

# CIS 550: Database and Information Systems

## Exercise 5: Relational Design Theory

### Part 1: Functional Dependencies

Your friend likes to keep track of their computers and has created an Excel spreadsheet with the following columns (attributes), none of which are null:

Manufacturer, Model#, Serial#, Description, Store, PurchaseDate, Price

Each row in this spreadsheet corresponds to a computer that they own. Since your friend has a lot of computers to keep track of, and you are a fan of databases, you wish to create a relational database to replace the Excel spreadsheet. You initially design the database as a single relation consisting of all the attributes in the spreadsheet, but realize there are certain redundancies and want to improve the design based on what you are learning in this course.

1. Give a *minimal* set of functional dependencies  $F$  that hold for this schema assuming **only** that:

- The manufacturer, model number and serial number uniquely identifies the store, purchase date and price;
- The description of a computer is determined by the manufacturer and model number -- in particular, it does not vary depending on the store in which the computer was bought or the serial number of the computer.

2. What is the key of your relation? Prove this by showing that the closure of the set of attributes in the key includes all attributes using the technique discussed in lecture.

Now suppose that you decompose into  $R_1(\text{Manufacturer, Model\#, Serial\#, Store, PurchaseDate, Price})$ ,  $R_2(\text{Manufacturer, Model\#, Description})$ .

3. Does this decomposition have a lossless join? Why or why not?

4. What is the projection of  $F$  over  $R_1$ ? The projection of  $F$  over  $R_2$ ? Does the decomposition preserve dependencies (and say why)?
5. Given a schema  $AB$  and functional dependencies  $F = \{A \rightarrow B\}$ . What is the closure of  $F$ ,  $F^+$ ?
6. Given a schema  $ABCD$  and functional dependencies  $F = \{A \rightarrow B, B \rightarrow D, C \rightarrow A, A \rightarrow D, C \rightarrow D\}$ , is the decomposition  $\{ABC, BD\}$  dependency preserving? Be careful to look at  $F^+$  in the projection of  $F$  over each schema.

## Part 2: Decompositions

Suppose we have a database for an investment firm, consisting of the following attributes:  $B$  (broker),  $O$  (office of a broker),  $I$  (investor),  $S$  (stock),  $Q$  (quantity of stock owned by an investor) and  $D$  (dividend paid by a stock).

Given  $R = BOISQD$ , the set of functional dependencies are:

$F = \{S \rightarrow D,$   
     $I \rightarrow B,$   
     $IS \rightarrow Q,$   
     $B \rightarrow O,$   
     $ISQ \rightarrow D\}$

7. Find a key for  $R$ .
8. How many keys does  $R$  have? Justify your answer.
9. Suppose we decompose  $R$  into  $ISQ$ ,  $IB$ ,  $SD$  and  $ISO$ . Find the minimal covers for  $F$  projected onto each of these relation schemes.
10. Does the decomposition  $(ISQ, IB, SD, ISO)$  preserve dependencies? If not, state the dependencies that are lost.
11. Find a decomposition of  $R$  into 3NF which has a lossless join and preserves dependencies, using the technique discussed in class.

### Part 3: Normal Forms

12. Given  $R = ABCD$ . For each of the following sets of FDs, say whether it is in 3NF, BCNF or neither. Justify your answers.

a.  $C \rightarrow D, C \rightarrow A, B \rightarrow C$

b.  $B \rightarrow C, D \rightarrow A$

c.  $ABC \rightarrow D, D \rightarrow A$