Anish Sankhwar (DTU/2K16/MC/13)

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Database Management System (DBMS)
Assignment 2 (MC-302)
Delhi Technological University (DTU)

Q1) Consider the relation shown in the following table and list all functional dependencies that this relation satisfies.

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

Ans 1) Now, for a relationship $\alpha \rightarrow \beta$ $\alpha, \beta \subseteq R$ to be satisfied the following needs to be true.

if $t_1[\alpha] = t_2[\alpha]$, then:
$t_1[\beta] = t_2[\beta]$.

Now, the following dependencies can exist.

i) $X \rightarrow Y$

$X[1] = x_1$ $X[3] = x_1$

$Y[1] = y_1$ $Y[3] = y_2$, hence not functionally dependent

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iii) $X \rightarrow Z$

$X[1] = x_1$ $X[3] = x_2$

$Z[1] = z_1$, $Z[3] = z_2$, hence functionally independent

iii) $Y \rightarrow X$

$Y[1] = y_1$ $Y[2] = y_1$

$X[1] = x_1$ $X[2] = x_2$, hence functionally dependent

iv) $Y \rightarrow Z$

$Y[1] = y_1$ $Y[2] = y_1$

$Z[1] = z_1$ $Z[2] = z_2$, hence functionally independent

v) $Z \rightarrow X$

$Z[2] = z_2$ $Z[3] = z_2$

$X[2] = x_2$ $X[3] = x_1$, hence functionally dependent

vi) $Z \rightarrow Y$

$Z[2] = z_2$ $Z[3] = z_2$

$Y[2] = y_1$ $Y[3] = y_2$, hence functionally dependent.

vii) $XY \rightarrow Z$

This is functionally dependent, and is a dependency

viii) $YZ \rightarrow X$

This is a valid functional dependency.

ix) $ZX \rightarrow Y$

This is a valid functional dependency.

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So, the functional dependencies present in the relation are:-

$F = \{XY \to Z,\ YZ \to X,\ ZX \to Y\}$

Q2) Given the following set S of functional dependencies

$F = \{M \to O,\ NP \to M,\ O \to N\}$.

Check if the following dependencies can be derived from S, If not then give counter example:-

A) $OP \to M$

$O \to M$ (F3)
$OP \to NP$ (Augmentation)
$NP \to M$ (F2)
$OP \to M$ (Transitive property)

B) $NO \to M$

This can't be achieved, as stated in the below example:-

N	O	M	P
n_1	o_1	m_1	p_1
n_1	o_1	m_2	p_2

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C) $MP \rightarrow N$

$M \rightarrow O$ (F1)

$O \rightarrow N$ (F3)

$M \rightarrow N$ (Transitivity)

$MP \rightarrow NP$ (Augmentation)

$MP \rightarrow N$ (Decomposition)

D) $MO \rightarrow P$

This functional dependency doesn't exist

M	O	P	N
m_1	o_1	p_1	n_1
m_1	o_1	p_2	n_1

E) $MN \rightarrow P$

This functional dependency isn't possible.

M	N	P	O
m_1	n_1	p_1	o_1
m_1	n_1	p_2	o_1

Q4) Consider the relational schema R(A, B, C, D, E, G) with functional dependencies

$F = \{AB \rightarrow C, AG \rightarrow E, B \rightarrow D, E \rightarrow G\}$. Notice this is a minimum cover of itself

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For each of the following decompositions $F(ABCDEG)$, determine whether it is a) lossless, b) Dependency preserving

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

$F_1 = \{AB \to C\}$

$F_2 = \{\}$

$F_3 = \{E \to G\}$

Functional dependencies are not preserved, now for lossless decomposition:-

	A	B	C	D	E	G
R_1	α	α	α			
R_2						
R_3					α	α

This is is clearly lossy.

ii) $\{ABCD, AEG\}$

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

$F_2 = \{AG \to E, E \to G\}$

This is functional dependency preserving.

	A	B	C	D	E	G
R_1	α	α	α	α		
R_2	α				α	α

This is lossy composition.

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iii) {ABC, BD, AG}

$F_1 = \{AB \rightarrow C\}$

$F_2 = \{B \rightarrow D\}$

$F_3 = \{AG \rightarrow E, E \rightarrow G\}$

This satisfies all functional dependencies.

	A	B	C	D	E	G
R_1	α	α	α			
R_2		α		α		
R_3	α				α	α

This is lossy decomposition.

iv) {AB, ADE, BCG}

$F_1 = \{\}$

$F_2 = \{\}$

$F_3 = \{\}$

No functional dependency is given and it is lossy compression.

v) {BDEG, ABC}

$F_1 = \{ B \to D, E \to G \}$

$F_2 = \{ AB \to C \}$

This doesn't cover all functional dependencies.

	A	B	C	D	E	G
R_1		∝		∝	∝	∝
R_2	∝	∝		∝	∝	

This is lossy decomposition.

Q3) Consider the relational schema R(A, B, C, D) with functional dependencies

$F = \{A \to D, B \to CD, AC \to D\}$

i) $A^+ = \{A, D\}$ as $(A \to D)$

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

iii) $A_{\{A \to D\}}^+ = A \neq A^+ = \{A, D\}$, Hence $\{A \to D\}$ is part of the canonical cover.

$B_{\{B \to C\}}^+ = BD \neq B^+ = \{B, C, D\}$

Hence $\{B \to C\}$ is part of the canonical cover.

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c) $B^+_{\{B \to D\}} = \{B, C\} \neq B^+ = \{B, C, D\}$

Hence $\{B \to D\}$ is part of the canonical cover.

$AC^+_{\overline{\{AC \to D\}}} = \{A, C, D\} = \{A, C\}^+ = \{A, C, D\}$

Hence $\{AC \to D\}$ is redundant.

$\overline{F} = \{A \to D, B \to C D\}$ New canonical cover of the functional dependencies.

d) Candidate keys of R

Non-determiner attributes = $\{A, B\}$

These attributes must be part of the candidate key.

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

Any other candidate key isn't possible as that will become a super key.

Candidate keys = $\{\{A, B\}\}$

Q5) Consider the relational schema $R(A, B, C, D)$ with functional dependencies $\{A \to B, BC \to A, B \to D\}$ which is minimum cover of itself.

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i) Find all candidate keys of R(A, B, C, D)

Non-determined attributes: {C}

Hence {C} must be part of the candidate key.

C^+: {C}

CA^+: {A, C, B, D}

CB^+: {C, B, D, A}

CD^+: {C, D}

Hence the candidate keys are:-

CK: {{C, A}, {C, B}}

∴ Is relation R in BCNF? Is it in 3NF?

	A → B	BC → A	B → D
BCNF	X	✓	X
3NF	✓	✓	X
2NF	✓	✓	X
1NF	✓	✓	✓

{A → B} isn't in BCNF as {A} is not a candidate key or a super key.

{B → D} isn't in BCNF as {B} is not a candidate key or Super key

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{B → D} isn't in 3NF normal form as {B} isn't a candidate key or super key and {D} is a non-prime attribute and there exists a transitive dependency.

{A → B} and {B → D} of non-prime attribute is dependent on prime attribute {B}.

c) Decompose into dependency-preserving lossless BCNF decomposition.

R(A, B, C, D)

$R_1(AB)$	$R_2(ABC)$	$R_3(BD)$
{A → B}	{BC → A}	{B → D}

This preserves functional dependencies.

	A	B	C	D
R_1	a	a		
R_2	a	a	a	a_4'
R_3		a		a

→ Here this is also a lossless decomposition.

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

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$R(A, B, C, D)$

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

$\{A \to B, BC \to A\}$ $\quad$ $\{B \to D\}$

Candidate Key: $\{B, C\}$ $\quad$ Candidate Key = $\{B\}$

They are both in 3NF form.

$\{A \to B\}$ doesn't have any transitive dependency.
$\{BC \to A\}$ has previous all candidate key as determinant
$\{B \to D\}$ has candidate key as determinant

The decomposition covers all functional dependencies.

	A	B	C	D	
R_1	α	α	α	α'_D	→ The decomposition is also lossless.
R_2		α		α	