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SWEN304 **Database System Engineering**

Assignment 3

Due date: 23:59, Monday 30 September

The objective of this assignment is to test your understanding of functional dependencies, normal forms, and database normalization. The assignment is worth 5% of your final grade. It will be marked out of 100.

Submission Instructions:

- Please submit your assignment in **pdf** with your **student ID and Name** via the submission system.
- Submissions not in pdf, or without ID and name will incur **3 marks** deduction from the total marks.

Question 1. Functional Dependencies and Normal Form[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.

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

A	*B*	*C*
3	*5*	*9*
3	*4*	*9*

1) A→ C

Yes. A value is always associated the same C value ,so true.
3→9 , 3→9 .

2) B→ A

Yes. B value is always associated the same A value ,so true.
5→3 , 4→3 .

3) B→ AC

Yes. B value is always associated the same AC value ,so true.
5→{3,9} , 4→{3,9} .

4) AC→ B

No. AC value is not always associated the same C value ,so false.
{3,9}→5 ,{3,9} → 4 .

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

BCNF. Because left hand sides (AB→C, AB→D)are both AB which is the minimal key and at sane time right hand sides C, D (AB→C, AB→D) are non-prime attributes then it is in BCNF.

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

2NF. AB→C ,this part satisfy the BCNF due to left hand side is minimal key (AB)and right hand side(C) is non-prime attribute so we suppose this F satisfy BCNF then we check C→D, which is not partially functionally dependency. So it is in 2NF.

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

1NF. AB→D ,this part satisfy the BCNF due to left hand side is minimal key (AB)and right hand side(D) is non-prime attribute so we suppose this F satisfy BCNF then we check B→C, which is partially functionally dependency. So it is not in 2NF.

4) $F = \{AB \rightarrow CD, C \rightarrow B\}$

3NF. AB→CD, this part satisfy the BCNF due to left hand side is minimal key (AB)and right hand side(CD) is non-prime attribute so we suppose this F satisfy BCNF then we check C→B, left hand side is not a key then it is not in BCNF, however , right hand side B is a prime attribute of F .So it is in 3NF .

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.*

Firstly, because of AD → C , then we need to de left reduction, we try to remove each of the LHS attributes and apply attribute closure algorithm to see if the RHS still functionally depends on the remainder of the LHS

(AD - A) + = D+ = D : C is not belong to (AD - A) + but AD → C so A can determine C (A → C) . So now F2 = {A → D, C → D, A → C}.

Because A → C, C → D. It satisfy the transitive rule then we can get A → D from this. So it have already cover all elements so A → D is redundancy. So, I removed it from F2 then we get F3 = {A → C, C → D}.

So F3 is the minimal cover.

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.

First of all, I built all possible closure for R:

A+ = A

B+ = B,C

C+ = C

D+ = D,A

AB+ = A,B,C

AC+ = A,C

AD+ = A,D

BC+ = B,C

BD+ = B,D,A,C

CD+ = C,D,A

Then we can see only BD+ can cover all elements in R.So the minimal key for N is {B,D}.

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

1NF. Because right hand side of A in D→A and C in B→C , are partially dependent on key BD.

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 1: Find the minimal cover, we have had it - B→C, D→A.

Step 2 : Group FDs from N according to the same left-hand side.

({B→C},{ D→A}),
make one relation schema in N
({B,C},{D,A})

Step 3 : Because none of relation schemas contains a key BD, so I create a new relation scheme in N that will contain only a key of (R,F). Then finally, ({B,C},{D,A},{B,D})

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

To check Attribute preservation we can union all attributes :

U = BC U DA U BD = {A,B,C,D} and we can see it contains all attributes in original R.

To check functional dependencies preservation :

From 3) we can get ({B,C},{D,A},{B,D}) then B→C, D→A, B→D.Compare with original F we preserve everything.

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.*

First of all, I built all possible closure for R:

A+ = A
B+ = B
C+ = C,A
D+ = D,B
AB+ = A,B,C,D
AC+ = A,C
AD+ = A,D,B,C
BC+ = B,C,A,D
BD+ = B,D
CD+ = C,D,A,B
ABC+ = A,B,C,D
ABD+ = A,B,D,C
BCD+ = B,C,D,A

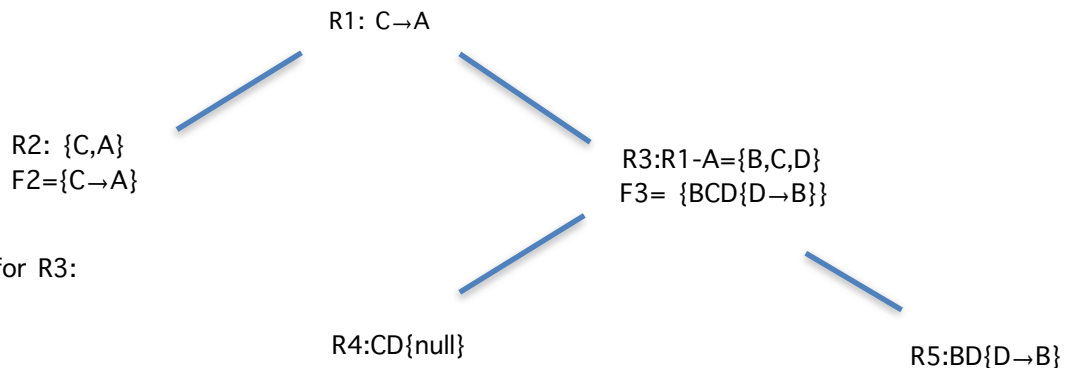
So as closures shows the minimal keys are:
AB+, AD+, BC+, CD+

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

I regard AB as my super key ,thus, on the contrast C and D are non-prime attributes. Then it is not in BCNF but A and B are prime (C→A, D→B) so it is in 3NF.

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.

As I mentioned in 2) C→A, D→B these two FDs are not in BCNF. So



Closures for R3:
B+ = B
C+ = C
D+ = D
BC+ = A,B,C,D
BD+ = B,D
CD+ = C,D,A,B

Closures for R4:
C+ = C,A
D+ = D,B
CD+ = C,D,A,B

So after BCNF Decomposition we got:

(CA{C→A} , CD{null} , BD{D→B})

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

To check Attribute preservation we can union all attributes :

U = CA U CD U BD = {A,B,C,D} and we can see it contains all attributes in original R.

To check functional dependencies preservation :

From 3) we can get ({C→A},{null},{D→B}) however compare with original F {AB→CD, C→A, D→B} we can see we miss AB→CD this FD.

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