SWEN304
Assignment three

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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 can hold C
2)B can hold A
3)B can hold AC
4)AC cannot hold B, AC have multiple Bs.

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) It is BCNF, AB is the super key for C and D.
2) It is in 2NF, it has transitive dependency. Key AB could hold D directly. Thus, it is not 3NF.
3) It is in 1NF, it has partial dependency. Because C is partially depends on AB.
4) it is in 3NF, it have neither partial dependency nor transitive dependency. Meanwhile, AB is key and CD is non-prime attributes and C is non-prime attribute and B is prime attribute.

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+ = ADC
C+ = CD
D+ = D
AD+ = ADC
AC+ = ADC
CD+ = CD

Step 1: As we can see above, A+ = ADC, thus, A –>C directly. D cannot hold C because C -> D. hence, AD-> C can be removed. {A->D, C->D, A->C} is equal to {A->D, C->D,AD->C}. I update F = { A->D, C->D, A->C }.

A->D and C->D have same prime attributes D. However, A->C and C->D can use transitive rule to infer A->D. A->D is considered as redundant FD. I removed A->D update F to {A->C, 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.

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

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

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

1)
A+ = A
B+ = BC
C+ = C
D+ = DA
AB+ = ABC
AC+ = AC
AD+ = AD
BC+ = BC
BD+ = BDCA
CD+ = CDA
ABC+ =ABC
ABD+ = ABCD
ACD+ = ACD
BCD+ = ABCD

BCD,ABD, and BD all infer ABCD. Hence, the key will be the minimal attributes then it will be BD.

2) it is in 1NF, Because the minimal key is BD which is verified in last process, thus, BD+= ABCD which means BD-> A and BD->C. Meanwhile B->C and D->A is given. it has partial dependency, then it is in 1NF.

3)
Step 1: {B->C},{ D->A}

Step 2: {BC}{B->C}, {DA}{D->A}

Step 3: add key to the function{{BC}{B,C},{DA}{D,A},{BD}{B,D}}

4) To make sure it is lossless, we should construct a relation schema (U,F) where U = union of all Rs and F = union of all Fs
In this question, U = BC U DA U BD = {A,B,C,D} and F = {B->C}U{D->A} = {B->C,D->A}. Hence, compared with given U and F. We didn’t lost anything. Then It is lossless.

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

1)
A+= A
B+= B
C+ = CA
D+ = DB
AB+ = ABCD
AC+ = AC
AD+ = ADBC
BC+ = BCAD
CD+ = ABCD
ABC+ = ABCD
ABD+ = ABCD
BCD+ = ABCD

As we can see above, There four minimal keys they are {AB, AD,BC,CD}

2)For this question, I consider AB as my key. Thus, C and D will be non-prime attributes. Thus, It should be 3NF. Because C and D is non-prime attributes and A and B are part of key (prime attribute). Hence, it should be 3NF.

3)

$R = \{A, B, C, D\}$

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

As we can see $C \rightarrow A$, $D \rightarrow B$ both violates the rule of BCNF

Let's start with $C \rightarrow A$

$N_1 = (BCD\{D \rightarrow B\})$ $N_2 = (AC\{C \rightarrow A\})$

$B^+ = B$

$C^+ = C$

$D^+ = BD$ $N_3 = (CD\{\emptyset\})$ $N_4 = (BD\{D \rightarrow B\})$

$BC^+ = ABCD$ $BC^+ = ABCD$ is key thus It haven't violated BCNF.

$BD^+ = BD$ $CD^+ = CDAB$ $CD \rightarrow B$ is not minimal. we

$CD^+ = CDAB$ replace $CD \rightarrow B$ by $D \rightarrow B$.

After BC Normalization we got

$(AC\{C \rightarrow A\}, CD\{\emptyset\}, BD\{D \rightarrow B\})$

4) We construct a relation schema (U,F) where U = union of all Rs and F = union of all Fs. We can get U = {A,C} U {C,D} U {B,D} = {A,B,C,D} F = {null} U {C->A} U {D->B} = {{C->A},{D->B}}. Compared with original F={{AB->CD},{C->A},{D->B}}, We lost function {AB->CD}.