

## Homework 4 參考答案

Due date: 6/17 before final exam.

1. Consider a relation schema  $R$  with attributes  $ABCDEF\ GH$  with functional dependencies  $F$ :

$$F = \{B \rightarrow CD, BF \rightarrow H, C \rightarrow AG, CEH \rightarrow F, CH \rightarrow B\}$$

- 1) Which of these functional dependencies violate BCNF?

$$\text{Ans: } \{B \rightarrow CD, BF \rightarrow H, C \rightarrow AG, CH \rightarrow B\}$$

$$B^+ = BCDAG, BF^+ = BFHCDAG, C^+ = CAG, CEH^+ = CEHAGFBD, CH^+ = CHAGBD$$

只有  $CEH$  是  $R$  的 superkey

- 2) Employ the BCNF decomposition algorithm to obtain a lossless decomposition of  $R$  into a collection of relations that are in BCNF. Make sure it is clear which relations are in the final decomposition and project the dependencies onto each relation in that final decomposition.

根據  $B \rightarrow CD$  將  $R$  拆解成  $R_1(B, C, D), R_2(A, B, E, F, G, H)$

$$F_1 = \{B \rightarrow CD\}, F_2 = \{B \rightarrow AG, BF \rightarrow H\}$$

$B \rightarrow AG$  讓  $R_2$  違反 BCNF, 將  $R_2$  拆解成  $R_3(A, B, G), R_4(B, E, F, H)$

$$F_3 = \{B \rightarrow AG\}, F_4 = \{BF \rightarrow H\}$$

$BF \rightarrow H$  讓  $R_4$  違反 BCNF, 將  $R_4$  拆解成  $R_5(B, F, H), R_6(B, E, F)$

$$F_5 = \{BF \rightarrow H\}, F_6 = \{\}$$

最後拆解結果為

$$(B, C, D), (A, B, G), (B, F, H), (B, E, F)$$

- 3) Is your decomposition dependency-preserving?

不是

$$F = \{B \rightarrow CD, BF \rightarrow H, C \rightarrow AG, CEH \rightarrow F, CH \rightarrow B\}$$

$$F' = \{B \rightarrow CD\} \cup \{B \rightarrow AG\} \cup \{BF \rightarrow H\}$$

$$F^+ \neq F'^+$$

2. Consider a relation R with attributes ABCDEFGH and functional dependencies S:

$$F = \{A \rightarrow CD, ACF \rightarrow G, AD \rightarrow BEF, BCG \rightarrow D, CF \rightarrow AH, CH \rightarrow G, D \rightarrow B, H \rightarrow DEG\}$$

1) Compute all keys for R.

$A^+ = ACDBEFHG$  所以 A 是 candidate key

$CF^+ = CFAHGDEB$  所以 CF 也是 candidate key

2) Compute a minimal basis (canonical cover) for F. In your final answer, put the FDs into alphabetical order.

去掉右邊多餘的 attribute:  $AD \rightarrow BEF \Rightarrow AD \rightarrow EF$

(因為結合  $D \rightarrow B$  可推導出  $AD \rightarrow B$ )

$$F = \{A \rightarrow CD, ACF \rightarrow G, AD \rightarrow EF, BCG \rightarrow D, CF \rightarrow AH, CH \rightarrow G, D \rightarrow B, H \rightarrow DEG\}$$

去掉左邊多餘的 attribute:  $CH \rightarrow G \Rightarrow H \rightarrow G$  ( $H \rightarrow G$  是可被推導出來的)

$$F = \{A \rightarrow CD, ACF \rightarrow G, AD \rightarrow EF, BCG \rightarrow D, CF \rightarrow AH, D \rightarrow B, H \rightarrow DEG\}$$

去掉左邊多餘的 attribute:  $ACF \rightarrow G \Rightarrow CF \rightarrow G$

$$F = \{A \rightarrow CD, AD \rightarrow EF, BCG \rightarrow D, CF \rightarrow AHG, D \rightarrow B, H \rightarrow DEG\}$$

去掉右邊多餘的 attribute:  $CF \rightarrow AHG \Rightarrow CF \rightarrow AH$

(因為結合  $H \rightarrow DEG$  可推導出  $CF \rightarrow G$ )

$$F = \{A \rightarrow CD, AD \rightarrow EF, BCG \rightarrow D, CF \rightarrow AH, D \rightarrow B, H \rightarrow DEG\}$$

去掉左邊多餘的 attribute:  $AD \rightarrow EF \Rightarrow A \rightarrow EF$  ( $A \rightarrow EF$  是可被推導出來的)

$$F = \{A \rightarrow CDEF, BCG \rightarrow D, CF \rightarrow AH, D \rightarrow B, H \rightarrow DEG\}$$

去掉右邊多餘的 attribute:  $A \rightarrow CDEF \Rightarrow A \rightarrow CF$

(因為結合  $CF \rightarrow AH, H \rightarrow DEG$  可推導出  $A \rightarrow DE$ )

$$F = \{A \rightarrow CF, BCG \rightarrow D, CF \rightarrow AH, D \rightarrow B, H \rightarrow DEG\}$$

3) Using the minimal basis from part (b), employ the 3NF synthesis algorithm to obtain a lossless and dependency-preserving decomposition of relation R into a collection of relations that are in 3NF.

分解成  $R_1(A, C, F)$ ,  $R_2(B, C, D, G)$ ,  $R_3(A, C, F, H)$ ,  $R_4(B, D)$ ,  $R_5(D, E, G, H)$

4) Does your schema allow redundancy?

$$F_1 = \{A \rightarrow CF\}, F_2 = \{BCG \rightarrow D, D \rightarrow B\}, F_3 = \{CF \rightarrow AH, A \rightarrow CF\}, F_4 = \{D \rightarrow B\}, F_5 = \{H \rightarrow DEG\}$$

其中  $D \rightarrow B$  但 D 不是  $R_2$  的 superkey, 所以  $R_2$  不滿足 BCNF, 會有 redundancy。

此狀況滿足 3NF, 且狀況 dependency preservation, 但不滿足 BCNF。

3. Questions about functional dependency:

1) Consider relation  $R(A,B,C,D,E)$  with functional dependencies:

$AB \rightarrow C, BC \rightarrow D, CD \rightarrow E, DE \rightarrow A, AE \rightarrow B$

Which of the following FDs is guaranteed to be satisfied by  $R$ ?

- a)  $D \rightarrow C$    b)  $CE \rightarrow B$    c)  $AC \rightarrow D$    d)  $ACD \rightarrow B$

Ans: d

$D^+ = D, CE^+ = CE, AC^+ = AC, ACD^+ = ACDEB$

2) Let relation  $R(A,B,C,D)$  satisfy the following functional dependencies:

$A \rightarrow B, B \rightarrow C, C \rightarrow A$

Call this set  $S1$ . A different set  $S2$  of functional dependencies is equivalent to  $S1$  if exactly the same FDs follow from  $S1$  and  $S2$ . Which of the following sets of FDs is equivalent to the set above?

- a)  $B \rightarrow A, B \rightarrow C, C \rightarrow B$   
b)  $C \rightarrow B, B \rightarrow A, A \rightarrow C$   
c)  $A \rightarrow B, B \rightarrow A, B \rightarrow C$   
d)  $A \rightarrow BC, C \rightarrow AB$

Ans: b

在兩組 functional dependencies:  $A^+$ 皆為 ABC,  $B^+$ 皆為 ABC,  $C^+$ 皆為 ABC

3) Suppose relation  $R(A,B,C)$  currently has only the tuple  $(0,0,0)$ , and it must always satisfy the functional dependencies  $A \rightarrow B$  and  $B \rightarrow C$ . Which of the following tuples may be inserted into  $R$  legally?

- a)  $(1,0,2)$    b)  $(0,1,2)$    c)  $(2,0,1)$    d)  $(1,2,3)$

Ans: d

a) 違反  $B \rightarrow C$ , b) 違反  $A \rightarrow B$ , c) 違反  $B \rightarrow C$

4. Questions about multi-valued dependency:

1) Here is an instance of a relation  $R(A,B,C)$ :

A	B	C	D
1	2	3	4
1	3	3	3
1	3	3	4
1	2	3	3
2	2	4	4

2	4	2	4
2	4	4	4
2	2	2	4

Which of the following multivalued dependencies does this instance of R satisfy?

- a)  $A \twoheadrightarrow B$
- b)  $BD \twoheadrightarrow C$
- c)  $D \twoheadrightarrow BC$
- d)  $B \twoheadrightarrow C$

Ans: a

2) Here is an instance of a relation R(A,B,C):

A	B	C
1	2	3
1	3	2
1	2	2
3	2	1
3	2	3

Which of the following multivalued dependencies does this instance of R not satisfy?

- a)  $AB \twoheadrightarrow A$
- b)  $C \twoheadrightarrow B$
- c)  $AB \twoheadrightarrow C$
- d)  $B \twoheadrightarrow C$

e) Ans: d 若  $B \twoheadrightarrow C$ ，有(1, 2, 2) 跟 (3, 2, 3) 就要有 (1, 2, 3) 跟 (3, 2, 2)

3) Consider relation R(A,B,C,D,E) with multivalued dependencies:

$A \twoheadrightarrow B, B \twoheadrightarrow D$

Suppose R contains the tuples (0,1,2,3,4) and (0,5,6,7,8). Which of the following tuples must also be in R?

- a) (0,1,2,7,8)
- b) (0,1,2,3,8)
- c) (0,5,6,3,8)
- d) (0,5,6,7,4)

R 中應包含(0,1,2,3,4), (0,5,6,7,8)及

(0,1,6,7,8), (0,5,2,3,4), (0,1,2,7,4) (0,1,6,3,8), (0,5,2,7,4), (0,5,6,3,8)