CS 3431: Assignment 5

Adam Camilli

October 10, 2017

1. For the relational schema given below and its corresponding functional dependencies (FDs):

   - R(A, B, C, D, E)
   - S = {AB → E}
     {B → C}
     {B → D}
     {CE → A}

   answer the following questions:

   (a) Find all candidate keys of the relation R through an exhaustive set of attribute closures. Note when an attribute set closure is trivial.

Set	**Closure**	**Set**	**Closure**	**Set**	**Closure**
A	Trivial	AB	ABCDE	BD	BCD
B	BCD	AC	Trivial	BE	ABCDE
C	Trivial	AD	Trivial	CD	Trivial
D	Trivial	AE	Trivial	CE	ACE
E	Trivial	BC	BCD	DE	Trivial
ABC	ABCDE	ADE	Trivial	ABCE	ABCDE
ABD	ABCDE	BCD	Trivial	ACDE	Trivial
ABE	ABCDE	BCE	Trivial	BCDE	ABCDE
ACD	Trivial	CDE	ACDE		
ACE	Trivial	ABCD	ABCDE		

   Candidate Keys = {AB,BE}

   (b) Assume that S is a minimal basis for R. List the dependencies that violate 3NF, if any.

$$B \rightarrow C \qquad (C \not\subset B, \text{ and } B \not\in \text{Super Keys.})$$
$$B \rightarrow D \qquad (D \not\subset B, \text{ and } B \not\in \text{Super Keys.})$$

(c) If R is NOT in 3NF, decompose it into multiple relations that are in 3NF.

$$\begin{aligned} B \to C, B \to D: &\quad \text{R1}(B, C, D),\ S = \{B \to C, B \to D\} \\ AB \to E: &\quad \text{R2}(A, B, E),\ S = \{AB \to E\} \\ CE \to A: &\quad \text{R3}(A, C, E),\ S = \{CE \to A\} \end{aligned}$$

(d) List the dependencies, in the order given in S, that violate BCNF.

$$\begin{aligned} B \to C \\ B \to D \\ CE \to A \end{aligned}$$

(e) If R is not in BCNF, provide decomposition into multiple relations where each one is in BCNF. For each decomposition step, use the first FD violation following the FD order given in S. For example, if AB $\to$ E and B $\to$ C are in BCNF but the other two FDs are in violation, then you would use B $\to$ D for the decomposition. Make sure to specify which FD is used to make the decomposition.

Using B $\to$ C to decompose:
B^+ = BCD, R1 = (BCD), R2 = (ABE)

R1: S = {B $\to$ C, B $\to$ D} No Violation
R2: S = {AB $\to$ E, B $\to$ E} B $\to$ E violates BCNF $\Rightarrow$ R3(ACE), R4(BCD), R5(BE)
Only examine R3: S = {CE $\to$ A} No Violation

$$\begin{aligned} &(BCD),\ S = \{B \to C, B \to D\} \\ &(ABE),\ S = \{AB \to E\} \\ &(ACE),\ S = \{CE \to A\} \end{aligned}$$

2. For the relational schema given below and its corresponding functional dependencies (FDs):

   - R(A, B, C, D, E)
   - S = {B → A}
     {B → E}
     {CE → D}
     {D → B}

   answer the following questions:

   (a) Find all candidate keys of the relation R through an exhaustive set of attribute closures. Note when an attribute set closure is trivial.

Set	**Closure**	**Set**	**Closure**	**Set**	**Closure**
A	Trivial	AB	ABE	BD	ABDE
B	ABE	AC	Trivial	BE	ABE
C	Trivial	AD	ABDE	CD	ABCDE
D	ABDE	AE	Trivial	CE	ABCDE
E	Trivial	BC	ABCDE	DE	ABDE
ABC	ABCDE	ADE	ABDE	ABCE	ABCDE
ABD	ABDE	BCD	ABCDE	ACDE	ABCDE
ABE	trivial	BCE	ABCDE	ABCD	ABCDE
ACD	ABCDE	CDE	ABCDE	BCDE	ABCDE
ACE	ABCDE	ABCD	ABCDE		

   Candidate Keys = {BD,CD,CE}

   (b) Decompose the relations to satisfy BCNF. Specify which FD is used to make the decomposition. If there is multi-step decomposition, then indicate each step along with which FD is used for the decomposition.

   Using B *to* A:

$$\begin{aligned} \text{R1(ABE)S} &= \{\text{B} \rightarrow \text{A, B} \rightarrow \text{E}\} \\ \text{R2(BD)S} &= \{\text{D} \rightarrow \text{B}\} \\ \text{R3(CD)S} &= \{\text{None}\} \end{aligned}$$

   Here we can see that the FD (CE → D) is lost. Since we see later that the FDs given to us are already the minimal basis, we can use the results given in the next question to answer this question as well (i.e., the decompositions turn out to be the same).

(c) List the dependencies, in the order given in S, that violate BCNF.

$$B \to A$$
$$B \to E$$
$$D \to B$$

(d) If the FDs are not in 3NF, calculate a minimal basis for the FDs and decompose the relations to satisfy 3NF.

Minimal Basis = {B → A, B → E, D → B, CE → D} = S.

$$\begin{aligned} \text{R1(ABE)},\ & \text{S} = \{\text{B} \to \text{A},\ \text{B} \to \text{E}\} \\ \text{R2(BD)},\ & \text{S} = \{\text{D} \to \text{B}\} \\ \text{R3(CDE)},\ & \text{S} = \{\text{CE} \to \text{D}\} \end{aligned}$$

(e) If R is NOT in 3NF, decompose it into multiple relations that are in 3NF.

$$\begin{aligned} B \to C, B \to D: &\quad \text{R1}(B, C, D),\ S = \{B \to C, B \to D\} \\ AB \to E: &\quad \text{R2}(A, B, E),\ S = \{AB \to E\} \\ CE \to A: &\quad \text{R3}(A, C, E),\ S = \{CE \to A\} \end{aligned}$$

3. Answer the questions using the table.

   (a) Indicate whether each of the following decompositions is Lossy or Lossless and state why?

      i. Artist and Artwork are in one relation. Gallery, Address, and Artwork are in the other relation.

         LOSSLESS: Since the artwork is present in both relations, artists will always match with the correct gallery and address and no information will be lost.

      ii. Gallery, Address, and Artwork are in one relation. Artist and Gallery are in one relation.

         LOSSY: Although the table does not show it, presumably a single artist should be able to have more than one artwork at a gallery. In this case, information is lost in the second relation. Every time you get a certain Artist and Gallery it won't necessarily be the same Artwork. As the table is, however, this is lossless.

   (b) From the data in the table above, identify the set of functional dependencies that hold. Then, specify which of the following decompositions preserve the dependencies and state why?

      Artist $\rightarrow$ Artwork
      Gallery $\rightarrow$ Address
      Artwork, Gallery, Address $\rightarrow$ Artist
      Artist, Artwork $\rightarrow$ Gallery
      Artist, Artwork $\rightarrow$ Address

      i. Gallery, Address, and Artist are in one relation. Artwork and Artist are in the other relation.

         Does not preserve all the dependencies because (Artist, Artwork) is not a super key.

      ii. Gallery, Artist are in one relation. Artwork, Artist, and Address are in the other relation.