

# Tutorial 5: Logical Database Design

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`StudentInfo(S, N, M, A, C, T, I, L, G)`

with the following FDs:

1.  $S \rightarrow N$
2.  $C \rightarrow T, I$
3.  $I \rightarrow L$
4.  $S, C, M \rightarrow G$
5.  $S, M \rightarrow A$
6.  $A \rightarrow M$

## 1 Find all keys and prove that you have found them all.

Since  $S$  and  $C$  do not appear in any RHS of the FDs,  
 $S$  and  $C$  must be part of every key.

$(S\ C)^+ = S\ C\ N\ T\ I\ L \neq SI$ , so  $(S\ C)$  is not a key.

Guess  $(S\ C\ M)$  and  $(S\ C\ A)$  are keys.

$(S\ C\ M)^+ = (S\ C\ M\ N\ T\ I\ L\ G\ A) = SI$  so  $(S\ C\ M)$  is a superkey.

$(S\ C\ A)^+ = (S\ C\ A\ N\ T\ I\ L\ G\ M) = SI$  so  $(S\ C\ A)$  is a superkey.

Since  $(S\ C)$  is not a key, so  $(S\ C\ M)$  and  $(S\ C\ A)$  are minimal, so they are keys.

Consider the maximal set  $X \subseteq (S\ N\ M\ A\ C\ T\ I\ L\ G)$  such that  $(S\ C) \subset X$   
and  $A, M \notin X$ . The maximal such  $X$  is  $(S\ N\ C\ T\ I\ L\ G)$

$X^+ = (S\ N\ C\ T\ I\ L\ G)^+ = S\ N\ C\ T\ I\ L\ G \neq SI$

So any set other than  $(S\ C\ M)$  and  $(S\ C\ A)$  cannot be a key.

Therefore,  $(S\ C\ M)$  and  $(S\ C\ A)$  are the only keys for the relation  $SI$ .

## 2 Find a minimal cover for this set of FDs.

1. Put the FDs in a Standard Form.  
 $S \rightarrow N$ ,  $C \rightarrow T$ ,  $C \rightarrow I$ ,  $I \rightarrow L$ ,  $SCM \rightarrow G$ ,  $SM \rightarrow A$ ,  $A \rightarrow M$ .
2. Minimize the Left Side of Each FD.  
Single attribute left sides are already minimized.  
 $SCM \rightarrow G$ :  $S, C$  do not appear on LHS.  $M$  cannot be reduced from  $S, C$ .  
 $SM \rightarrow A$ :  $S$  does not appear on LHS.  $M$  cannot be reduced from  $S$ .  
So the left sides are all minimized.
3. Delete Redundant FDs.  
 $N, T, I, L, G, A, M$  only appear once on RHS, so there is no redundant FD.

So the minimum cover for this set of FDs is:

1.  $S \rightarrow N$
2.  $C \rightarrow T$
3.  $C \rightarrow I$
4.  $I \rightarrow L$
5.  $S, C, M \rightarrow G$
6.  $S, M \rightarrow A$
7.  $A \rightarrow M$

## 3 Obtain a lossless-join, BCNF decomposition of StudentInfo.

For FD (1):  $S \rightarrow N$ , we decompose  $SI$  to

$S1 = (S \ N)$

$S2 = (S \ M \ A \ C \ T \ I \ L \ G)$

For FD (3):  $I \rightarrow L$ , we decompose  $S2$  to

$S3 = (I \ L)$

$S4 = (S \ M \ A \ C \ T \ I \ G)$

For FD (2):  $C \rightarrow T, I$ , we decompose  $S4$  to

$S5 = (C \ T \ I)$

$S6 = (S \ M \ A \ C \ G)$

For FD (4):  $S, C, M \rightarrow G$ , we decompose  $S6$  to

$S7 = (S \ C \ M \ G)$

$S8 = (S \ C \ M \ A)$

For FD (6):  $A \rightarrow M$ , we decompose  $S8$  to

$S9 = (A\ M)$

$S10 = (S\ C\ A)$

Note that FD (5) cannot be applied to any final decomposed relation, so the decomposition is done. FD (5):  $S, M \rightarrow A$  is not preserved. So the final decomposition of StudentInfo is:

$S1 = (S\ N)$

$S3 = (I\ L)$

$S5 = (C\ T\ I)$

$S7 = (S\ C\ M\ G)$

$S9 = (A\ M)$

$S10 = (S\ C\ A)$

#### 4 Obtain a lossless-join, dependency-preserving, 3NF decomposition of StudentInfo by making use of the BCNF decomposition in Question (c).

The BCNF decomposition we obtained from (c) does not preserve FD (5):  $S, M \rightarrow A$ , so we add  $S11 = (S\ M\ A)$ .

So the final 3NF decomposition is:

$S1 = (S\ N)$

$S3 = (I\ L)$

$S5 = (C\ T\ I)$

$S7 = (S\ C\ M\ G)$

$S9 = (A\ M)$

$S10 = (S\ C\ A)$

$S11 = (S\ M\ A)$

#### 5 Obtain a lossless-join, dependency-preserving, 3NF decomposition of StudentInfo via synthesis by making use of your minimal cover in Question (b).

The minimum cover is  $S \rightarrow N$ ,  $C \rightarrow T$ ,  $C \rightarrow I$ ,  $I \rightarrow L$ ,  $SCM \rightarrow G$ ,  $SM \rightarrow A$ ,  $A \rightarrow M$ .

The relations obtained from a minimum cover set is:

$R1 = (S\ N)$

$R2 = (C\ T)$

$R3 = (C\ I)$

$R4 = (I\ L)$

$R5 = (S\ C\ M\ G)$

$R6 = (S\ M\ A)$

$R7 = (A\ M)$

- 6 Comment on the differences, if any, between your answers to Questions (d) and (e).