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DATABASE DESIGN I - 1DL300

Assignment 1 - Normalization

1 Normalization

The purpose of this exercise is to get an understanding of the different normal forms and of the problems that can be prevented by normalization. After the lab, the student should be able to determine if a database schema conforms to the 1NF, 2NF, 3NF or the Boyce-Codd normal form (BCNF). The students should be familiar with modeling real world scenarios in terms of entity-relationship (ER) models and to translate an ER diagram into a relational database schema.

2 Preparation

You should prepare for this assignment by reading about Normalization treated in:

- Elmasri and Navathe [EN10]: Chapter 7, 14, Sections 8.1, 15.1 and 15.2.
- Padron-McCarthy and Risch [PMR05]: Chapter 2, 5, 6, and 11.

There is an supervised introduction to the assignment in your schedule.

3 Assignment

3.1 The scenario - a library database

The city library of Uppsala has a database to keep track of its books; the people who borrow books, and which books have been borrowed by who. The tables, with the data, are included below in Sections 3.3 and 3.4. (For well-known reasons, there are very few books in the library.)

Unfortunately, the design of the database is not very good. Your mission is to analyze the problems with the design, and suggest a better one.

The output of your work should be a report that addresses all the faults you find regarding normalization along with a description of why they are problematic. Furthermore, you should develop an alternative design that is in BCNF.

3.2 Exercises

1. Specify all full functional dependencies for each table in the library scenario. Then state in which normal form (1NF, 2NF, 3NF or BCNF) each of the existing tables is, and why. Assume that there is one telephone number per address. Assume that an author's name uniquely identifies an author.

2. For each table that does not fulfill the requirements for BCNF, explain the problems that this lack of normalization has and their potential consequences. Give some examples – at least two examples per table.

3. Design a new database for the library, where all the tables fulfill BCNF without losing any information. Use the top-down approach for the relational database design by starting with an ER-diagram for the database and mapping the diagram to relational tables.

All attributes contain information. You are not allowed to remove attributes only because of convenience. New attributes are not needed and should not be added. It is part of the assignment to make do with what you have.

Hints:

- Consider dates as atomic (there is a data type `date` in SQL).

- For more details on ER-to-Relational mapping you can study Elmasri & Navathe [EN10] Chapter 8.1.

3.3 The schema of the existing database

There are three tables:

- A table called `BOOK`, which contains data about the books. It has the attributes `TitleNo` (a number that this library assigns), `ISBN`, `CopyNo` (which is used to separate different copies of the same book), `Title`, `PublYear`, `Author`, and `AuthorNat`. The primary key consists of `TitleNo`, `CopyNo` and `Author`. An alternative key is formed by `ISBN`, `CopyNo` and `Author`.

- A table called `CUSTOMER`, which contains data about the persons who can borrow books. It has the attributes `CustomerNo` (a unique number identifying a person, assigned by the library), `SSN` (which is a unique number identifying a person, assigned by the Swedish state), `Name`, `Address`, `Phone`, and `NoBooks` (the number

of books that this person has borrowed at the moment). `CustomerNo` is the primary key. `SSN` is an alternative key.

- A table called `LOAN`, where the loans are stored. It has the attributes `TitleNo`, `CopyNo`, `CustomerNo`, `Date` (which is the date when the book was borrowed), and `BorrowerName` (which is the name of the customer who borrowed the book). The primary key consists of `TitleNo` and `CopyNo`.

3.4 The contents of the existing database

The tables look like this:

```
BOOK
+---------+------------+--------+-------------+----------+-------------+-----------+
| TitleNo |    ISBN    | CopyNo | Title       | PublYear | Author      | AuthorNat |
+---------+------------+--------+-------------+----------+-------------+-----------+
|    1    | 0071148108 |   1    | Database    |   1997   | Silberschatz|    USA    |
|    1    | 0071148108 |   1    | Database    |   1997   | Korth       |    USA    |
|    1    | 0071148108 |   1    | Database    |   1997   | Sudarshan   |   India   |
|    2    | 0805317538 |   1    | Fundamentals|   1994   | Elmasri     |    USA    |
|    2    | 0805317538 |   1    | Fundamentals|   1994   | Navathe     |    USA    |
|    2    | 0805317538 |   2    | Fundamentals|   1994   | Elmasri     |    USA    |
|    2    | 0805317538 |   2    | Fundamentals|   1994   | Navathe     |    USA    |
|    3    | 0198642253 |   1    | Murder      |   1995   | Guillou     |   Sweden  |
|    3    | 0198642253 |   2    | Murder      |   1995   | Guillou     |   Sweden  |
|    4    | 3411021764 |   1    | Violence    |   1998   | Guillou     |   Sweden  |
+---------+------------+--------+-------------+----------+-------------+-----------+


CUSTOMER
+------------+------------+---------------+----------+--------+---------+
| CustomerNo | SSN        | Name          | Address  | Phone  | NoBooks |
+------------+------------+---------------+----------+--------+---------+
|     1      | 6312111658 | McCarthy      | Road 7   | 282677 |    1    |
|     2      | 4403149901 | Larsson       | Street 6 | 146000 |    1    |
|     3      | 4010229910 | Ericsson      | Street 8 | 241000 |    1    |
|     4      | 4501129921 | Schwarzenegger| Road 3   | 174590 |    0    |
+------------+------------+---------------+----------+--------+---------+


LOAN
+---------+--------+------------+--------+--------------+
| TitleNo | CopyNo | CustomerNo | Date   | BorrowerName |
+---------+--------+------------+--------+--------------+
|    1    |   1    |     3      | 7/1 98 | Ericsson     |
|    3    |   2    |     1      | 1/9 98 | McCarthy     |
|    2    |   1    |     2      | 7/1 98 | Larsson      |
+---------+--------+------------+--------+--------------+
```

4   Examination

You should hand in the solutions and answers to questions as one report per group. The report should contain your answers to the questions in Section 3.

The database design in Section 3.2, Exercise 3 should be presented both in an entity-relationship (ER) diagram and by the corresponding relational tables in a table format:

```
table_name(column1, column2, ...)
```

Motivate why your relations are in BCNF by specifying all full functional dependencies. If you choose to use weak entity types, you must motivate why they are weak. All relation types must be two-way, i.e. each relation must involve no more than two entities.

References

[EN10]   Elmasri, R. and Navathe, S. B.: Fundamentals of Databases, 6th Edition, Addison-Wesley, 2010 (available e.g. at Akademibokhandeln).

[PMR05] Padron-McCarthy, T. and Risch, T.: Databasteknik, Studentlitteratur, 2005 (available e.g. at Akademibokhandeln).