Databases: Supervision 2

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2009 Paper 4 Question 8

1. (a) Define the concept of a *functional dependency*. [2]

    A set of attributes X functional determines another set of attributes if, and only if, each X value is associated with precisely one Y value.

   (b) Let `R(A, B, C, D, E, F)` be a database schema with functional dependencies

$$\begin{aligned} A, B &\rightarrow C \\ B, C &\rightarrow A, D \\ D &\rightarrow E \\ C, F &\rightarrow B \end{aligned}$$

      i. Compute the closure of $\{A, B\}$. [3]

        $\{A, B, C, D, E\}$

      ii. Is $A, B \rightarrow D, F$ a functional dependency over R? Justify your answer. [1]

        No, because F is not in the closure.

   (c) Define the concept of a *multivalued dependency*. [2]

    A multivalued dependency on R is a constraint such that if two tuples of R agree on all the attributes of X, then their components in Y can be swapped and the result will be two tuples that are also in the relation.

(d) Suppose the functional dependency $X \to Y$ holds on a relational schema. Does this mean that the multivalued dependency $X \twoheadrightarrow Y$ holds? Justify your answer. [3]

Every functional dependency is a multivalued dependency since if it is a functional dependency then swapping their components in y will result in the same tuple (since they are neccessarily the same for tuples that agree on X).

(e) Define the concept of a *lossless-join decomposition*. [3]

A lossless-join decomposition is splitting a relation R into two relations R_1 and R_2 such that $R_1 \bowtie R_2 = R$.

(f) Let $R(X)$ be a database schema, where X is a set of attributes. Show that $S(Y \cup Z)$ and $T(Y \cup (X - Z))$ is a lossless-join decomposition of $R(X)$ if and only if the multivalued dependency $Y \twoheadrightarrow Z$ holds over R. [6]

- Suppose $Z \twoheadrightarrow W$
- We know (from proof of Heath's rule) that $R \subseteq \pi_{Z,W}(R) \bowtie \pi_{Z,Y}(R)$ so we only need to show $\pi_{Z,W}(R) \bowtie \pi_{Z,Y}(R) \subseteq R$.
- Suppose $r \in \pi_{Z,W}(R) \bowtie \pi_{Z,Y}(R)$.
- There must be a $t \in R$ and $u \in R$ with $\{r\} = \pi_{Z,W}(\{t\}) \bowtie \pi_{Z,Y}(\{u\})$.
- In other words there must be a $t \in R$ and $u \in R$ with $t.Z = u.Z$
- So the MVD tells is that there must be some tuple $v \in R$ such that
  - v agrees with both t and u on the attributes of Z
  - v agrees with t on the attributes of W.
  - v agrees with u on the attributes of Y.
- This v must be the same as r, so $r \in R$.
- Suppose $R = \pi_{Z,W}(R) \bowtie \pi_{Z,Y}(R)$
- Let t and u be any records in R with $t.Z = u.Z$.
- Let v be defined by $\{v\} = \pi_{Z,W}(\{t\}) \bowtie \pi_{Z,Y}(\{u\})$
- By construction we have:

> – $v.Z = t.Z = u.Z$
>
> – $v.W = t.W$
>
> – $v.Y = u.Y$
>
> Therefore, $Z \twoheadrightarrow W$ holds.

2010 Paper 4 Question 5

2. (a) Suppose that $R(A, B, C)$ is a relational schema with functional dependencies $F = \{A, B \rightarrow C, C \rightarrow B\}$.

   i. Is this schema in 3NF? Explain. [2]

   > A, B and A, C are keys for R and therefore there are no non-prime attributes.

   ii. Is this schema in BCNF? Explain. [2]

   > C is not a key and $C \rightarrow B$ therefore the schema is not in BCNF.

   (b) Decomposition plays an important role in database design.

   i. Define what is meant by a *lossless-join decomposition*. [2]

   > A lossless-join decomposition is splitting a relation R into two relations R_1 and R_2 such that $R_1 \bowtie R_2 = R$.

   ii. Define what is meant by a *dependency preserving decomposition*. [2]

   $\boxed{}$

   (c) Let $R(A, B, C, D, E)$ be a relational schema with the following functional dependencies.

$$
\begin{aligned}
A, B &\rightarrow C \\
D, E &\rightarrow C \\
B &\rightarrow D \\
l &
\end{aligned}
$$

   i. What is the closure of $\{A, B\}$? [2]

$\{A, B, C, D\}$

ii. What is the closure of $\{B, E\}$? [2]

$\{B, C, D, E\}$

iii. Decompose the schema to BCNF in two different ways. In each case, are all dependencies preserved? Explain. [8]

Using $A, B \rightarrow C, D$