5DV119 Introduction to Database Management Spring 2015
Class Exercises on Normalization

The following questions will be solved in class, as illustrations of techniques for normalizing relational database schemata

1. Given is a relational database schema on ocean-going shipping. The schema consists of a single relation R, with attributes as follows:

   R(Ship_ID, Ship_Name, Ship_Type, Ship_Country, Voyage_ID,
   Start_Date, End_Date, Cargo, Port, Dock_Date)

   The following functional dependencies (FDs) hold.

   $$\{\mathsf{Ship\_ID}\} \rightarrow \{\mathsf{Ship\_Name}, \mathsf{Ship\_Type}, \mathsf{Ship\_Country}\}.$$
   $$\{\mathsf{Ship\_Name}, \mathsf{Ship\_Country}\} \rightarrow \{\mathsf{Ship\_ID}\}.$$
   $$\{\mathsf{Voyage\_ID}\} \rightarrow \{\mathsf{Ship\_ID}, \mathsf{Cargo}, \mathsf{Start\_Date}, \mathsf{End\_Date}\}$$
   $$\{\mathsf{Ship\_ID}, \mathsf{Dock\_Date}\} \rightarrow \{\mathsf{Voyage\_ID}, \mathsf{Port}\}.$$

   (a) Find a canonical cover for this set of FDs.

   (b) Identify the candidate keys of this schema.

   (c) Using the decomposition algorithm, construct a lossless decomposition of this schema into BCNF.

   (d) Using the synthesis algorithm, construct a lossless, dependency-preserving decomposition of this schema into 3NF. If possible, find such a decomposition which is also fully independent. If no such decompostion is possible, explain why.

   (e) Explain why there is no lossless, dependency-preserving decomposition of this schema into BCNF.

   To simplify the presentation, use the following table of one-letter representations for the attributes.

Attribute	Abbr.	Comment
Ship_ID	S	
Ship_Name	N	
Ship_Type	T	
Ship_Country	L	L = Land
Voyage_ID	V	
Start_Date	B	B = Beginn
End_Date	E	
Cargo	C	
Port	P	
Dock_Date	D	

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2. Given is the relational database schema $R[ABCDEFGH]$, constrained by the FDs in
$$\mathcal{F}_2 = \{AB \rightarrow CDEF,\ CD \rightarrow E,\ E \rightarrow DG,\ DEG \rightarrow F\}.$$

   (a) Find a canonical cover for $\mathcal{F}_2$.

   (b) Using the synthesis algorithm, find a dependency-preserving 3NF representation of $\langle R, \mathcal{F}_2 \rangle$.

   (c) Find all keys for $\mathcal{F}_2$.

   (d) Find a lossless extension to the answer of (b).

   (e) Indicate which of the relations in the answer to (d) are not in BCNF, and explain why.

   (f) Show that there is no lossless and fully independent of $\langle R, \mathcal{F}_2 \rangle$ into BCNF. In other words, show that the BCNF-decomposition algorithm cannot yield such a decomposition. (Hint: Look for a small subschema with three attributes which is known not to admit such a representation.)

   (g) Determine whether or not the synthesis found in (b) is fully independent.

3. Given is the relational database schema $R[ABCDEF]$, constrained by the FDs in
$$\mathcal{F}_3 = \{AB \rightarrow CDEF,\ CD \rightarrow E,\ E \rightarrow D.\ EF \rightarrow AB\}.$$

   Repeat (a)-(e) of Problem 2, this time for $\mathcal{F}_3$.