Database Systems, CSCI 4380-01
Homework # 2 Answers
Due Thursday September 19, 2019 at 11:59:59 PM

Question 1. Given the following set of functional dependencies, convert it to a minimal basis. Show the main steps, list the changes and explain why the change was made.

$$\mathcal{F} = \{BCF \to CE, AD \to EF, BC \to AF, ACD \to DF\}$$

Answer.

First, convert to a basis:

$\mathcal{F} = \{BCF \to C, BCF \to E, AD \to E, AD \to F, BC \to A, BC \to F, ACD \to D, ACD \to F\}$

Remove all trivial functional dependencies:

$\mathcal{F} = \{BCF \to E, AD \to E, AD \to F, BC \to A, BC \to F, ACD \to F\}$

Remove all dependencies implied by others. We will check all one by one, but I will show the successful results:

Can we remove $ACD \to F$? Given: $\mathcal{F} = \{BCF \to E, AD \to E, AD \to F, BC \to A, BC \to F\}$

$ACD+ = \{A, C, D, E, F\}$. Since it includes F, then we can remove this functional dependency. (Note that we cannot remove $AD \to F$!)

Next step: Can we simplify any functional dependency by removing attributes from the left hand side? Can we replace $BCF \to E$ with $BC \to E$?

$\mathcal{F} = \{BCF \to E, AD \to E, AD \to F, BC \to A, BC \to F\}$, $BC+ = \{B, C, A, F, E\}$

$\mathcal{F}_2 = \{BC \to E, AD \to E, AD \to F, BC \to A, BC \to F\}$, , $BC+ = \{B, C, A, F, E\}$

Since, they are equal, we can remove F in $BCF \to E$.

The final set of functional dependencies: $\mathcal{F} = \{BC \to E, AD \to E, AD \to F, BC \to A, BC \to F\}$
You can also represent it as: $\mathcal{F} = \{BC \to AEF, AD \to EF\}$

Question 2. You are given the relation $R(A, B, C, D, E, F, G, H)$ with the set $\mathcal{F}$ of functional dependencies: $\mathcal{F} = \{AB \to CD, BD \to EF, AD \to G, F \to B\}$.

Given the decomposition: $R1(A, F, H), R2(A, B, C, D), R3(B, D, E, F), R4(A, D, G)$, check if the decomposition is lossless or not using the Chase algorithm. Show the crucial steps and discuss whether it is lossy or lossless.

Answer.

Let's first draw the canonical database for this:

A	B	C	D	E	F	G	H
a	b_1	c_1	d_1	e_1	f	g_1	h
a	b	c	d	e_2	f_2	g_2	h_2
a_3	b	c_3	d	e	f	g_3	h_3
a	b_4	c_4	d	e_4	f_4	g	h_4

Apply $BD \to EF$:

A	B	C	D	E	F	G	H
a	b_1	c_1	d_1	e_1	f	g_1	h
a	b	c	d	e	f	g_2	h_2
a_3	b	c_3	d	e	f	g_3	h_3
a	b_4	c_4	d	e_4	f_4	g	h_4

Apply $F \to B$:

A	B	C	D	E	F	G	H
a	b	c_1	d_1	e_1	f	g_1	h
a	b	c	d	e	f	g_2	h_2
a_3	b	c_3	d	e	f	g_3	h_3
a	b_4	c_4	d	e_4	f_4	g	h_4

Apply $AB \to CD$:

A	B	C	D	E	F	G	H
a	b	c	d	e_1	f	g_1	h
a	b	c	d	e	f	g_2	h_2
a_3	b	c_3	d	e	f	g_3	h_3
a	b_4	c_4	d	e_4	f_4	g	h_4

Apply $AD \to G$:

A	B	C	D	E	F	G	H
a	b	c	d	e_1	f	g	h
a	b	c	d	e	f	g	h_2
a_3	b	c_3	d	e	f	g_3	h_3
a	b_4	c_4	d	e_4	f_4	g	h_4

Apply $BD \to EF$:

A	B	C	D	E	F	G	H
a	b	c	d	e	f	g	h
a	b	c	d	e	f	g	h_2
a_3	b	c_3	d	e	f	g_3	h_3
a	b_4	c_4	d	e_4	f_4	g	h_4

First row has no subscripts, hence this decomposition is lossless.

Note these may not be the most efficient sequence of steps. However, the order in which you apply the actual functional dependencies is not important. Continue applying them and stop when there is no possible changes or a row with no subscript is found.

Question 3. You are given the following relations and set of functional dependencies. For each relation, (i) list the keys, (ii) check if relation is in BCNF or not, (iii) check if the relation is in 3NF or not. Explain your reasoning.

(a) $R1(A, B, C, D, E)$, $\mathcal{F}_1 = \{AB \to CD, ABC \to E\}$

Answer. Key: AB. It is both in BCNF and 3NF as both functional dependencies have a superkey on the left.

(b) $R2(A, B, C, D, E)$, $\mathcal{F}_2 = \{AB \to CD, BC \to E\}$

Answer. Key: AB.

It is not in BCNF because BC is not a superkey but it is on the left hand side of a functional dependency.

It is not in 3NF because BC is not a superkey and E is not a prime attribute.

(c) $R3(A, B, C, D, E)$, $\mathcal{F}_3 = \{AB \to CD, ABC \to E, ED \to A\}$

Answer. Key: AB, BED.

It is not in BCNF because in $ED \to A$, ED is not a superkey.

It is in 3NF because in the above functional dependency, A is a prime attribute.