School of Engineering and Computer Science

SWEN304 **Database System Engineering**

Assignment 3

Due date: 23:59, Monday 30 September

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*
3	*5*	*9*
3	*4*	*9*

Determine if the following functional dependencies hold over the relation schema *N*? *Justify your answer*.

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

1. A cannot determine C as there are duplicate values of A, so we cannot uniquely determine what value A refers to.

2. B can determine A as there are different values of B so can be associated to a unique value of A.

3. B can determine AC as there are different values of B so can be associated to a unique value of AC.

4. AC can determine B as AC can be values such as fruit name and barcode, which can be associated to a specific unique store.

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 minimal key for *N*.

1) $F = \{AB \rightarrow C, AB \rightarrow D\}$
2) $F = \{AB \rightarrow C, C \rightarrow D\}$
3) $F = \{AB \rightarrow D, B \rightarrow C\}$
4) $F = \{AB \rightarrow CD, C \rightarrow B\}$

1. This is BCNF. This is because both RHS stated are AB, which is a super key, and a super key is a prerequisite for the BCNF. This specific set is also assumed to be all atomic

numbers and no part of the composite key is pointing to a pointing to a non-prime, and no other non-primes point to other non-primes.

2. This is 2NF. It is assumed that they are all atomic numbers and no part of the composite key is pointing to a non-prime. It is not 3NF has this specific set has non-primes pointing to other non-primes (C→D).

3. This is 1NF. It is assumed that they are all atomic numbers. A part of the composite key is pointing to a non-prime attribute (B→C) which is why it is not 2NF.

4. This is 3NF. It is assumed that they are all atomic numbers and no part of the composite key is pointing to a non-prime attribute. There are also no non-primes pointing to other non-primes.

Question 2. Minimal Cover of a set of Functional Dependencies [20 marks]

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

A → D
C → D
AD → C

1. There should be only one attribute on the RHS – this is done for us.

2. Reduce the LHS.
A → D
C → D
AD → C

As AD → C, this means that AD → D which also means that A → AD → C → D so the minimal cover can just become:

F = {A→D, C → D}

Question 3. Lossless Third Normal Form Normalization [25 marks]

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

1) Identify all minimal keys for *N*. Show your process.

Only one minimal key = BD as both are on the LHS and make up the RHS only.

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

Candidate key = BD

The highest normal form is 1NF. It is assumed that they are all atomic numbers. A part of the composite key is pointing to a non-prime attribute (B→C, D→A) which is why it is not 2NF.

3) If *N* is not in 3NF, compute a lossless transformation into a set of 3NF relation schemas that preserve attributes and functional dependencies.

Step One: {B→C}, {D →A}

Step Two: {BC}{B→C}, {DA}{D→A}

Step Three: {{BC}{B,C}, {DA}{D,A}, {BD}{B,D}}

4) Verify explicitly that your result has the lossless property, satisfies 3NF, and that all attributes and functional dependencies are preserved.

U = BC U DA U BD = {A, B, C, D}

F = {B→C} U {D→A} = {B→C, D→A}

This is the relation schema (U, F), with U is the union of the R, and F is the union of F's from the original relation schema. As shown above it is lossless with the unions.

Question 4. BCNF Normalization [35 marks]

Suppose you are given a relation schema N (R, F), where $R = \{A, B, C, D\}$ and $F = \{AB \rightarrow CD, C \rightarrow A, D \rightarrow B\}$.

1) Identify all minimal keys for N. *Justify your answer*.

A+ = A

B+ = B

C+ = CA

D+ = DB

AB+ = ABCD

AC+ = AC

AD+ = ADBC

BC+ = BCAD

BD+ = BD

CD+ = CDAB

Minimal keys are AB, AD, BC, CD

2) Identify the highest normal form that N satisfies (1NF, 2NF, 3NF, BCNF). Justify your answer.

This is 3NF. It is assumed that they are all atomic numbers and no part of the composite key is pointing to a non-prime attribute. There are also no non-primes pointing to other non-primes.

3) If N is not in BCNF, transform it into a set of at least BCNF relation schemas that preserve attributes and functional dependencies and have a lossless join property.

4) Check whether your decomposition preserves all the functional dependencies. Justify your answer.

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