Fall, 2004 CIS 550

Database and Information Systems
Homework 3 Solutions

Problem 1 [15 points]: Consider a relation R with five attributes $ABCDE$. You are given the following dependencies: $A \rightarrow D$, $A \rightarrow E$, $DE \rightarrow BC$, $B \rightarrow A$, $D \rightarrow C$.

1. List all keys for R.

   A, B, DE

2. Is R in 3NF?

   No. $D \rightarrow C$ is non-trivial, but D is not a superkey, while C is not part of some key.

3. Is R in BCNF?

   No. $D \rightarrow C$ is non-trivial, but D is not a superkey.

Problem 2 [20 points]:

See Figure 1.

Problem 3 [25 points]: Consider a relation R with five attributes $ABCDXYZ$ and the FD set $F = \{AB \rightarrow X, AC \rightarrow D, Y \rightarrow C, YZ \rightarrow X, XB \rightarrow D, BD \rightarrow Z\}$. Let F^+ denote the closure set of F.

1. For each of the following attribute sets, do the following: (i) write down a minimal cover of the subset of F^+ that holds over the set; (ii) name the strongest normal form that is not violated by the relation containing these attributes; (iii) decompose it into a collection of BCNF relations if it is not already in BCNF.

   (a) ABC

   (i) $\emptyset$; (ii) BCNF, trivially; (iii) already in BCNF, trivially

   (b) $ABCD$

   (i) $\{AB \rightarrow D, AC \rightarrow D\}$; (ii) 1NF; (iii) $\{ABC, ACD\}$

2. For each of the following decompositions of $R = ABCDXYZ$, with the same set of functional dependencies F, say whether the decomposition is (i) dependency preserving, and (ii) lossless join.

   (a) $\{ABXYD, ABCYZ\}$

   (i) no; (ii) yes

(b) $\{ABX, ACD, YC, XYZ, BDX, BDZ\}$
(i) yes; (ii) no

Problem 4 [20 points]: Suppose you are given a relation $R(A, B, C, D)$. For each of the following (complete) sets of FDs, (i) identify the candidate key(s) for R, and (ii) state whether or not the proposed decomposition of R into smaller relations is a "good" decomposition and briefly explain why or why not.

1. $A \to B$, $B \to C$, $C \to D$. Decompose into AB, BC, and CD.

   (i) A; (ii) "good" because decomposition is both lossless-join and dependency-preserving

2. $C \to A$, $B \to D$. Decompose into AC and BD.

   (i) BC; (ii) "bad" because not a lossless-join decomposition

Problem 5 [15 points]: Let R be a relation on attributes $ABCD$, and let $F = \{B \to A, B \to CD\}$ be a set of FDs on R. Prove that $S = \{AB, BC, BD\}$ is a lossless join decomposition of R under F. (Hint: construct a binary tree for the decomposition, then apply Theorem 3 from Chapter 19 in the text.)

Proof. Clearly B is a key for R, since we can infer $B \to ABCD$ from the FDs given. Now consider the following derivation tree for S:

$$\frac{ABCD}{AB \quad \dfrac{BCD}{BC \quad BD}}$$

It suffices to show that the decomposition is lossless at each step. In the first step, we have the decomposition of $ABCD$ into AB and BCD. But $AB \cap BCD = B$, and B is a key for R. So by Theorem 3 from Chapter 19 in the text, the decomposition is lossless. Likewise, in the second step, since $BC \cap BD = B$, the decomposition there is lossless as well. $\square$

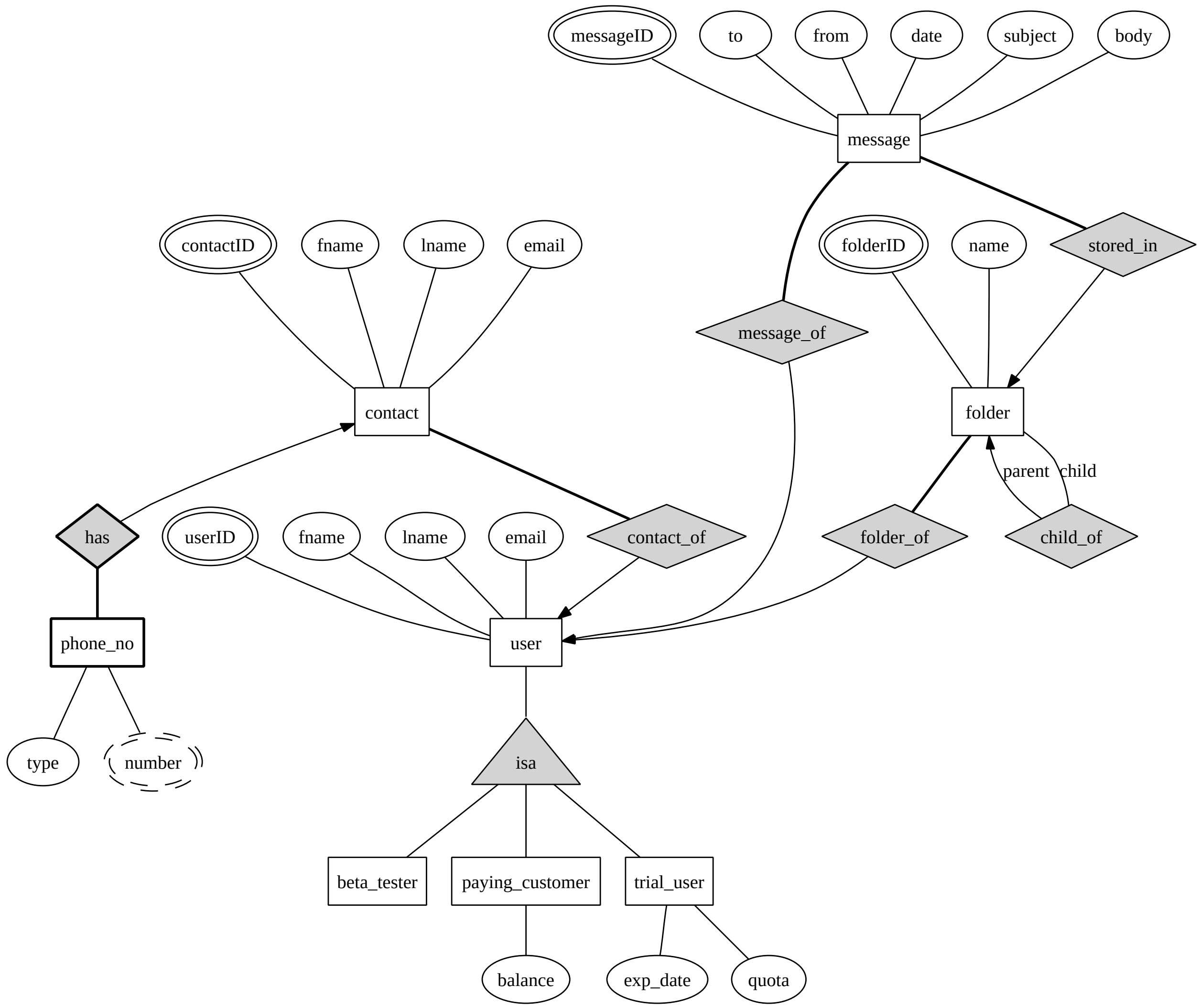

Figure 1: ER-diagram for Problem 2.

Constraints:
Trial-User `AND` Paying-Customer `COVER` User
Beta-Tester `OVERLAPS` Trial-User
Beta-Tester `OVERLAPS` Paying-Customer

Note: Keys indicated by double solid line around attribute. Partial keys indicated by double dashed line around attribute. (DOT doesn't know how to do underlining.)