Assignment 6: Schema Refinement

Due: 3/27 3/29, 1:30 pm, in class – hard copy

Reminders

- Weight: 5% of the homework grade.
- The points of this homework add up to 100.
- Lead TA: Bin Fu (binf@andrew.cmu.edu).
- Please type all your answers.
- Rough time-estimates: 2~4 hours.
- The textbook referred to in the homework is Database Management Systems by Ramakrishnan and Gehrke, 3rd edition.
**Question 1: Functional dependency examples [6 points]**

Consider the relation shown in the following table:

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>x₁</td>
<td>y₁</td>
<td>z₁</td>
</tr>
<tr>
<td>x₂</td>
<td>y₁</td>
<td>z₂</td>
</tr>
<tr>
<td>x₁</td>
<td>y₂</td>
<td>z₂</td>
</tr>
<tr>
<td>x₂</td>
<td>y₁</td>
<td>z₂</td>
</tr>
</tbody>
</table>

List all the functional dependencies that this relation instances satisfy.

**Question 2: Functional dependency deductions [24 points]**

Consider the following set S of functional dependencies:

- A -> C (F1)
- BD -> A (F2)
- C -> B (F3)

For each of the following dependencies, if it can be deduced from S, give the rigorous proof; if not, give a counter-example with 3 tuples or less.

- [Q2.1] CD -> A [8 points]
- [Q2.2] BC -> A [8 points]
- [Q2.3] AD -> B [8 points]

**Question 3: Related Concepts I [20 points]**

Consider the relation schema R(A, B, C, D) with functional dependencies A->D, B->CD and AC->D.

- [Q3.1] Find the attribute closure \(\{A\}^+\). [5 points]
- [Q3.2] Find the attribute closure \(\{A, B\}^+\). [5 points]
- [Q3.3] Find the minimum cover (i.e. canonical cover) of the given functional dependencies. [5 points]
- [Q3.4] List all the candidate key(s) of R. [5 points]
Question 4: Decompositions [15 points]

Consider the relation schema R(A, B, C, D, E, G) with functional dependencies F = {AB->C, AG->E, B->D, E->G}. Notice F is the minimum cover of itself.

For each of the following decompositions R(A, B, C, D, E, G), determine whether it is (a) dependency-preserving, and (b) lossless.

i)   {ABC, CDE, EG} [5 points]
ii)  {ABCD, AEG} [5 points]
iii) {ABCE, BD, AEG} [5 points]

Question 5: BCNF and 3NF [35 points]

Consider the relation schema R(A, B, C, D) with functional dependencies A->B, BC->A and B->D, which is the minimum cover itself.

[Q5.1] Find all the candidate key(s) of R. [5 points]

[Q5.2] Is relation R in BCNF? Is it in 3NF? Justify your answers. [10 points]

[Q5.3] Decompose the relation R(A, B, C, D) into a collection of BCNF relations, so that the decomposition is lossless. Please follow the instructions on section 19.6.1 of the textbook (R+G, 3rd edition, p622). Is the decomposition dependency-preserving? [10 points]

[Q5.4] Decompose the relation R(A, B, C, D) into a collection of 3NF relations, so that the decomposition is both lossless and dependency-preserving. Please follow the instructions on page 627 of the textbook. [10 points]