CS 440 - Assignment 2

Team member:
Junhyeok Jeong - jeongju@oregonstate.edu, jeongju
Ashyan Ashley Rahavi - rahavia@oregonstate.edu, rahavia

1: BCNF and 3NF (2 points)
Consider a relation R with five attributes A, B, C, D, and E. You are given the following functional dependencies: A → B, BC→E, and ED→A.

(a) List all keys for R. (1 point)
- C,D is not on the right side in FD, so C,D are candidate keys.
- Therefore, keys can be ACD, BCD, and CDE

(b) Is R in BCNF? If it is not, decompose it into a collection of BCNF relations. (0.5 point)
- For each non-trivial FD X Y, X is a super key of R
- R is not in BCNF because ED is not a super key for ACDE.
- (A,B)
- (A,D,E)
- (B,C,E)

(c) Is R in 3NF? If it is not, convert it into a collection of 3NF relations. (0.5 point)
- If the relation R is in 3NF, then a function dependency X -> Y holds in R, either
- (a) X is a superkey of R
- (b) Y is a prime attribute of R.
- Therefore, R is in 3NF because A, B, E are part of keys for R as a 3NF condition (b).

2: BCNF and 3NF (1.5 points)
Consider the relation schema R with attributes A, B, C, and D and the following functional dependencies: AB→C, AC→B, B→D, BC→A.

(a) List all keys for R. (0.5 point)
- AB, AC, BC

(b) Is R in BCNF? If it is not, decompose it into a collection of BCNF relations. (0.5 point)
- R is not in BCNF, it needs to decompose into the following:
  - (B,D)
  - (A,B,C)

(g) Is R in 3NF? If it is not, convert it into a collection of 3NF relations. (0.5 point)
- No, because of FD B->D. Since B is not a super-key and D is not part of any key, then it is not in 3NF. Since the decomposition in part B is already in 3NF, then a collection of 3NF relations can look like:
  - (B,D)

- (A,B,C)

3: FD Implication & Schema Decomposition (1 point)

(a) Given that X, Y, W, Z are attributes in a relation, using the Armstrong's axioms, prove that if we have $X \rightarrow Y$ and $Y W \rightarrow Z$, then $XW \rightarrow Z$. (0.25 point)

- By the augmentation axiom, since X -> Y, then we know XW -> YW. Since we know that YW -> Z, we can use the transitivity axiom to to replace YW with XW, giving us XW -> Z

(b) Given that X, Y, Z are attributes in a relation, using the Armstrong's axioms, prove that if we have $X \rightarrow Y$ and $X \rightarrow Z$, then $X \rightarrow Y Z$. (0.25 point)

1. Using the augmentation axiom, given X -> Z, we know X Y -> Z Y
2. Using augmentation with X - > Y, we know that X X -> X Y, which reduces down to X -> XY
3. Using the transitive axiom with 1 and 2, we can derive X -> ZY, or X -> Y Z

(c) Prove that, if relation R has only one simple key, it is in BCNF if and only if it is in 3NF. (0.5 point)

- If R has only one simple key, then every attribute can be defined with only one key. To be 3NF, the FDs should follow one or two of the below rules:
- (a) X is a superkey of R
- (b) Y is a prime attribute of R.
- Since every key is simple, every prime attribute is a key itself. R is in 3NF. When it comes to BCNF, there are no transitive dependencies due to R being in 3NF. This implies that X is not a prime attribute but a superkey of R. Therefore, R is in BCNF also.

4: Information preservation (0.5 point)

(a) Suppose you are given a relation R(A,B,C,D) with functional dependencies $B \rightarrow C$ and $D \rightarrow A$. State whether the decomposition of R to S1(B,C) and S2(A,D) is lossless or dependency preserving and briefly explain why or why not. (0.5 point)

- I think this is dependency preserving not lossless. First, S1 and S2 violates the condition of lossless, which is R1 ∩ R2 = R1 or R2. For S1 and S2, S1 ∩ S2 = no common. As dependency preserving, the union of relations should be all attributes. In S1 and S2, it satisfies with S1 U S2 = (A,B,C,D).