CS4221: Database Design -- Assignment #2

Due on 5 March 2015 (Thursday)

The solutions must be hand written, no computer printout, and no photocopy.

1. Let R = (*A, B, C, D, E*) and let *M* be the following set of MVDs:

$$A \twoheadrightarrow BC$$
$$B \twoheadrightarrow CD$$
$$E \twoheadrightarrow AD$$

List all the nontrivial multi-valued dependencies with LHS equal to A in M^+.

2. Let *R* = (*A, B, C, D, E*) be a relation which consists of the following FDs and MVDs:

$$A \rightarrow BC$$
$$B \rightarrow D$$
$$CD \rightarrow E$$
$$E \twoheadrightarrow A$$

a) Find the closure of {*C, D*}.

b) Prove or disprove that the following set of projections of *R*

$$R_1(A, B, C)$$
$$R_2(B, D)$$
$$R_3(C, D, E)$$

is a non-loss decomposition of R.

3. Let BOOK be a relation which consists of the following attributes:

Call#, Title, Author, Date, Publisher, Keyword

A tuple <c#, t, a, d, p, k> in the relation BOOK means the book with call number c# and title t is written by author *a* and published by publisher *p* on date *d* and has key word k. Note that each book has unique Call#, a title, and is published once by only one publisher on a date. A book may be written by more than one author and an author may write several books. A book also has several keywords.

Find all the essential FDs and MVDs in the relation BOOK. Find a non-loss decomposition on of the relation BOOK into a set of 4NF relations. Is the decomposition dependency preserving?

4. Let $\mathcal{F}$ be a set of dependencies which consists of the following FDs and MVDs:

$$
\begin{aligned}
A &\rightarrow BC \\
B &\rightarrow AC \\
E &\rightarrow G \\
AE &\rightarrow H \\
BE &\rightarrow J \\
B &\twoheadrightarrow CD
\end{aligned}
$$

Design a relational database schema for $\mathcal{F}$ using Bernstein's Algorithm with some extensions such that

a) If a relation generated has more than one key, choose one of them as its primary key. Only primary keys can be used as foreign keys.
b) All the relations are in 4NF.
c) The set of relations satisfies the reconstructibility criterion.
d) There is no local or global redundant attribute in the set of relations.

5. Consider a relation R (A, B, C, D, E). For each of the following instances of R, state whether (i) it violates the FD BC $\rightarrow$ D, and (ii) it violates the MVD BC $\twoheadrightarrow$ D.

a) {} (i.e. empty relation)
b) {(a,2,3,4,5), (2,a,3,5,5)} (Your answer may depend on the value of a which is an unknown integer)
c) {(a,2,3,4,5), (2,a,3,5,5), (a,2,3,4,6)}

6. Suppose we have a relation Person which stores person information together with their children and automobiles owned. For each person, we want to record their Social Security number (*SSN*), name (*name*), sex (sex), and birthdate. Also, for each child of the person, the name (*cName*), Social Security number (*cSSN*), sex (cSex) and birthdate of the child (*cBirthdate*); and for each automobile the person owns its license plate number (*plateNo*), car make (*make*), and car model (model). Note that no two car manufacturers produce automobiles with the same model name.

   Person (SSN, name, sex, birthdate, cName, cSSN, cSex, cBirthdate, plateNo, make, model)

   a) Show all the non-trivial functional and multivalued dependencies we would expect to hold in the relation Person.
   b) Suggest a lossless decomposition of the relation into 4NF. Is your decomposition dependency preserving?

7. Consider a relation R(A,B,C,D,E,F) with the following multivalued dependencies $A \twoheadrightarrow B$, $B \twoheadrightarrow EF$, $CD \twoheadrightarrow E$, and no functional dependencies. Decompose R to 4NF in steps. Show your result after each step.

8. Prove the Decomposition Theorem, i.e. $X \twoheadrightarrow Y$ in $R(X, Y, Z)$ if and only if R is the natural join of its projections $R_1(X, Y)$ and $R_2(X, Z)$.

9. Prove that a 4NF relation is also in BCNF using the definitions given in the lecture notes.