Lab3: Normalization

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Question 1

Consider the relation schema R(A, B, C, D, E, F) and the set of functional dependencies F = { FD1: A $\rightarrow$ BC; FD2: C $\rightarrow$ AD; FD3: DE $\rightarrow$ F }. Use the Armstrong rules to derive each of the following two functional dependencies. In both cases, describe the derivation process step by step (i.e., which rule did you apply to which FDs).

a) C $\rightarrow$ B

$$FD4: \quad AD \rightarrow BCD \quad\quad Augmentation \quad FD1$$
$$FD5: \quad C \rightarrow BCD \quad\quad Transitivity \quad FD2 \;\; and \;\; FD4$$
$$FD6: \quad C \rightarrow BC \quad\quad Decomposition \quad FD5$$
$$FD7: \quad C \rightarrow B \quad\quad Decomposition \quad FD6$$

b) AE $\rightarrow$ F

$$FD4: \quad AE \rightarrow BCE \quad\quad Augmentation \quad FD1$$
$$FD5: \quad CE \rightarrow ADE \quad\quad Augmentation \quad FD2$$
$$FD6: \quad ADE \rightarrow FA \quad\quad Augmentation \quad FD3$$
$$FD7: \quad CE \rightarrow FA \quad\quad Transitivity \quad FD5 \;\; and \;\; FD6$$
$$FD8: \quad BCE \rightarrow BFA \quad\quad Augmentation \quad FD7$$
$$FD9: \quad AE \rightarrow BFA \quad\quad Transitivity \quad FD4 \;\; and \;\; FD8$$
$$FD10: \quad AE \rightarrow FA \quad\quad Decomposition \quad FD9$$
$$FD11: \quad AE \rightarrow F \quad\quad Decomposition \quad FD10$$

Question 2

For the aforementioned relation schema with its functional dependencies, compute the attribute closure X^+ for each of the following two sets of attributes.

a) X = { A }

$$X^+ = \{A\}$$
$$X^+ = \{ABC\} \quad using \quad FD1: A \rightarrow BC$$
$$X^+ = \{ABCD\} \quad using \quad FD2: C \rightarrow AD$$
$$X^+ = \{ABCD\} \quad using \quad FD3: DE \rightarrow F$$

b) X = { C, E }

$$X^+ = \{CE\}$$
$$X^+ = \{CEAD\} \quad using \quad FD2: C \to AD$$
$$X^+ = \{CEADF\} \quad using \quad FD3: DE \to F$$
$$X^+ = \{ABCDEF\} \quad using \quad FD1: A \to BC$$

Question 3

Consider the relation schema R(A, B, C, D, E, F) with the following FDs

FD1: AB → CDEF
FD2: E → F
FD3: D → B

The elements which are on left side but not on right side we can remove those from relation R

a) Determine the candidate key(s) for R

$$X = \{ABDE\}, \qquad X = \{ABD\}$$
$$X = \{ABE\}, \qquad X = \{ADE\}$$
$$X = \{AB\}, \qquad X = \{AD\}$$
$$X = \{AE\}, \qquad X = \{A\}$$

1. $X^+ = \{A\}$

2. $X^+ = \{AE\}$
   - $X^+ = \{AE\} \quad FD1: AB \to CDEF$
   - $X^+ = \{AEF\} \quad FD2: E \to F$
   - $X^+ = \{AEF\} \quad FD3: D \to B$

3. $X^+ = \{AD\}$
   - $X^+ = \{ADB\} \quad FD3: D \to B$
   - $X^+ = \{ADBCEF\} \quad FD1: AB \to CDEF$
   - $X^+ = \{ADBCEF\}$

4. $X^+ = \{AB\}$
   - $X^+ = \{ABCDEF\} \quad FD1: AB \to CDEF$
   - $X^+ = \{ADBCEF\} \quad FD2: E \to F$
   - $X^+ = \{ADBCEF\} \quad FD3: D \to B$

So $Ck = \{AB, AD\}$ are minimal candidate key.

b) Note that R is not in BCNF. Which FD(s) violate the BCNF condition?

R is not in BCNF $FD2$ and $DF2$ violates BCNF condition.

c) Decompose R into a set of BCNF relations, and describe the process step by step (don't forget to determine the FDs and the candidate key(s) for all of the relation schemas along the way).

$D \to B$ violate BCNF condition we decompose

R3(DB) with FD3 : $ck = \{D\}$
R4(ACDE) with FD7 : $AD \rightarrow \{CE\}$ $ck = \{AD\}$

where new FDs is formed

$$FD4: \quad AD \rightarrow AB \qquad Augmentation \quad FD3$$

$$FD5: \quad AD \rightarrow CDEF \qquad Transitivity \quad FD1 \ \ and \ \ FD4$$

$$FD6: \quad AD \rightarrow CDE \qquad Decomposition \quad FD5$$

$$FD7: \quad AD \rightarrow CE \qquad Decomposition \quad FD6$$

Question 4

Consider the relation schema R(A, B, C, D, E) with the following FDs

FD1: ABC → DE
FD2: BCD → AE
FD3: C → D

a) Show that R is not in BCNF.

The elements which are on left side but not on right side we can remove those from relation R.

$$X = \{ABCD\}, \qquad X = \{ABC\}$$

$$X = \{BCD\}, \qquad X = \{BC\}$$

1. $X^+ = \{BC\}$
    - $X^+ = \{BCD\} \quad FD1 : C \rightarrow D$
    - $X^+ = \{BCDAE\} \quad FD2 : BCD \rightarrow AE$
    - $ck = \{BC\}$

So $Ck = \{BC\}$ are minimal candidate key and relation FD3 violates the BCNF.

b) Decompose R into a set of BCNF relations (describe the process step by step).

R2(CD) with $FD3 : C \rightarrow D \quad ck = \{C\}$
R3(ABCE) with $FD4 : BC \rightarrow AE(using \ \ pesduo - transitivtyon \ FD2 \ and \ FD3) \ FD5 : ABC \rightarrow E \ \ Decomposition \ of \ \ FD1$

$ck = \{BC\}$