

CS 4320/5320 Homework 3

Fall 2015

Due Friday October 23, 2015

This assignment is due Friday, 10/23/2015 at 11:59pm. It is out of 60 points and counts for 10% of your overall grade. There is both a written part and a programming part to this assignment.

As usual we assume that you are familiar with the course policies and we do not repeat information on group work, academic integrity, etc.

1 Written Part (30 Points)

1.1 Functional Dependencies (12 Points)

The following section requires you to write proofs. Remember that if a statement is bidirectional (“if and only if”), to prove it you must provide a proof in both directions.

- (a) (4 Points) Let \mathcal{R} be a relation and let U be the set of all attributes of \mathcal{R} , with X a subset of U . Show that if $\pi_X(\mathcal{R})$ has the same number of tuples as \mathcal{R} , then \mathcal{R} satisfies $X \rightarrow Y$ for any subset Y of U .
- (b) (4 Points) Two sets of functional dependencies F and G are equivalent, written $F \equiv G$, if $(F)^+ = (G)^+$. Furthermore, we say that F is redundant if there exists a proper subset $F' \subset F$ such that $F' \equiv F$. Show that F is redundant if and only if F contains a functional dependency $X \rightarrow Y$ such that $F - \{X \rightarrow Y\} \models X \rightarrow Y$.
- (c) (4 Points) Prove or provide a counterexample: Let R be a table with only one key, it is in BCNF if and only if it is in 3NF. Remember to consider both directions, providing either a proof or a counterexample for each one.

1.2 ER Diagram (10 Points)

You are tasked with building a management system for future space missions. Draw an ER diagram for the following design.

A mission is uniquely identified by its *mission name* and contains another attribute, *status*. A mission can either be a voyage that explores an area in the universe or it can be a maintenance job that services a particular piece of equipment. Voyages record the *destination* of the journey, and maintenance trips record the *equipment name* of the object to be worked on.

An assignment is tracked by the astronauts, shuttle, and mission associated with it. To allow everyone a chance to explore the universe, astronauts can only participate in a single mission in their lifetime. An astronaut is uniquely identified by *astronautid* and contains the other attributes *name*, *age*, and *gender*. One astronaut per mission supervises all the other astronauts for this mission.

A shuttle is uniquely identified by *shuttleid* and contains other attributes *model*, *totalmiles*, and *topspeed*. To ensure that all spacecraft are used, it is required that every shuttle is assigned to at least one mission.

1.3 Normal Forms (8 Points)

Consider a relation R with attributes ABCDEFG and the following functional dependencies:

- $D \rightarrow BC$
- $AF \rightarrow E$
- $B \rightarrow AC$

- (2 points) Give one advantage and disadvantage of decomposing your tables vs keeping a single table with all your information.
- (3 points) Find all keys of R without checking all the subsets of attributes and explain how you arrived at your answer.
- (3 points) Give a decomposition of R into BCNF and show your work.

2 Implementation Part (30 Points)

In this section, you will implement an algorithm to perform BCNF decomposition. Please look at this outline of the algorithm to decompose a given relation:

- Pick a subset set of attributes X from the relation.
- Find X^+ , which is the closure of that set of attributes with respect to the provided set of functional dependencies.
Hint: *Make sure to consider the case where the set of functional dependencies includes attributes not in the relation.*
- If X is a key or determines only itself, try a different set of attributes.

- If all attribute sets have been tried, we are done.
- Otherwise, separate the table into two tables, X^+ and $X \cup (X^+)^c$, and recurse on each side.

Note the algorithm to compute a closure is Algorithm 4.4 here:

<http://web.cecs.pdx.edu/~maier/TheoryBook/MAIER/C04.pdf>

For your convenience, we will provide you with the following skeleton code:

- **BCNF.java**: Main class to implement.
- **FunctionalDependency.java**: A class representing functional dependencies.
- **BCNFTest.java**: A JUnit test class containing one test example. Please add more test cases, although we will not grade them.
- **Attribute.java**: A class representing a database attribute.
- **AttributeSet.java**: A class representing a set of attributes. This is for the representation of functional dependencies, nothing else.

Submission Instructions

Submit two files:

- A .pdf file containing all of your written answers. As usual, these must be typed, scans of handwritten answers are not accepted.
- A .zip file containing all of your .java files, and a README file which includes your name, netids of everyone in your group, and any comments about the code which might be relevant to the graders.

Ensure all files contain the netID of everyone in your group and clearly state which answer corresponds to which question. Also be sure to include an **acknowledgements.txt** should you consult any external sources for this homework assignment.