CS4221 - Database Design

Assignment #1 – Relational Database Schema Design

Due on **16 February 2015** (**Monday**)

Question answers must be hand written, no computer printout, and no photocopy.

Please submit your written assignment answers to Prof Ling Tok Wang's office COM2-03-01 by 16 Feb 2015 (Monday). Penalty will be imposed on late submissions.

1. Consider a relation R(A,B,C,D,E) with FDs

$$\mathcal{F} = \{AB \rightarrow C,\ CD \rightarrow E,\ C \rightarrow A,\ C \rightarrow D,\ D \rightarrow B\}.$$

   (a) Determine all the keys of R. Justify your answer.
   (b) Is the relation in 3NF? Justify your answer. If not, decompose it to 3NF. Is your decomposition dependency preserving?
   (c) Is the resulting relation set in BCNF? Justify your answer. If not, decompose it to BCNF. Is your decomposition dependency preserving?

2. Let R = { R1 (a, b, c, d, e, f, g, h), R2 (b, c, e), R3 (c, d)} be a schema with the following set of FDs:

ab→f	ae→h	e→b
ac→g	b→c	c→d
ad→b	b→e	

   (a) Find all the keys of relation R1.
   (b) Find all the non-prime attributes in relation R1 that are transitively dependent on some keys of relation R1.
   (c) Are all the 3 relations in 3NF?
   (d) Are there redundancies among the 3 relations?

3. Consider a relation R (A,B,C,D,E,F,G,H) with the following FDs:

$$\mathcal{F} = \{A \rightarrow E,\ BE \rightarrow D,\ AD \rightarrow BE,\ BDH \rightarrow E,\ AC \rightarrow E,\ F \rightarrow A,\ E \rightarrow B,\ D \rightarrow H,\ BG \rightarrow F,\ CD \rightarrow A.\}$$

   Design a relational schema for R using Bernstein's Method. Show the result of each step. Are all the relations constructed in BCNF?

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

b1, b2 → a	d1, d2 → b1, b2
b1 → c1	b2 → c2
d1 → a	d2 → a
a, b1, c2 → d2	a, b2, c1 → d1
g, b1 → c1	

   (a) Find the closure of {b1, b2}.
   (b) Design a relational schema for the given set of FDs using Bernstein's Method. Show the result of each step. Are the set of relations constructed a lossless decomposition of the given universal relation (i.e. the relation which consists of all the mentioned attributes)? If not, how do you resolve it?
   (c) Are all the relations constructed in BCNF? Justify your answers.

5. Design a relational schema using Bernstein's method for the below set of FDs:

   $\mathcal{F}$ = {ad→b, b→cd, c→dg, ab→eh, ac→f }

   Are all the relations generated in BCNF? Are there redundancies among the relations generated?

6. Consider the following relational schema and set of functional dependencies:

   R (A,B,C,D,E,F,G,H)

   with FD set $\mathcal{F}$ ={A → BG, C → D, EF → CH}.

   Decompose R into BCNF. Show your intermediate results step by step. Is your decomposition dependency preserving?

   Is the set of relations obtained the same as the set of relations generated by Bernstein's Algorithm? If not, why?

7. Prove the following statement:

   A relation R is in 3NF if each nonprime attribute is not transitively dependent on an **arbitrarily chosen** key of R.

8. Prove or disprove the following statements using the three inference rules in the lecture notes: Projectivity, Transitivity, and Union.

   (a) If $\{X \rightarrow Y, XY \rightarrow Z\}$, then $\{X \rightarrow Z\}$.
   (b) If $\{XY \rightarrow Z, Z \rightarrow X\}$, then $\{Z \rightarrow Y\}$.
   (c) If $\{XY \rightarrow Z, Z \rightarrow W\}$, then $\{X \rightarrow W\}$.

9. Suppose you are given a relation R with four attributes A, B, C, and D. For each of the following sets of FDs, assuming those are the only dependencies that hold for R, do the following: (i) Identify the candidate key(s) for R. (ii) Identify the best normal form that R satisfies. (iii) If R is not in BCNF, decompose it into a set of BCNF relations that preserve the dependencies.

   (a) $B \rightarrow C,\ D \rightarrow A$
   (b) $AB \rightarrow C,\ AB \rightarrow D,\ C \rightarrow A,\ D \rightarrow B$