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Carnegie Mellon University
15-415 - Database Applications
Fall 2009, Faloutsos
Assignment 8: Schema Refinement

Due: 11/3, 1:30pm, in class - hard-copy please

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Reminders

- Weight: **5%** of the homework grade.
- Out of **100** points.
- Lead TA: B. Aditya Prakash

Notes:

- Rough time-estimate: 2∼4 hours (about 30-60mins per question).
- You are encouraged to **type** your answers. Illegible handwriting may get no points, at the discretion of the grader.
- Whenever you are making an assumption, please state it clearly.

Question 1 [5 points]

You are given a table R(A, B, C) with the following FDs: $AB \rightarrow C$ and $B \rightarrow C$. Can we deduce from these that $A \rightarrow C$ holds? If yes, give a short proof. If no, give a counter-example with 3 tuples or less.

Question 2 [20 points, 5 points each]

Table 1 shows an instance of relation R(A, B, C, D, E). In future, the instance *can change* by insertion, deletion, and update operations but the schema will *remain the same*.

Do the following **four** functional dependencies hold? Choose between (A) "*always holds*"; (B) "*does not hold*"; (C) "*cannot say*".

(A) If it *always holds*, give the proof
(B) If it *does not hold*, give tuple-id(s) which violate the dependency
(C) If you *cannot say*, then give a SQL query that checks whether the given FD holds. Assume that no record has `NULL` values.

Q2.1 $A \rightarrow CD$
Q2.2 $AC \rightarrow B$
Q2.3 $AB \rightarrow CD$
Q2.4 $BD \rightarrow CE$

tuple-id	A	B	C	D	E
T1	4	7	22	48	1
T2	5	6	22	49	7
T3	5	7	24	53	9
T4	3	2	10	23	8
T5	6	0	12	30	3
T6	3	2	10	23	0
T7	2	3	10	22	9
T8	5	1	12	29	1
T9	5	6	22	49	2

Table 1: Instance of R

Question 3 [40 points]

Consider the relation schema R(A, B, C, D, E, F) with functional dependencies $AC \rightarrow B$, $BD \rightarrow F$ and $F \rightarrow CE$.

Q3.1 How many candidate keys does R have? [**2 points**]

Q3.2 List all the candidate keys of R. If a candidate key is composite then use parenthesis e.g. (A, B). [**3 points**]

Q3.3 Find the attribute closure of $\{A\}^+$. [**5 points**]

Q3.4 Find the attribute closure of $\{A, C\}^+$. [**5 points**]

Q3.5 Is R in 3NF? If yes, justify. If no, specify at least one FD which violates the definition? [**5 points**]

Q3.6 Which FD(s) (if any) of R violates BCNF? [**5 points**]

Q3.7 Suppose we project R onto S(A, C, D, E). Give one non-trivial FD that holds in S. [**5 points**]

Q3.8 Out of the 6 subsets of five out of the six attributes (A, B, C, D, E, F), how many and which ones are in BCNF w.r.t. to the given FD's? [**5 points**]

Q3.9 Consider the decomposition of R into R1(A, B, C), R2(C, E, F) and R3(A, D, F). Give YES/NO answers for the following:

  (a) Is this decomposition lossless? [**2 points**]
  (b) Is this decomposition dependency preserving? [**2 points**]
  (c) Is this decomposition in BCNF (i.e. are R1, R2 and R3 all in BCNF)? [**1 point**]

Question 4 [20 points]

Consider the following set S of functional dependencies:

$$A \rightarrow B \quad (F1)$$
$$AB \rightarrow C \quad (F2)$$
$$AC \rightarrow B \quad (F3)$$
$$B \rightarrow C \quad (F4)$$

Q4.1 Given F1 and F4, prove **rigorously** that F2 holds. [**8 points**]

Q4.2 Again, given F1 and F4 prove **rigorously** that F3 holds. [**8 points**]

Q4.3 Give a minimal cover for the set S. [**4 points**]

Hint: Keep in mind the proofs above

Question 5 [15 points]

You are given the functional dependencies set $S \equiv \{AB \rightarrow C, C \rightarrow B, C \rightarrow D\}$.

Q5.1 Given S, is the relation R1(A, B, C) in 3NF? If yes, justify. If no, specify at least one FD which violates the definition? [**5 points**]

Q5.2 Given S, give the strongest normal form (BCNF, 3NF, 2NF, 1NF) obeyed by the relation R2(C, D). [**5 points**]

Q5.3 Decompose the relation R(A, B, C, D) into a collection of BCNF relations. Of course make sure that the decomposition is lossless. Specifically:

  - How many different decompositions exist? [**1 point**]
  - List all such decompositions. [**4 points**]