CISC637 Spring 2015, Homework 3

Due Monday, 3/23, at 11:55pm on Sakai. If you would like some feedback before the exam, turn it in by Friday 3/20!

Assignment - each question is worth 10 points for a total of 80.

Functional Dependencies

1. Suppose we have a relation schema $R(a, b, c)$. Suppose we have a relation instance containing the following four records:

a	b	c
1	2	2
1	3	2
1	4	2
2	5	2

   For each of the following functional dependencies, state whether or not the dependency is satisfied by this relation instance.

   (a) $a \to b$
   (b) $a \to c$
   (c) $b \to a$
   (d) $b \to c$
   (e) $c \to a$
   (f) $c \to b$
   (g) $ab \to c$
   (h) $ac \to b$
   (i) $bc \to a$

2. Consider a relation $R(a, b, c, d, e)$ with the following functional dependencies:

   $$\begin{aligned} a &\to b \\ cd &\to e \\ e &\to a \\ b &\to d \end{aligned}$$

   List all candidate keys for R.

3. Consider a relation $R(a, b, c, d, e, f, g, h)$ with the following functional dependencies:

   $$\begin{aligned} a &\to bcd \\ ad &\to e \\ efg &\to h \\ f &\to gh \end{aligned}$$

   Find the only possible candidate key for R. One FD can be removed without changing the key; which one is redundant?

4. Consider a relation $R(a, b, c, d, e, f)$ with the following functional dependencies:

$$a \to c$$
$$de \to f$$
$$b \to d$$

Find the only possible candidate key for R.

Then suppose a new functional dependency $a \to b$ is added to the set above. If we want a to be a candidate key, what one new FD would we need to add?

Normal Forms

5. Suppose we have a relation $R(a, b, c)$ and an instance of R with the following four records:

a	b	c
1	2	3
1	2	4
5	2	3
5	2	6

(a) List all nontrivial functional dependencies that are satisfied on this instance of R.

(b) Is this instance of R in Boyce-Codd Normal Form (BCNF) with respect to those FDs you listed for part (a)? If not, state which FDs violate BCNF and provide a valid decomposition of R into BCNF relations.

6. Suppose we have a relation $R(a, b, c, d, e)$ with four functional dependencies:

$$ab \to c$$
$$bc \to d$$
$$cd \to e$$
$$de \to a$$

(a) Find all candidate keys for R.

(b) Which of the FDs given above violate BCNF?

(c) Write two different decompositions of R into BCNF relations based on the FDs above.

7. What if, in our university database, we consolidated the *takes*, *teaches*, and *section* relations into the following relation:

takesSecTaughtBy(s_ID, course_id, sec_id, semester, year, building, room_no, time_slot_id, grade, i_ID)

Each row in *takesSecTaughtBy* records the fact that the student with ID *s_ID* took section *course_id, sec_id, semester, year* (which was scheduled in exactly one *building,room_no* at exactly one *time_slot_id*) from the instructor with ID *i_ID* and earned at most one *grade*. Students can take many sections, and sections have many students enrolled. Instructors can teach many different sections. A section can only be taught by one instructor.

(a) List the nontrivial functional dependencies that need to hold on *takesSecTaughtBy* to capture the assumptions above.

(b) Based on those functional dependencies, find all candidate keys for *takesSecTaughtBy*.

(c) Is *takesSecTaughtBy* in BCNF based on your answers to (a) and (b)? If not, give a decomposition of the relation into BCNF relations.

(d) Why might it be a problem if *takesSecTaughtBy* is not in BCNF? Give examples of possible update anomalies, delete anomalies, and insert anomalies that could occur.

(e) Suppose we have the following additional requirements related to courses (NB: to courses, not to sections):

- No student takes two different courses from the same instructor.
- No course is taught by more than one instructor.

How would your FDs in part (a) change to take these new requirements into account?

(f) Based on the new requirements and modified FDs, find all candidate keys for *takesSecTaughtBy*.

(g) Is *takesSecTaughtBy* in BCNF based on your answer to (e) and (f)? If not, give a decomposition of the relation into BCNF relations.

8. For each relation and set of FDs given below, state whether the relation is in BCNF, 3NF, or neither. If not in either, decompose the relation into two or more 3NF relations.

(a) Relation $R(a, b, c)$; functional dependencies $a \to b, b \to c$.

(b) Relation $R(a, b, c, d)$; functional dependencies $ab \to c, c \to d, d \to a$.

(c) Relation $R(a, b, c, d)$; functional dependencies $b \to c, b \to d$.

(d) Relation $R(a, b, c, d)$; functional dependencies $ab \to c, bc \to d, cd \to a, ad \to b$.