

Homework Assignment 6 Solutions

15-415 Database Applications
Carnegie Mellon University

April 18, 2003
Due: April 25, 2003 (3pm)

1 Functional Dependencies (40 points)

1. Consider the following tables and functional dependencies.

$R(A_1, B_1, C_1, D_1)$

(a) $A_1 \rightarrow B_1 C_1 D_1$

(b) $C_1 \rightarrow A_1 B_1$

$S(A_2, B_2, C_2, D_2, E_2, F_2, G_2)$

(a) $A_2 \rightarrow B_2 C_2$

(b) $A_2 B_2 C_2 \rightarrow D_2$

$T(A_3, B_3, C_3, D_3, E_3, F_3)$

(a) $A_3 \rightarrow B_3 C_3$

(b) $A_3 C_3 \rightarrow D_3 E_3 F_3$

(c) $F_3 \rightarrow A_3 B_3$

For each of the tables R, S, and T, answer the following questions:

- (a) List all of the candidate keys. (3x3 points)

R: A, C

S: AEFG

T: A, F

- (b) Give the minimal cover of the set of functional dependencies. (3x5 points)

(Decompose so that there is only one attribute on the right side of these)

R: $A \rightarrow BCD$, $C \rightarrow A$

S: $A \rightarrow BCD$

T: $A \rightarrow BCDEF$, $F \rightarrow A$

2. Recall the following axioms:

Reflexivity: If $Y \subseteq X$, then $X \rightarrow Y$.

Augmentation: If $X \rightarrow Y$, then $XW \rightarrow YW$.

Transitivity: If $X \rightarrow Y$ and $Y \rightarrow Z$, then $X \rightarrow Z$.

Union: If $X \rightarrow Y$ and $X \rightarrow Z$, then $X \rightarrow YZ$.

Decomposition: If $X \rightarrow YZ$, then $X \rightarrow Y$ and $X \rightarrow Z$.

Pseudotransitivity: If $X \rightarrow Y$ and $WY \rightarrow Z$, then $XW \rightarrow Z$.

Set accumulation: If $X \rightarrow YZ$ and $Z \rightarrow W$, then $X \rightarrow YZW$.

From the following set of four functional dependencies, derive (a), (b), and (c). Label each step with the rule from the above axioms.

1. $A \rightarrow B$
2. $C \rightarrow B$
3. $D \rightarrow ABC$
4. $AC \rightarrow D$

(a) $D \rightarrow ABCD$ (3 points)

1. $D \rightarrow ABC$ - Given
2. $D \rightarrow D$ - Reflexivity
3. $D \rightarrow ABCD$ - Union, 1, 2

(b) $AC \rightarrow BD$ (5 points)

1. $A \rightarrow B$ - Given
2. $AC \rightarrow D$ - Given
3. $AC \rightarrow BC$ - Augmentation, 1
4. $AC \rightarrow B$ - Decomposition, 3
5. $AC \rightarrow BD$ - Union, 2, 4

(c) $AC \rightarrow ABCD$ (8 points)

1. $AC \rightarrow BD$ - Given from above
2. $AC \rightarrow AC$ - Reflexivity
3. $AC \rightarrow ABCD$ - Union, 1, 2

2 Decompositions (35 points)

1. Decompose the table S from the last question into two tables, S1 and S2, so that they are all in BCNF, with a lossless and dependency-preserving decomposition. (10 points)

Decompose to ABCD, and AEFG.

2. Consider the table $U(A_4, B_4, C_4, D_4, E_4, F_4)$, with the following functional dependencies.

- (a) $B_4C_4 \rightarrow D_4$
- (b) $D_4E_4 \rightarrow A_4F_4$
- (c) $B_4C_4 \rightarrow E_4$

Decompose U into two tables, U1 and U2, such that the decomposition is lossless and dependency preserving, and U1 and U2 are in BCNF. (10 points)

Decompose to ADEF, and BCDE

3. Suppose we have a relational schema $V(A_5, B_5, C_5)$, with the only functional dependency being $A \rightarrow B$. Suppose also that we decide to decompose this schema into $V1(A_5, B_5)$ and $V2(B_5, C_5)$. Give an example of an instance of relation V whose projection onto V1 and V2 and subsequent rejoining does not yield the same relation instance. (15 points)

Any instance that is not 1 to 1.

3 Normal Forms (25 points)

1. Consider the table $X(A,B,C)$. Give a pair of functional dependencies for X that would put it in 3NF, but not BCNF. (5 points)

$AB \rightarrow C$, and $C \rightarrow A$

2. For each of the tables R , S , T , and U above, answer the following questions.

- (a) Is the table in 3NF? (4x3 points)

R : Yes

S : No

T : Yes

U : No

- (b) Is the table in BCNF? (4x2 points)

R : Yes

S : No

T : Yes

U : No