COM S 461: ASSIGNMENT II

Date Assigned: September 24, 2004
Due: October 8, 2004 by 2:00 pm
Percentage in your final grade: 6%
Maximum score for this assignment: 60 points

Objectives:

1. To test your understanding of functional dependencies and normalization.

Questions

1. (20 points): Suppose that we have the following three tuples in a legal instance of a relation schema S with three attributes ABC (listed in order): (1,2,3), (4,2,3), and (5,3,3).
   - Which of the following dependencies can you infer does not hold over schema S?
     - $A \rightarrow B$, $BC \rightarrow A$, $B \rightarrow C$
   - Can you identify any dependencies that hold over S?

   Answers:
   - $BC \rightarrow A$ due to tuples (1,2,3) and (4,2,3)
   - No.

2. (20 points): Consider the attribute set $R=ABCDEG$ with the set of dependencies $F = \{AB \rightarrow C, AC \rightarrow B, AD \rightarrow E, B \rightarrow D, BC \rightarrow A, E \rightarrow G\}$.
   - Is $D_1 = \{ABC, ACDE, ADG\}$ a lossless join decomposition?
   - Is $D_1$ a dependency-preserving decomposition?
   - What is the strongest normal form of ABC and why?

   Answers:
   Let $R_1 = ABC$, $R_2 = ACDE$, and $R_3 = ADG$.
   (a) $D_1$ is a lossless join decomposition. The common attributes of $R_1$ and $R_2$ is AC, and AC is a key of $R_1$. The common attributes of $R_2$ and $R_3$ is AD, and AD is a key of $R_3$.
   (b) $D_1$ is not a dependency-preserving decomposition.
   It is obvious that $AB \rightarrow C$, $AC \rightarrow B$, and $BC \rightarrow A$ are preserved in $R_1$. $AD \rightarrow E$ is preserved in $R_2$.
   We need to check whether $B \rightarrow D$ and $E \rightarrow G$ are preserved or not.
   - Compute attribute closure sets of every left-hand side of each functional dependency (FD) in $F$.
     - $\{AB\}^+$ (with respect to $F$) = $\{A, B, C, D, E, G\}$
     - $\{AC\}^+$ (with respect to $F$) = $\{A, C, B, D, E, G\}$
     - $\{AD\}^+$ (with respect to $F$) = $\{A, D, E, G\}$
     - $\{B\}^+$ (with respect to $F$) = $\{B, D\}$
     - $\{BC\}^+$ (with respect to $F$) = $\{B, C, A, D, E, G\}$
     - $\{E\}^+$ (with respect to $F$) = $\{E, G\}$
   - Based on these attribute closure sets, important FDs in the projection of each relation of the decomposition $D_1$ are known.
     - $F_{R_1} = \{X \rightarrow Y | X \cup Y \subseteq R_1\}$.
     - $\{AB \rightarrow C, AC \rightarrow B, BC \rightarrow A\} \subset F_{R_1}$.
     - $F_{R_2} = \{X \rightarrow Y | X \cup Y \subseteq R_2\}$.
3. (20 points): Consider the universal relation $R = \{A, B, C, D, E, F, G, H, I, J\}$ and the set of functional dependencies $F = \{AB \rightarrow C, A \rightarrow DE, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$.

Given the following decomposition.

$D_2 = \{R_1, R_2, R_3, R_4, R_5\}$

$R_1 = \{A, B, C, D\}$

$R_2 = \{D, E\}$

$R_3 = \{B, F\}$

$R_4 = \{F, G, H\}$

$R_5 = \{D, I, J\}$

- Is $D_2$ a dependency-preserving decomposition? Why?
- Is $D_2$ a lossless-join decomposition? Explain your answer using the matrix algorithm discussed in the class (i.e., the slide titled "Testing for the lossless join property").

Answers:

(a) $D_2$ is not a dependency-preserving decomposition.

$AB \rightarrow C$ and $A \rightarrow D$ are preserved in $R_1$. $B \rightarrow F$ is preserved in $R_3$. $F \rightarrow GH$ is preserved in $R_4$. $D \rightarrow IJ$ is preserved in $R_5$. $A \rightarrow E$ is not preserved in any of the relations in the decomposition.

(b) $D_2$ is not a lossless-join decomposition.

**Step 3:**

$$
\begin{array}{cccccccccc}
 & A & B & C & D & E & F & G & H & I & J \\
R_1 & a_0 & a_1 & a_2 & a_3 & b_{04} & b_{05} & b_{06} & b_{07} & b_{08} & b_{09} \\
R_2 & b_{10} & b_{11} & b_{12} & a_3 & b_{15} & b_{16} & b_{17} & b_{18} & b_{19} \\
R_3 & b_{20} & a_1 & b_{22} & b_{23} & b_{24} & a_5 & b_{26} & b_{27} & b_{28} & b_{29} \\
R_4 & b_{30} & b_{31} & b_{32} & b_{33} & b_{34} & a_5 & a_6 & a_7 & b_{38} & b_{39} \\
R_5 & b_{40} & b_{41} & b_{42} & a_3 & b_{44} & b_{45} & b_{46} & b_{47} & a_{8} & a_{9} \\
\end{array}
$$

**Step 4:** Consider each FD in $F$.

- For $AB \rightarrow C$, nothing to be done to the matrix.
- For $A \rightarrow DE$, nothing to be done to the matrix.
- For $B \rightarrow F$, change $b_{05}$ to $a_5$ since $a_1$ of $R_1$ matches $a_1$ of $R_3$.
- For $F \rightarrow GH$, change $b_{26}$ to $a_6$, $b_{27}$ to $a_7$ and $b_{06}$ to $a_6$ and $b_{07}$ to $a_7$ since $R_1, R_3, R_4$ have the same $a_5$.
- For $D \rightarrow IJ$, change $b_{08}$ to $a_8$, $b_{09}$ to $a_9$ and $b_{18}$ to $a_8$ and $b_{19}$ to $a_9$ since $R_1, R_2, R_5$ have the same $a_3$.

The final matrix is

$$
\begin{array}{cccccccccc}
 & A & B & C & D & E & F & G & H & I & J \\
R_1 & a_0 & a_1 & a_2 & a_3 & b_{04} & b_{05} & a_5 & a_6 & a_7 & a_9 \\
R_2 & b_{10} & b_{11} & b_{12} & a_3 & b_{15} & b_{16} & b_{17} & a_8 & a_9 \\
R_3 & b_{20} & a_1 & b_{22} & b_{23} & b_{24} & a_5 & a_6 & a_7 & b_{28} & b_{29} \\
R_4 & b_{30} & b_{31} & b_{32} & b_{33} & b_{34} & a_5 & a_6 & a_7 & b_{38} & b_{39} \\
R_5 & b_{40} & b_{41} & b_{42} & a_3 & b_{44} & b_{45} & b_{46} & b_{47} & a_{8} & a_{9} \\
\end{array}
$$
Step 5: Since no rows contain all “a”s, the decomposition is not a lossless-join decomposition.

Submission Requirements:
Put your answers in a Word document. Submit your word document using the turnin script with “hw2” as the last argument for the script.