
Question 1 (20%)
Consider the relation scheme \( R = \{A, B, C, D, E\} \), with the following functional dependencies:
\[
\begin{align*}
A &\rightarrow BC \\
CD &\rightarrow E \\
B &\rightarrow D \\
E &\rightarrow A
\end{align*}
\]
Find all candidate keys of \( R \). Note that, in general, a relation may have several candidate keys. SHOW YOUR WORK.

Question 2 (20%)
(a) Is it possible to have a relation (instance) on the scheme \( R = \{A, B, C, D\} \) that satisfies the FDs \( A \rightarrow CD \) and \( D \rightarrow B \) but violates the FD \( A \rightarrow B \)? If it is possible, then write down such a relation with the fewest number of tuples possible. If it is not possible then prove (justify, argue) why it is not possible.

(b) Is it possible to have a relation (instance) on the scheme \( R = \{A, B, C\} \) that satisfies the FDs \( A \rightarrow C \) and \( B \rightarrow C \) but violates the FD \( A \rightarrow B \)? If it is possible, then write down such a relation with the fewest number of tuples possible. If it is not possible then prove (justify, argue) why it is not possible.

Note: In the above questions, if an instance exists, then it is possible to find one with only two tuples.

Question 3 (20%)
Find a canonical (or minimal) cover for the following set of functional dependencies.
\[
\begin{align*}
AB &\rightarrow CD \\
AD &\rightarrow EFG \\
F &\rightarrow BC \\
AB &\rightarrow GH \\
H &\rightarrow E
\end{align*}
\]

Question 4 (20%)
Given \( R = \{A, B, C, D\} \), and the set of FDs \( A \rightarrow BC \), \( B \rightarrow D \). For each decomposition below determine (1) Is the decomposition lossless? (2) Is it dependency preserving? (3) Is \( R1 \) in BCNF (if not, is it in 3NF)? (4) Is \( R2 \) in BCNF (if not, is it in 3NF)?
(a) \( R1 = \{A, B, C\} \), \( R2 = \{A, D\} \).
(b) \( R1 = \{A, B, C\} \), \( R2 = \{B, D\} \).
(c) \( R1 = \{A, B, C\} \), \( R2 = \{C, D\} \).
(d) \( R1 = \{A, B, D\} \), \( R2 = \{A, C\} \).
Question 5. (20%) Consider the following relation scheme:
\[ \text{Hospital} = \{ \text{pid, pname, paddress, date-in, date-out, illness-code, balance} \} \]
We use the following abbreviations:
\[ H = \{ \text{i, n, a, di, do, c, b} \} \]
with the following FDs
\[ i \rightarrow n, a \]
\[ i, di \rightarrow do, c, b \]
\[ i, do \rightarrow di, c, b \]
(a) (10%) Find a canonical cover for the FDs. Show your work.
(b) (10%) Give a lossless and dependency preserving decomposition of Hospital into 3NF relations. Show your work.

Additional practice questions

Question 1 Consider the relation scheme
\[ \text{library} = \{ \text{branch, address, isbn, title, author, publisher, copyNo} \} \]
with the following FDs \[ \text{branch} \rightarrow \text{address, isbn} \]
\[ \text{isbn} \rightarrow \text{title, publisher} \]
(a) Find all candidate keys of library. Show your work.
(b) Give a lossless and dependency preserving decomposition of library into 3NF relations. Show your work.
(c) For each scheme in your decomposition of part (b), determine whether it is in BCNF or not. Show your work.
(d) Does any of the 3NF relation schemes in your decomposition of part (b) have the possibility of having redundancy in their data (instances)? If so, give examples that demonstrate redundancies.

Question 2 Consider the relation scheme
\[ R = \{ A, B, C, D, E, F, G, H \} \]
With the FDs
\[ A \rightarrow BC \]
\[ ABE \rightarrow CDGH \]
\[ C \rightarrow GD \]
\[ D \rightarrow G \]
\[ E \rightarrow F \]
(a) Find a canonical cover of the given set of FDs. Show your work.
(b) Find all candidate keys of R. Show your work.
(c) Give a lossless and dependency preserving decomposition of R into 3NF relations. Show your work.