

Database Systems I
CS3431
B term-2011

Solution of Homework 3

Problem 1

1- Several Nontrivial FDs are (You are required to derive 5 only):

$C \rightarrow D$
 $D \rightarrow A$
 $C \rightarrow A$
 $BD \rightarrow A$
 $CD \rightarrow A$
 $BC \rightarrow A$
 $AB \rightarrow C$
 $AC \rightarrow D$
 $AB \rightarrow D$
 $BD \rightarrow C$
 $BC \rightarrow D$
 $ABD \rightarrow C$
 $ABC \rightarrow D$
 $BCD \rightarrow A$

2- The attribute closures are:

$\{AD\}^+ = \{AD\}$
 $\{C\}^+ = \{ACD\}$
 $\{AB\}^+ = \{ABCD\}$

3- Candidate keys of R are: $\{AB\}$, $\{BC\}$, $\{BD\}$

Proof:

$\{AB\}^+ = \{ABCD\}$, and neither $\{A\}^+$ nor $\{B\}^+$ contain all the attributes of R
 $\{BC\}^+ = \{ABCD\}$, and neither $\{B\}^+$ nor $\{C\}^+$ contain all the attributes of R
 $\{BD\}^+ = \{ABCD\}$, and neither $\{B\}^+$ nor $\{D\}^+$ contain all the attributes of R

Problem 2

- When decompose a relation R, you need to recheck the new relations against the FDs that you have. In some cases you may need to decompose multiple times as shown below.
- The decomposition is not unique, that is you may find more than one decomposition that satisfy the required normalization level.
- The underlined attributes are the key for its relation.

Relation Number	Candidate Keys	BCNF Violations	BCNF Decomposition	3NF Violations	3NF Decomposition
1	AB, BC, BD	$C \rightarrow D$ $D \rightarrow A$	Using $C \rightarrow D$ $(\underline{C}, D), (\underline{A}, B, C)$ Using $D \rightarrow A$ $(\underline{A}, D), (\underline{B}, C, D)$ Then (B, C, D) is broken based on $C \rightarrow D$ to have: $(\underline{A}, D), (\underline{C}, D), (\underline{B}, C)$	None	
2	AB, BC, CD, AD	None		None	
3	AB, AC, AD	$C \rightarrow D$ $D \rightarrow B$ $D \rightarrow E$	Using $C \rightarrow D$ $(\underline{C}, D), (\underline{A}, B, E, C)$ Then (A, B, C, E) is broken based $AB \rightarrow C$ to have: $(\underline{C}, D), (\underline{A}, B, C), (\underline{A}, B, E)$ Using $D \rightarrow B$ $(\underline{D}, B), (\underline{A}, C, E, D)$ Then (A, C, E, D) is broken based on $C \rightarrow D$ to have: $(\underline{D}, B), (\underline{C}, D), (\underline{A}, C, E)$	$D \rightarrow E$	Same decomposition as in the BCNF: $(\underline{C}, D), (\underline{A}, B, C), (\underline{A}, B, E)$ Using $D \rightarrow E$ $(\underline{D}, E), (A, B, C, D)$

Problem 3

Part 1

a- (Department, Surname), (Surname, FirstName, Address)

- Lossy decomposition.
- The reason is that the common attribute (Surname) is not a key in either relations and hence the natural join will generate more tuples than that of the original relation.

b- (Department, FirstName, Surname), (FirstName, Address)

- Lossless decomposition.
- The reason is that the common attribute (FirstName) can be a key (after removing the duplicates) for the second relation (FirstName, Address) and hence the natural join will generate the same tuples as in the original relation.

Part 2

Dependencies that hold from the given data are:

- Department \rightarrow Surname
- Department \rightarrow FirstName
- Department \rightarrow Address
- FirstName \rightarrow Address
- FirstName \rightarrow Surname

a- (Department, FirstName, Surname), (Surname, Address)

- Does not preserve the dependencies because Department \rightarrow Address cannot be derived.

b- (Department, FirstName, Surname), (Surname, FirstName, Address)

- Preserve the dependencies because all dependencies can be derived including the Department \rightarrow Address dependency.

Problem 4

$R = (A, B, C, D)$ and the FD set = $\{AB \rightarrow C, AC \rightarrow B, B \rightarrow D, BCD \rightarrow A\}$

The set of canonical cover is:

$\{AB \rightarrow C, A \rightarrow B, B \rightarrow D, BC \rightarrow A\}$