Fall, 2003 CIS 550

Database and Information Systems

Homework 3 Solutions

Problem 1:

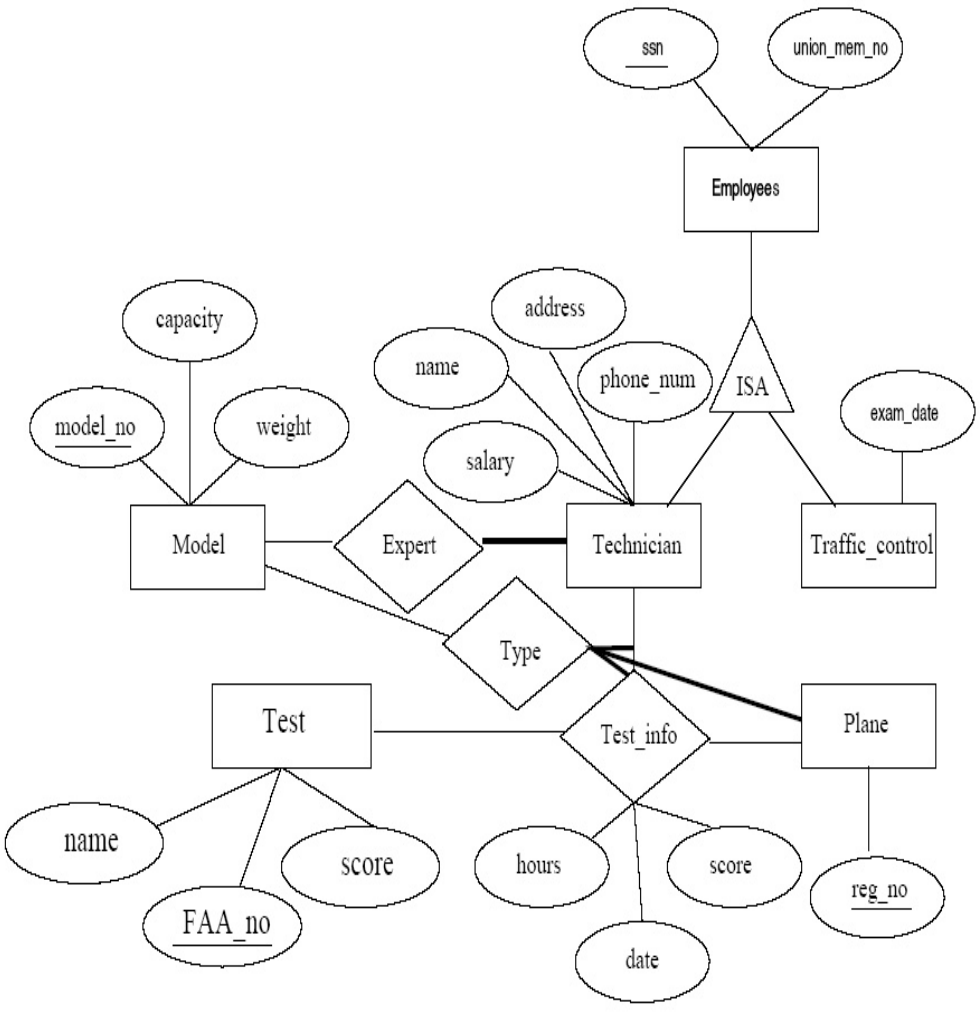

Figure 1: ER Diagram for Problem 1

1. Since all the employees belong to a union, there is a covering constraint on the Employees ISA hierarchy.

2. You cannot denote the expert technician constraint the FAA requires in an ER diagram. There is no notation for equivalence in an ER diagram, and this is what is needed here: the Expert relation must be equivalent to the Type relation.

Problem 2:

1. The keys are: CDE,ACD,BCD.

2. R is in 3NF because B,E and A are all parts of superkeys.

3. R is not in BCNF because none of A,BC and ED contain a key.

Problem 3:

1. (a) R1=ABC
    i. The FDs are $AB \rightarrow C, AC \rightarrow B, BC \rightarrow A$.
    ii. This is already a minimal cover.
    iii. This is in BCNF since AB,BC and AC are superkeys for R1.

   (b) R2=ABCD
    i. The FDs are $AB \rightarrow C, AC \rightarrow B, B \rightarrow D, BC \rightarrow A$
    ii. This is a minimal cover.
    iii. The keys for R2 are AB,AC,BC. R2 is neither in BCNF or 3NF because of the FD $B \rightarrow D$.
    iv. Decompose into ABC, BD.

   (c) R3=ABCEG
    i. The FDs are $AB \rightarrow C, BC \rightarrow A, AC \rightarrow B, E \rightarrow G$.
    ii. This is a minimal cover.
    iii. The keys are ABE, ACE, BCE. R3 is not in BCNF or 3NF.
    iv. Decompose as ABE,ABC,EG

   (d) R4=DCEGH
    i. The only FD is $E \rightarrow G$
    ii. This is a minimal cover already.
    iii. The key is DCEH. It is not in BCNF or 3NF because E is not a superkey and G is not a subset of a key.
    iv. Decompose into DCEH and EG.

   (e) R5=ACEH

i. No FDs exist.

ii. This is a minimal cover.

iii. The key is ACEH itself and it is in BCNF.

2. (a) i. The decomposition $\{AB, BC, ABDE, EG\}$ is not lossless. To prove this consider the following instance of R:
$\{(a_1, b, c_1, d_1, e_1, g_1), (a_2, b, c_2, d_2, e_2, g_2)\}$
Because of the functional dependencies $BC \rightarrow A$ and $AB \rightarrow C$, $a_1 \neq a_2$ iff $c_1 \neq c_2$. It is easy to see that the join $AB \bowtie BC$ contains 4 tuples:
$\{(a_1, b, c_1), (a_1, b, c_2), (a_2, b, c_1), (a_2, b, c_2)\}$
So the join of AB,BC,ABDE and EG will contain atleast 4 tuples. So we have a lossy decomposition here.

ii. This is not a dependency preserving decomposition since it does not preserve the FD $AB \rightarrow C$.

(b) i. The decomposition $\{ABC, ACDE, ADG\}$ is lossless. The join of ABC, ACDE and ADG can be constructed in 2 steps; first construct the join of of ABC and ACDE: this is lossless because their intersection is AC which is a key for ABCDE. Now join this intermediate join with ADG. This is also lossless because the attribute intersection is AD and $AD \rightarrow AGD$. Hence the decompostion is lossless.

ii. The projection of the FDs of R onto ABC gives us:$AB \rightarrow C, AC \rightarrow B$ and $BC \rightarrow A$. The projection of the FDs of R onto ACDE gives us:$AD \rightarrow E$ and the projection onto ADG gives us:$AD \rightarrow G$. The closure of this set of dependencies does not contain $E \rightarrow G$ nor does it contain $B \rightarrow D$. So this decompostion is not dependency preserving.

Problem 4:

1. Candidate key:BD. The decomposition is lossy and hence not a good one.

2. Candidate keys A and C. Since both A and C are keys, the relation is in BCNF. Hence from normalization point of view it does not make sense to decompose it further.

3. Candidate key:A. This is not a dependency preserving since the closure does not contain $B \rightarrow C$. Hence this is not the best decomposition.