

# Database Management Systems, Aug–Dec 2023

## Problem sheet, 29 September 2023

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**Problem 1** Consider the following functional dependencies over the attributes  $(A, B, C, D, E)$ .

$$\begin{aligned}A &\rightarrow BC \\ CD &\rightarrow E \\ B &\rightarrow D \\ E &\rightarrow A\end{aligned}$$

Compute the attribute closure  $X^+$  for each attribute  $X \in \{A, B, C, D, E\}$ .

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**Problem 2** Consider the following tables for an online book seller.

```
CREATE TABLE Books (  
  isbn CHAR(10),  
  title CHAR(80),  
  author CHAR(80),  
  qty_in_stock INTEGER,  
  price REAL,  
  year_published INTEGER,  
)
```

```
CREATE TABLE Customers (  
  cid INTEGER,  
  cname CHAR(80),  
  address CHAR(200)  
)
```

```
CREATE TABLE Orders (  
  ordernum INTEGER,  
  isbn CHAR(10),  
  cid INTEGER,  
  cardnum CHAR(16),  
  qty INTEGER,  
  order_date DATE,  
  ship_date DATE  
)
```

We have the following assumptions about these tables.

- `isbn` is a unique identifier for each book published.
- A book has only one title but may have multiple authors.
- `cid` is a unique customer id for each customer.
- `ordernum` is a unique identifier for each order.
  - An order is placed by a single customer `cid`, paid by a single card `cardnum` on a single order date `order_date`.
  - An order may consist of several books (distinct `isbn`) each with its own order quantity (`qty`).
  - Each book is shipped (`ship_date`) as soon as the quantity required is ready.
  - Hence each order is split in several rows, one per `isbn` ordered.

Questions:

1. Enumerate the functional dependencies that you can infer from this information.
2. For each table, determine if it in BCNF or 3NF. If not, suggest a decomposition and check if the decomposition is dependency preserving.

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**Problem 3** Suppose we have dependencies  $\{A \rightarrow BC, B \rightarrow CA, C \rightarrow AB\}$  on attributes  $(A, B, C)$ .

Questions:

1. Show that  $C$  is extraneous on the right hand side of the first dependency.
  2. If we replace the first dependency by  $A \rightarrow C$ , show that both  $A$  and  $B$  are (separately) extraneous in  $C \rightarrow AB$ .
  3. If we replace  $C \rightarrow AB$  by  $C \rightarrow A$ , so that the dependencies are  $\{A \rightarrow B, B \rightarrow AC, C \rightarrow A\}$ , show that  $A$  is extraneous in  $B \rightarrow AC$ .
  4. If we replace  $C \rightarrow AB$  by  $C \rightarrow B$ , so that the dependencies are  $\{A \rightarrow B, B \rightarrow AC, C \rightarrow B\}$ , show that neither  $A$  nor  $C$  are extraneous in  $B \rightarrow AC$ .
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