Information and Database Management Systems I (CIS 4301)
(Spring 2017)
Instructor: Dr. Markus Schneider
TA: Yang Peng

Homework 4

Name: _____________________________________________
UFID: ____________
Email Address: ___________________________________

Pledge (Must be signed according to UF Honor Code)
On my honor, I have neither given nor received unauthorized aid in doing this assignment.

__________________________________________________________________________
Signature

For scoring use only:

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Exercise 1 (Knowledge Questions) [25 points]

1. Explain functional dependencies, 1NF, 2NF and 3NF [5 points]
2. Give a set of FDs for the relation schema R(A,B,C,D) with primary key AC under which R is in 1NF but not in 2NF. [5 points]
3. Give a set of FDs for the relation schema R(A,B,C,D) with primary key BC under which R is in 2NF but not in 3NF. [5 points]
4. A decomposition of a relation into n relations should fulfill the requirements of lossless join decomposition and dependency preservation. Describe the meaning of these two concepts. [5 points]
5. Usually, a decomposition of a database schema in Boyce-Codd normal form (BCNF) relation schemas is regarded as the ultimate decomposition in order to eliminate redundancy and potential update anomalies. Why is the third normal form (3NF) still of interest? [5 points]

Exercise 2 (Functional Dependencies I) [20 points]

Consider the following set S of functional dependencies:

\[
\begin{align*}
A & \rightarrow B \\
AB & \rightarrow C \\
AC & \rightarrow B \\
B & \rightarrow C
\end{align*}
\]

1. Given (1) and (4), prove (2) using Armstrong axioms or closure test. [5 points]
2. Given (1) and (4), prove (3) using Armstrong axioms or closure test. [5 points]
3. Give all candidate keys of relation R(ABC) that satisfies (1-4). Explain your answer. [5 points]
4. Give a minimal cover for the set S. [5 points]

Exercise 3 (Functional Dependencies II) [20 points]

For the following exercises, suppose you are given the functional dependencies set \( S = \{ \text{AB} \rightarrow \text{C}; \text{C} \rightarrow \text{B}; \text{C} \rightarrow \text{D} \} \).

1. Given S, is the relation R1(A, B, C) in 3NF? If yes, justify. If no, specify at least one FD which violates the definition. [6 points]
2. Given S, which normal form(s) (BCNF, 3NF) does relation R2(C, D) obey? [6 points]
3. Decompose the relation R(A, B, C, D) into a collection of BCNF relations. Of course make sure that the decomposition is lossless. Specifically:
   i. How many different decompositions exist? [2 points]
   ii. List all such decompositions. [6 points]
Exercise 4 (Decomposition) [35 points]

Let R(A, B, C, D, E) be decomposed into relations with the following three sets of attributes: {A, B, C}, {B, C, D}, and {A, C, E}. Consider the following sets of functional dependencies:

(a) $B \rightarrow E$ and $CE \rightarrow A$.
(b) $AC \rightarrow E$ and $BC \rightarrow D$.
(c) $A \rightarrow D$, $D \rightarrow E$, and $B \rightarrow D$.
(d) $A \rightarrow D$, $CD \rightarrow E$, and $E \rightarrow D$.
(e) $A \rightarrow B$, $BC \rightarrow D$, and $E \rightarrow B$.

1. For each set of FDs, use the chase test to tell whether the decomposition of R is lossless. For those that are not lossless, give an example of an instance of R that returns more than R when projected onto the decomposed relations and rejoined. [4 points each]

2. For each set of the FDs, are dependencies preserved by the decomposition? Explain why. [3 points each]