School of Engineering and Computer Science

SWEN304 **Database System Engineering**

Assignment 3

Due date: 23:59, Monday 17 May

The objective of this assignment is to test your understanding of functional dependencies, normal forms, database normalization. The assignment is worth **10%** of your final grade. It will be marked out of 100.

Submission instructions:

- Submit your assignment in **pdf** via the submission system
- Please make sure to write your **student ID and Name** on your assignment.

Note: Assignments without IDs and names OR not in **pdf** will incur a deduction of 3 marks.

Question 1. Functional Dependencies and Normal Forms [20 marks]

a) [4 marks] Consider a relation schema *N (R, F)* where *R* = {*A, B, C*}. Suppose we find the following two tuples in an instance of this relation schema.

A	*B*	*C*
1	*2*	*3*
4	*2*	*3*

Which of the following functional dependencies do definitely **not** hold over the relation schema *N*? Justify your answer.

1) $C \rightarrow A$
2) $A \rightarrow C$
3) $B \rightarrow A$
4) $B \rightarrow C$

1) and 3) do **not** hold over the relation schema *N*. This is because 1) C corresponds to different values in A, which are 1 and 3. 2) B corresponds to different values in A as well. So, C and B corresponds to different values which means that it is not holding.

b) [16 marks] Consider a relation schema *N* (*R, F*) where *R* = {*A, B, C, D*}. For each of the following sets *F* of functional dependencies, determine which normal form (1NF, 2NF, 3NF, BCNF) the relation schema *N* is in. Justify your answer.

Hint: Note that in all four cases *AB* is the only key for *N*.

1) $F = \{AB \rightarrow C, C \rightarrow D\}$

2NF. The first part, $AB \rightarrow C$ satisfies the BCNF. Because the left hand side is the only key (AB) and the right hand side (C) will satisfy BCNF. Check $C \rightarrow D$, and we see that it is not a partially functional dependency. Therefore, 2NF.

2) $F = \{AB \rightarrow D, B \rightarrow C\}$

1NF. The first part, $AB \rightarrow D$ satisfies the BCNF. Because the left hand side is the key (AB) and right hand side (D) will satisfy BCNF. Check $B \rightarrow C$, and we see that it is a partially functional dependency. Part of the composite key points to a non-prime

attribute which is $B \rightarrow C$. Therefore, not 2NF so it is 1NF.

3) $F = \{AB \rightarrow C, AB \rightarrow D\}$
BCNF. Both the left hand sides of the dependency are the same (AB) which is the key (AB), and the right hand sides are different which are non-prime attributes. No part of the composite key points to a non-prime, and no other non-primes point to other non-primes. Therefore, it is BCNF.

4) $F = \{AB \rightarrow CD, C \rightarrow B\}$
3NF. The first part, $AB \rightarrow CD$ satisfies BCNF because the left hand side is the key (AB) and the right hand side is (CD). This satisfies BCNF, so we check $C \rightarrow B$ and the left hand side of this is not a key therefore is not BCNF. But, the right hand side (B) is a prime attribute of F. So, this dependency is 3NF.

Question 2. Candidate Key [5 marks]

Consider a relation schema $N(R, F)$ where $R=\{A, B, C, D, E\}$ with the set of functional dependencies

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

Is *AB* a candidate key of this relation? Explain your answer. Is *AE* a candidate key of this relation? Explain your answer.

AB is not the candidate key. First we calculate the closure AB += ABCDE.
A+ includes B, therefore += *AB*
AB gives *C*, then *A*+ gives *ABCE*
Because *C* and *E* gives *D*, *AE*+ will give us *ABCDE*.

Question 3. Minimal Cover of a set of Functional Dependencies [20 marks]

Consider the set of functional dependencies $F = \{A \rightarrow B, B \rightarrow CD, D \rightarrow A, AC \rightarrow D\}$. Compute a minimal cover of *F*. Justify your answer.

1. First the RHS must be all single attributes. Therefore, set will become:
$F = \{A \rightarrow B, B \rightarrow C, B \rightarrow D, D \rightarrow A, AC \rightarrow D\}$.
2. Because of $AC \rightarrow D$, we need to do LHS reduction. Because AC→D, this means that $AC \rightarrow B$ which also means $A \rightarrow AC \rightarrow D \rightarrow B$.

Therefore, the minimal cover can be F = { $A \rightarrow B, B \rightarrow C, B \rightarrow D$}.

Question 4. 3NF Normalization [25 marks]

Consider a relation schema $N(R, F)$ where $R = \{A, B, C, D\}$ and $F = \{A \rightarrow B, C \rightarrow D\}$. Perform the following tasks. Justify your answers.

1) **[5 marks] Identify all keys for *N*. Show your process.**

There is only one minimal key which is AC. This is because A and C are on the LHS and could only create the RHS.

2) **[5 marks] Identify the highest normal form (1NF, 2NF, 3NF, BCNF) that *N* satisfies.**

The highest normal form is 1NF. Part of the composite key points to a non-prime attribute and partial dependency. Therefore, not 2NF so it is 1NF.

3) **[10 marks] If *N* is not in 3NF, compute a lossless transformation into a set of 3NF relation schemas using the Synthesis algorithm.**

1: $\{A \rightarrow B\}, \{C \rightarrow D\}$

2: $\{AB\}\{A \rightarrow B\}, \{CD\}\{C \rightarrow D\}$

3: $\{\{AB\{A,B\}, \{CD\}\{C,D\}, \{AC\}\{A,C\}\}$

Where *AC* is the key.

4) **[5 marks] Verify explicitly that your result has the lossless property, satisfies 3NF, and that all functional dependencies are preserved.**

U = $AB \cup CD \cup AC = \{A,B,C,D\}$

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

We see above that we compare U and F and there is no loss. Therefore, is lossless.

Question 5. BCNF Normalization [30 marks]

Consider a relation schema *N* (*R*, *F*), where *R* = {*A*, *B*, *C*, *D*} and *F* = {$A \rightarrow C$, $D \rightarrow B$, $BC \rightarrow A$, $BC \rightarrow D$}. Perform the following tasks. Justify your answers.

1) **[5 marks] Identify all keys for *N*. Show process.**

A += *A*
B += *B*
D += *DB*
AB += *CD*
AC += *CA*
AD += *ABCD*
BC += *ADBC*
BD += *BD*
CD += *CDAB*

Keys are: *AC*, *BC*, *CD*

2) **[4 marks] Identify the highest normal form (1NF, 2NF, 3NF, BCNF) that *N* satisfies.**

The highest normal form is 3NF. BC are part of the key, which means AD are non-prime attributes. No part of the composite key points to non-prime attributes. Therefore, it is 3NF.

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