Assignment 6

Over the last weekend the interface between the web front end and the Oracle test database was not working properly. Since we promised the availability of the database system we decided to extend the date for the hand in of assignment 5 to December 2. If you want, you can also replace the solution you already handed in by a more recent version.

Task 6.1 (Functional Dependencies I)

a) Given is the following relation $r$:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>a1</td>
<td>b1</td>
<td>c1</td>
<td>d1</td>
<td>e1</td>
</tr>
<tr>
<td>a2</td>
<td>b2</td>
<td>c2</td>
<td>d3</td>
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<tr>
<td>a2</td>
<td>b1</td>
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<td>a2</td>
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<tr>
<td>a3</td>
<td>b1</td>
<td>c4</td>
<td>d2</td>
<td>e1</td>
</tr>
</tbody>
</table>

Which of the following functional dependencies apply to $r$?

$A \rightarrow D, AB \rightarrow D, C \rightarrow E, E \rightarrow A, A \rightarrow E, CD \rightarrow B$

b) Consider the following two sets of functional dependencies:

$F = \{A \rightarrow C, AC \rightarrow D, E \rightarrow AD, E \rightarrow H\}$, $G = \{A \rightarrow CD, E \rightarrow AH\}$

Are they equivalent? Why?

c) Given is the following set of functional dependencies:

$F = \{AB \rightarrow E, BE \rightarrow I, E \rightarrow G, GI \rightarrow H\}$

Can the dependency $AB \rightarrow GH$ be derived from $F$? If yes, how?

Task 6.2 (Functional Dependencies II)

Let $F$ be a set of functional dependencies and $F^+$ its closure (as defined in the lecture).

Prove the following proposition:

$|F^+|$ is exponential in $|F|$, i.e. the size of $F^+$ can be exponentially big with respect to the size of $F$.

Task 6.3 (Deduction Rules)

Give for each of the following deduction rules a formal proof of its correctness or provide a counterexample if you think it does not hold.

a) $X \rightarrow Y \land YZ \rightarrow W \Rightarrow XZ \rightarrow W$

b) $XY \rightarrow Z \land Z \rightarrow X \Rightarrow Z \rightarrow Y$
**Task 6.4 (Key Attributes and Normal Forms)**

Given is a relational schema \( R = (U, F) \) with其 attribute set \( U = \{A, B, C, D, E\} \) and functional dependencies \( F = \{A \rightarrow BCD, CD \rightarrow EA, AB \rightarrow D, E \rightarrow A\} \).

a) Which attributes of \((U, F)\) are key-attributes, which are non-key-attributes? Why?

b) Compute \( \text{BASIS}(F) \), i.e. do the first step of the synthesis algorithm.

c) Consider the attribute set \( U_2 = \{A, C, D, E\} \) and the above set \( F \) of functional dependencies (restricted to the attributes of \( U_2 \)) \( F_2 \). In which normal form is \((U_2, F_2)\)? Why?

**Task 6.5 (Normal Forms and Decomposition)**

Consider the relational schema \( R = (U, F) \) with \( U = \{A, B, C, D, E, G\} \) and \( F = \{E \rightarrow D, C \rightarrow B, CE \rightarrow G, B \rightarrow A\} \).

a) Find the key attributes of \( R \) and justify your answer.

b) In which normal form is \( R \)? Why?

c) Use the decomposition algorithm to normalize \( R \).