# COSC 3318 - Database Management Systems

# (Assignment 5)

**Assigned on November 3, 2017. Hardcopy due at the start of class on November 17, 2017.**

1. (20 points) Consider a relation about people in the United States, including their name, Social Security number, street address, city, state, ZIP code, area code, and phone number (the last 7 digits). What FD’s would you expect to hold? What are the keys for the relation?
   1. Functional Dependencies
      1. SS# 🡪 Name
      2. Area Code 🡪 State
      3. Street address, city, state 🡪 zipcode
   2. Keys:
      1. {SS#, Street Address, City, State, area code, phone #}
2. (20 points) Consider a relation with schema R(A, B, C, D) and FD’s AB → C, C → D, and D → A.
3. Identify and proof whether the following FDs follow from the given FDS.

AC → D, CD → A

1. C🡪A, AB🡪D, AC🡪D, BC🡪A, BC🡪D, BD🡪A, BD🡪C, CD🡪A, ABC🡪D, ABD🡪C, and BCD🡪A
2. What are the keys of R?
   1. {AB, BC, BD}
3. What are the superkeys for R that are not keys?
   1. The superkeys are all those that contain one of those three keys. A superkey that is not a key must contain B and more than one of A, C, and D. The superkeys are ABC, ABD, BCD, and ABCD.
4. (20 points) Suppose we have relation R(A, B, C, D, E), with some set of FD’s. Compute the attribute closure for each of the following cases:
5. AB → DE, C → E, D → C, and E → A. Compute .
   1. {BC}+=ABCDE
6. A → D, BD → E, AC → E, and DE → B. Compute .
   1. {AB}+=ABDE
7. (20 points) For each of the following relation schemas and sets of FD’s:
8. R(A, B, C, D) with FD’s AB → C, C → D, and D → A.
9. R(A, B, C, D, E) with FD’s AB → C, C → D, D → B, and D → E.

Decompose the relations, as necessary, into collections of relations that are in BCNF. Do not forget to consider FD’s that are not in the given set, but follow from them.

* In the solution to 2B we found that there are 14 nontrivial dependencies, including the three given ones and eleven derived dependencies. They are: C🡪A, C🡪D, D🡪A, AB🡪D, AB🡪 C, AC🡪D, BC🡪A, BC🡪D, BD🡪A, BD🡪C, CD🡪A, ABC🡪D, ABD🡪C, and BCD🡪A.

We also learned that the three keys were AB, BC, and BD. Thus, any dependency above that does not have one of these pairs on the left is a BCNF violation. These are: C🡪A, C🡪D, D🡪A, AC🡪D, and CD🡪A.

One choice is to decompose using the violation C🡪D. Using the above FDs, we get ACD and BC as decomposed relations. BC is surely in BCNF, since any two-attribute relation is. Using Algorithm 3.12 to discover the projection of FDs on relation ACD, we discover that ACD is not in BCNF since C is its only key. However, D🡪A is a dependency that holds in ABCD and therefore holds in ACD. We must further decompose ACD into AD and CD. Thus, the three relations of the decomposition are BC, AD, and CD.

* By computing the closures of all 31 nonempty subsets of ABCDE, we can find all the nontrivial FDs. They are: C🡪B, C🡪D, C🡪E, D🡪B, D🡪E, AB🡪C, AB🡪D, AB🡪E, AC🡪B, AC🡪D, AC🡪E, AD🡪B, AD🡪C, AD🡪E, BC🡪D, BC🡪E, BD🡪E, CD🡪B, CD🡪E, CE🡪B, CE🡪D, DE🡪B, ABC🡪D, ABC🡪E, ABD🡪C, ABD🡪E, ABE🡪C, ABE🡪D, ACD🡪B, ACD🡪E, ACE🡪B, ACE🡪D, ADE🡪B, ADE🡪C, BCD🡪E, BCE🡪D, CDE🡪B, ABCD🡪E, ABCE🡪D, ABDE🡪C and ACDE🡪B. From the closures we can also deduce that the keys are AB, AC and AD. Thus, any dependency above that does not contain one of the above pairs on the left is a BCNF violation. These are: C🡪B, C🡪D, C🡪E, D🡪B, D🡪E, BC🡪D, BC🡪E, BD🡪E, CD🡪B, CD🡪E, CE🡪B, CE🡪D, DE🡪B, BCD🡪E, BCE🡪D and CDE🡪B.

One choice is to decompose using the violation D🡪B. Using the above FDs, we get BDE and ABC as decomposed relations. Using Algorithm 3.12 to discover the projection of FDs on relation BDE, we discover that BDE is in BCNF since D, BD, DE are the only keys and all the projected FDs contain D, BD, or DE in the left side. Going back to relation ABC, following Algorithm 3.12 tells us that ABC is not in BCNF because since AB and AC are its only keys and the FD C🡪B follows for ABC. Using violation C🡪B to further decompose, we get BC and AC as decomposed relations. Both BC and AC are in BCNF because they are two-attribute relations. Thus the three relations of the decomposition are BDE, BC and AC.

1. (20 points) For each of the relation schemas and sets of FD’s of Question 4. Decompose the relations, as necessary, into collections of relations that are in 3NF.
   1. In the solution to 4A we found that there are 14 nontrivial dependencies. They are: C🡪A, C🡪D, D🡪A, AB🡪D, AB🡪 C, AC🡪D, BC🡪A, BC🡪D, BD🡪A, BD🡪C, CD🡪A, ABC🡪D, ABD🡪C, and BCD🡪A.

We also learned that the three keys were AB, BC, and BD. Since all the attributes on the right sides of the FDs are prime, there are no 3NF violations.

Since there are no 3NF violations, it is not necessary to decompose the relation.

* 1. In the solution to 4B we found that there are 41 nontrivial dependencies. They are: C🡪B, C🡪D, C🡪E, D🡪B, D🡪E, AB🡪C, AB🡪D, AB🡪E, AC🡪B, AC🡪D, AC🡪E, AD🡪B, AD🡪C, AD🡪E, BC🡪D, BC🡪E, BD🡪E, CD🡪B, CD🡪E, CE🡪B, CE🡪D, DE🡪B, ABC🡪D, ABC🡪E, ABD🡪C, ABD🡪E, ABE🡪C, ABE🡪D, ACD🡪B, ACD🡪E, ACE🡪B, ACE🡪D, ADE🡪B, ADE🡪C, BCD🡪E, BCE🡪D, CDE🡪B, ABCD🡪E, ABCE🡪D, ABDE🡪C and ACDE🡪B.

We also found out that the keys are AB, AC and AD. FDs where the left side is not a superkey or the attributes on the right are not part of some key are 3NF violations. The 3NF violations are C🡪E, D🡪E, BC🡪E, BD🡪E, CD🡪E and BCD🡪E.

Using algorithm 3.26, we can decompose into relations using the minimal basis AB🡪C, C🡪D, D🡪B and D🡪E. The resulting decomposed relations would be ABC, CD, BD and DE. Since relation ABC contains a key, we can stop with the decomposition. The final set of decomposed relations is ABC, CD, BD and DE.