Database Systems I
CS3431

Solution of Homework 3

Problem 1

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

C → D
D → A
C → A
BD → A
CD → A
BC → A
AB → C
AC → D
AB → D
BD → C
BC → D
ABD → C
ABC → D
BCD → 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

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 → Surname
Department → FirstName
Department → Address
FirstName → Address
FirstName → Surname

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

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

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

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

Problem 3

- 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→ D D → A	Using C→D (C, D) , (A, B, C) Using D→A (A,D), (B, C, D) Then (B, C, D) is broken based on C→D to have: (A,D), (C,D), (B,C)	None	
2	AB, BC, CD, AD	None		None	
3	AB, AC, AD	C →D D→B D→E	Using C→D (C,D), (A,B,E,C) Then (A,B,C,E) is broken based AB→C to have: (C,D), (A,B,C), (A,B,E) Using D→B (D,B), (A,C,E,D) Then (A,C,E,D) is broken based on C→D to have: (D,B), (C,D), (A,C,E)	D→E	Same decomposition as in the BCNF: (C,D), (A,B,C), (A,B,E) Using D→E (D,E), (A,B,C,D)

**** Note the question did not ask for 3NF, but I just included them in the table**