrow M$

Applying Transitive rule to F4 & F2, we get:

$OP \rightarrow M$

Hence proved

B) $NO \to M$

This FD cannot be derived from the given FDs

Counterexample :

M	N	O	P
m_1	n_1	O_1	P_1
m_2	n_2	O_2	P_2
m_3	n_1	O_1	P_3
m_4	n_2	O_4	P_1
m_5	n_5	O_5	P_5

C) $MP \to N$

F1) $M \to O$, F3) $O \to N$

Applying Transitive rule, we get

f5) $M \to N$

Reflexivity ~~Rule~~ : $NP \to N$ — (F6)

(since N is a subset of NP)

Applying Augmentation rule to F5

$MP \to NP$ (F7)

Applying Transitive rule to F6 & F7

$MP \to N$

Hence proved

d) $MO \to P$

This FD cannot be derived from given FDs

Counterexample:

M	N	O	P
m_1	n_1	O_1	P_1
m_2	n_2	O_2	P_2
m_3	n_3	O_3	P_3
m_2	n_2	O_2	P_4
m_5	n_5	O_5	P_5

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E) $MN \to P$

This FD cannot be derived from the given FDs

Counterexample:

M	N	O	P
m_1	n_1	o_1	p_1
m_2	n_2	o_2	p_2
m_3	n_3	o_3	p_1
m_2	n_2	o_2	p_4
m_5	n_5	o_5	p_5

Que-3 Consider the relation schema $R(A, B, C, D)$ with functional dependencies $A \to D$, $B \to CD$ and $AC \to D$

A) find the attribute closure $\{A\}^+$

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

B) find the attribute closure ~~of~~ $\{A, B\}^+$

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

C) Find the minimum cover (i.e. canonical cover) of the given functional dependencies

Step1: split

$A \to D$ (1)

$B \to C$ (2')

$B \to D$ (2'')

$AC \to D$ (3)

Step2: Delete duplicate FDs

No duplicate FDs, set remains same

Step3: In (3) 'C' is ~~redundant~~ extraneous

$A \to D$ (1)

$B \to C$ (2')

$B \rightarrow D$ (2'')

$AC \rightarrow D$ (3) $\qquad A \rightarrow D$ (3')

Step 4: Removing (3') as it is redundant

$A \rightarrow D$ (1)

$B \rightarrow C$ (2')

$B \rightarrow D$ (2'')

~~This is the canonical cover of given set of FDs~~

D) ~~List all the candidate key(s) of R~~

- nothing is extraneous
- all RHS are single attributes
- checking if initial & final set of FDs are equivalent or not

Let $E = \{A \rightarrow D, B \rightarrow CD, AC \rightarrow D\}$

$F = \{A \rightarrow D, B \rightarrow C, B \rightarrow D\}$

Checking if F covers E

In E

$A \rightarrow D$	$B \rightarrow CD$	$AC \rightarrow D$
Computing ~~FDs~~ A+ using FDs in F	Computing B+ using F	Computing AC+
$A+ = \{A, D\}$	$B+ = \{B, C, D\}$	$AC+ = \{A, C, D\}$
It contains D	It contains C & D	It contains D

$\therefore$ F covers E

Checking if E covers F

In F

$A \rightarrow D$	$B \rightarrow C$	$B \rightarrow D$
Computing A+ using E	Computing B+ using E	Computing B+ using E
$A+ = \{A, D\}$	$B+ = \{B, C, D\}$	$B+ = \{B, C, D\}$
It contains D	It contains C	It contains D

$\therefore$ E covers F

$\therefore$ E & F are equivalent

$\therefore$ F is canonical cover of E

D) List all the candidate Key(s) of R

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

$A+ = \{A, D\}$ $B+ = \{B, C, D\}$

$\{A,B\}+ = \{A, B, C, D\}$

AB is a superkey because its closure contains all the attributes of relation R

But its proper subsets A & B do not have all the attributes in their closure.

So AB is a candidate key

Que-4 Consider the relation schema $R(A, B, C, D, E, G)$ with functional dependencies $F = \{AB \to C, AG \to E, B \to D, E \to G\}$

Notice F is the minimum cover of itself.

For each of the following decompositions of $R(A, B, C, D, E, G)$ determine whether it is

(a) dependency-preserving &

(b) lossless

i) $\{ABC, CDE, EG\}$

a) Dependency-preserving

let $R_1 = ABC$, $R_2 = CDE$, $R_3 = EG$

$AB \to C$ is preserved in R_1

$E \to G$ is preserved in R_3

Closure of R_1

$A+ = \{A\}$

$B+ = \{B, D\}$ but D is not in R_1 so

$= \{B\}$

$C+ = \{C\}$

$AB+ = \{A, B, C, D\}$ but D is not in R_1 so

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

$AB \to C$ — (F_1)

$AC+ = \{A, C\}$

$BC+ = \{B, C, D\}$ but D is not in R_1 so

$= \{B, C\}$

Closure in R_2

$C+ = \{C\}$

$D+ = \{D\}$

$E+ = \{E, G\}$ but G is not in R_2 so

$= \{E\}$

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

$CE+ = \{C, E, G\}$ but G is not in R_2 so

$= \{C, E\}$

$DE+ = \{D, E, G\}$ but G is not in R_2 so

$= \{D, E\}$

Closure in R_3

$E+ = \{E, G\}$

$E \rightarrow G$

$G+ = \{G\}$

$AB \rightarrow C$ & $E \rightarrow G$ are preserved but not $AG \rightarrow E$, $B \rightarrow D$

So the decomposition is not dependency preserving

b) lossless

(ii) $\{ABCD, AEG\}$

a) dependency preserving

$AB \to C$ is preserved in ABCD

$AG \to E$ is preserved in AEG

$B \to D$ is preserved in ABCD

$E \to G$ is preserved in AEG

$\therefore$ The decompositions are dependency preserving

b) lossless

1) $ABCD \cup AEG = ABCDEG = R$

2) $ABCD \cap AEG = A \neq \phi$

3) $ABCD \cap AEG = A$

$A^+ = \{A\} \neq \{A, B, C, D\}$ or $\neq \{A, E, G\}$

$\therefore$ The decompositions are not lossless

(iii) $\{ABCE, BD, AEG\}$

a) $AB \to C$ is preserved in ABCE

$AG \to E$ is preserved in AEG

$B \to D$ is preserved in BD

$E \to G$ is preserved in AEG

The decompositions are dependency preserving

b) 1) $ABCE \cup BD \cup AEG = ABCDEG = R$

~~Considering ABCE & BD~~ Chase Test :

	A	B	C	D	E	G
1	A	B	C	$\cancel{d_1}$ D	E	$\cancel{g_1}$, G
2	a_2	B	c_2	D	e_2	g_2
3	A	b_3	c_3	d_3	E	G

1 & 3 have ~~common~~ AE in common

& $E \to G$

So g_1 becomes G, B is common in 1&2 & $B \to D$

so d_1 becomes D

$\therefore$ This is a lossless decomposition

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(iv) {AB, ADE, BCG}

a) Closure in R_1 = AB

A+ = {A}

B+ = {B, D} but D is not in R_1 so
= {B}

Closure in R_2 = ADE

A+ = {A}

D+ = {D}

E+ = {E, G} but G is not in R_2 so
= {E}

AD+ = {A, D}

DE+ = {D, E, G} but G is not in R_2 so
= {D, E}

~~AG+ = {A, G, E~~ AE+ = {A, E, G} but G is not in R_2
= {A, E}

Closure in R_3 = BCG

B+ = {B, D} but D is not in R_3 so
= {B}

C+ = {C}

G+ = {G}

BC+ = {B, C, D} but D is not in R_3 so
= {B, C}

~~CD+ = {C, D} but D is r~~

~~BD+ = {B, D}~~

CG+ = {C, G}

BG+ = {B, G, D} but D is not in R so
= {B, G}

None of the FDs are preserved
so the decompositions are not dependency preserving

b) i) AB ∪ ADE ∪ BCG = ABCDEG = R

Chase Test:

	A	B	C	D	E	G
1	A	B	c_1	d_1 D	e_1	g_1
2	A	b_2	c_2	D	E	g_2
3	a_3	B	C	d_3 D	e_3	G

This cannot generate a row which has all the attributes
So this decomposition is not lossless

v) {BDEG, ABC}

a) R_1 = BDEG

Closure in R_1 = BDEG

B+ = {B, D}
B → D
D+ = {D}
E+ = {E, G}
E → G
G+ = {G}
BD+ = {B, D}
DE+ = {D, E, G}
DE → G
EG+ = {E, G}
BE+ = {B, E, D, G}
BE → DG
BG+ = {B, G, D}
BG → D

DG+ = {D, G}
BDE+ = {B, D, E, G}
BDE → G
DEG+ = {D, E, G}
BEG+ = {B, E, G, D}
BDG+ = {B, D, G}
BEG → D

The FDs in R_1
B → D, E → G,

Closure in R_2 = ABC

A+ = {A}
B+ = {B, D}
= {B}
C+ = {C}

~~CD+ = {C, D~~ AC+ = {A, C}
but D is not in R_2 so

AB+ = {A, B, C}
AB → C

BC+ = {B, C, D}
= {B, C}

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The dependency $AG \rightarrow E$ is not preserved

b) 1) $BDEG \cup ABC = ABCDEG = R$

2) $BDEG \cap ABC = B \neq \Phi$

3) $BDEG \cap ABC = B$

$B^+ = \{B, D\} \neq \{B, D, E, G\} \neq \{A, B, C\}$

$\therefore$ The decomposition is not lossless

Que-5 Consider the relation schema R(A, B, C, D) with functional dependencies $A \rightarrow B$, $BC \rightarrow A$ and $B \rightarrow D$, which is the minimum cover itself.

A) Find all the candidate Keys of R

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

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

$AB^+ = \{A, B, D\}$ ✓ $AC^+ = \{A, B, C, D\}$

✓ $BC^+ = \{B, C, A, D\}$ $CD^+ = \{C, D\}$

BC is a superkey, AC is a superkey

$AD^+ = \{A, B, D\}$ $BD^+ = \{B, D\}$

$ABC^+ = \{A, B, C, D\}$ $BCD^+ = \{B, C, D, A\}$

$ACD^+ = \{A, C, D, B\}$ $ABD^+ = \{A, B, D\}$

ABC, BCD, ACD are superkeys

but their subsets ~~A~~ BC & AC are also superkeys

$\therefore$ AC & BC are candidate keys

B) Is relation R in BCNF? Is it in 3NF? Justify your answers.

Assuming no multivalued attributes,

R is in 1NF

A, B, C are prime attributes, D is non prime attribute

$B \rightarrow D$, i.e a subset of candidate key BC which is B determines ~~B~~ D so R has partial dependency

R is not in 2NF
Consequently R is not in 3NF or BCNF

c) Decompose the relation R(A, B, C, D) into a collection of BCNF relations, so that the decomposition is lossless. Is the decomposition dependency preserving?

~~AC & BC~~
~~AC, BC, ABC, BCD, ACD are superkeys in R~~
~~for A→B, A is not a superkey but A→B is a FD of R~~
~~∴ R is not in BCNF~~

Acc. to Algorithm:

$S = \{R\}$

Picking $A \to B$

$\Rightarrow S = \{AB, ACD\}$

∴ The decomposition is $\{AB, ACD\}$

1) $AB \cup ACD = ABCD = R$
2) $AB \cap ACD = A \neq \phi$
3) $AB \cap ACD = A$, ~~$A \to$~~
$A^+ = \{A, B\}$ [and D which is not in AB]

∴ $A \to AB$

∴ $\{AB, ACD\}$ is lossless decomposition

$BC \to A$ is not preserved in this decomposition
So it is not dependency preserving

D) Decompose the relation R(A, B, C, D) into a collection of 3NF relations so that the decomposition is both lossless and dependency preserving

Let us consider the decomposition $\{ABC, BD\}$
It preserves all the dependencies so it is dependency preserving

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1) ABC ∪ BD = ABCD = R

2) ABC ∩ BD = B ≠ φ

3) ABC ∩ BD = ~~B → R1 or R2~~. B → R_2 (BD)

~~BC+ = {A, B, C, D}~~

∴ The decomposition is lossless

1) Both decomposed relations are in 1NF as there are no multivalued attributes

2) There is no partial dependency so they are in ~~3A~~ 2NF

3) There is no transitive dependency so they are in 3NF