CPSC 304 Midterm 1
Oct 6, 2004
Total: 20 points

Question 1 (12 points)
Consider the relation $R = (A, B, C, D)$ with the following functional dependencies:

- (FD1) $A \rightarrow B$
- (FD2) $C \rightarrow D$

a) *Determine the candidate key(s) of R.*

(1 point) There is only one candidate key: {A, C}.

b) *Pick any one of the candidate keys you specify for part a, and prove that it is indeed a candidate key. You can use Armstrong's axioms, the Union and the Decomposition rules in your proof.*

(2 points) Proof of AC being a superkey:
1. $A\ C \rightarrow B\ D$ (Union rule on FD1, FD2)
2. $A\ C \rightarrow A\ B\ C\ D$ (Augmentation on 1)

(1 point) Proof of AC being a candidate key:
C alone is not a superkey because it does not determine *A*, for instance. Conversely, *A* alone is not a superkey because it does not determine *C*.

c) *Determine the highest normal form R is in. Explain your answer. (For example, if you think that R is in 3NF, then you should explain why it is in 3NF and why it is not in BCNF.)*

YOU ARE NOT RESPONSIBLE FOR 1NF AND 2NF
(1 point) The relation is in 1NF.
(1 point) It is not in 2NF because of the partial dependencies (e.g., FD1, FD2).

d) *Decompose R , if necessary, so that all the resultant relations are in BCNF. Show that each one of your (decomposed) relations is indeed in BCNF.*

(2 points) Decompose into $S = (A, B)$ and $T = (A, C, D)$. *S* is in BCNF because the only candidate key *A* is also the only functional determinant applicable to *S*.
(2 points) Further decompose *T* into $U = (C, D)$ and $V = (A, C)$.
(2 points) *U* is in BCNF because the only candidate key *C* is also the only functional determinant applicable to *U*. *V* is in BCNF because there is no non-trivial functional dependency applicable to *V*.

Question 2 (8 points)
Consider the following relation instance:

A	B	C
John	1	Van
John	1	Rmd
Jane	2	Rmd
Jane	2	Van
Jill	4	Bby
Jill	5	Cql

a) *Observe that $B \rightarrow A$ appears to hold with respect to the given instance. Check to see if all of the following dependencies hold with respect to the instance:*
   - $A \rightarrow B$
     (1 point) No because of A = Jill.
   - $A \rightarrow C$
     (1 point) No because of A = John, for instance.
   - $B \rightarrow C$
     (1 point) No because of B = 1, for instance.
   - $C \rightarrow A$
     (1 point) No because of C = Van, for instance.
   - $C \rightarrow B$
     (1 point) No because of C = Van, for instance.

b) *Determine the minimum number of tuples that can be added to the above instance to invalidate $B \rightarrow A$. Demonstrate your answer by showing example(s) of such tuple(s).*
   (2 points) It takes two tuples to invalidate a functional dependency. Thus, the minimum number of tuples to add to the instance is 1.
   (1 point) We can add for instance the tuple <Jane, 1, Van> to the relation instance.

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