

Tutorial 5: Logical Database Design

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February 2018

`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.
 - a) Single attribute left sides are already minimized.
 - b) For FD $SCM \rightarrow G$, notice that S, C do not appear on LHS, and M cannot be reduced from S, C . Therefore the LHS is minimal.
 - c) For FD $SM \rightarrow A$, notice that S does not appear on LHS, and M cannot be reduced from S . Therefore the LHS is minimal.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:

1. S1 = (S N)
2. S3 = (I L)
3. S5 = (C T I)
4. S7 = (S C M G)
5. S9 = (A M)
6. 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)

Since $S9 \subset S11$, we can drop S9. So the final decomposition is:

1. S1 = (S N)
2. S3 = (I L)
3. S5 = (C T I)
4. S7 = (S C M G)
5. S10 = (S C A)
6. 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)

Check if any relation contains a key to the original relation: $R_5 = (S \ C \ M \ G)$ contains key $(S \ C \ M)$, so it is a lossless-join decomposition.

Since $R_7 \subset R_6$, we can drop R_7 . Since R_2 and R_3 share the same key C , we can merge them to $R_{23} = (C \ T \ I)$.

So the final decomposition is:

1. $R_1 = (S \ N)$
2. $R_{23} = (C \ T \ I)$
3. $R_4 = (I \ L)$
4. $R_5 = (S \ C \ M \ G)$
5. $R_6 = (S \ M \ A)$

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

The decomposition obtained from (d) has one extra relation $R = (S \ C \ A)$ comparing to the decomposition obtained from (e).

So the synthesis approach usually results in less number of tables than the BCNF decomposition approach.