Introduction to Databases (summer term 2007)

Assignment 7

hand in on June 11, 2007 during the tutorial

Please hand in your solutions in groups of up to 3 students.
Do not forget to write down your name and matriculation number on the solutions you hand in. Please also add your study course (e.g. Dipl.-Inf., Master SSE, ...). 

Task 7.1 (Normal Forms) (2 Points)
Let \( R = (U, F) \) be a relational schema. Prove the following propositions:

a) \( R \) is in 3NF \( \Rightarrow \) \( R \) is in 2NF.

b) \( R \) is in 2NF \( \not\Rightarrow \) \( R \) is in 3NF.

c) \( R \) is in BCNF \( \Rightarrow \) \( R \) is in 3NF.

d) \( R \) is in 3NF \( \not\Rightarrow \) \( R \) is in BCNF.

Task 7.2 (Normal Forms and Decomposition) (5 Points)
Consider the following relation schema:
\( R = (U, F) = \{(A, B, C, D, E, G), \{A \rightarrow BC, BE \rightarrow G, G \rightarrow CD, AD \rightarrow BG, AE \rightarrow G\}\} \).

1. Is there a redundant functional dependency in \( F \)? Prove your answer.

2. Find all candidate keys of \( R \) and prove that they are candidate keys.

3. In which normal form is \( R \)? Why?

4. Apply the decomposition algorithm to derive a schema in BCNF. Does your decomposition have the dependency preservation property\(^1\)? Why (not)?

Task 7.3 (Projection of FD sets) (3 Points)
In the decomposition algorithm as presented in the lecture the projection operator on functional dependency sets is used to calculate the FD sets for the resulting two relation schemes. 
This projection of an FD set \( F \) on the attribute set \( X \) is formally defined as follows:
\[
\pi_X(F) := \{ f \in F | \text{attr}(f) \subseteq X \},
\]
where \( \text{attr}(f) \) is the set of attributes occurring in the left and right hand side of \( f \).

a) Let \( F := \{AB \rightarrow CD, B \rightarrow F, AG \rightarrow B, BC \rightarrow A\} \). Calculate \( \pi_{ABC}(F) \).

b) Consider \( F \) as defined above and calculate a FD set, that is equivalent to \( \pi_{ABC}(F^+) \).\(^2\)

c) Let \( F := \{AB \rightarrow D, D \rightarrow EF, BF \rightarrow CD, F \rightarrow A\} \). Calculate an FD set that is equivalent to \( \pi_{ABC}(F^+) \).

\(^1\)i.e. is it an independent decomposition

\(^2\)Note that this is actually the operation used in the decomposition algorithm, although it is not explicitly mentioned there that the calculation of an equivalent FD set to \( \pi_{X,i}(F^+) \) is sufficient.