



## Tutorial: Third Normal Form

Your company, Apasaja Private Limited, is commissioned by an online company offering several services to design the relational schema the management of their users' profiles. A service is fully described and identified by its name. Each user can register to one or more services. A user is uniquely identified by her email as well as by her mobile number. Each user has both a postal address and a country of residence. The postal address, however, unambiguously identifies the country in which it is located. There can be several users with the same address.

We are only given an abstract schema for this application as follows.

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

$$\Sigma = \{ \{A\} \rightarrow \{A, B, C\}, \{A, B\} \rightarrow \{A\}, \{B, C\} \rightarrow \{A, D\}, \{B\} \rightarrow \{A, B\}, \{C\} \rightarrow \{D\} \}$$

This tutorial continues from the computation of candidate keys and minimal cover in “Tutorial: Functional Dependencies”. You are advised to compute them before continuing. This tutorial also uses the schema from “Tutorial: Creating and Populating Tables” before the updates done during the tutorial.

### Questions

*Not all questions will be discussed during tutorial. You are expected to attempt them before coming to the tutorial. You may be randomly called to present your answer during tutorial. You are encouraged to discuss them on Canvas Discussion.*

1. **Third Normal Form.**(a) Is  $R$  with  $\Sigma$  in 3NF?2. **Normalization.**

- (a) Decompose<sup>1</sup>  $R$  with  $\Sigma$  into a 3NF decomposition using the algorithm from the lecture.
- (b) Is the result dependency preserving?

3. **3NF or BCNF.**

In this question, we will be revisiting the “issues” with the original schema from “Tutorial: Creating and Populating Tables”. For simplicity, we will work with only the relevant attributes. The following tables provide the mapping from those attributes to letters.

**book** (A,B)

Attribute	Letter
isbn	A
title	B

**copy** (A,C,F)

Attribute	Letter
copy	F

**student** (C,D,E)

Attribute	Letter
email	C
department	D
faculty	E

**loan** (A,C,F,G,H)

Attribute	Letter
borrowed	G
returned	H

We also rename **owner** to **email** and **book** to **isbn**.

Note that some attributes are not listed with the table as they are referencing another table. We assume those attributes are present nonetheless.

You are advised to figure out the functional dependencies on your own. Check that they match the following set of functional dependencies.

$$\Sigma = \{ \{A\} \rightarrow \{B\}, \{C\} \rightarrow \{D, E\}, \{A, C, F, G\} \rightarrow \{H\} \}$$

- (a) Recall that we found that **department** should uniquely identify **faculty**. This is represented as  $\{D\} \rightarrow \{E\}$ . Is the table **student** still in BCNF if we add  $\{D\} \rightarrow \{E\}$  to  $\Sigma$ ? Is it in 3NF?
- (b) Consider instead that we replace  $\{C\} \rightarrow \{D, E\}$  in  $\Sigma$  with  $\{C, E\} \rightarrow \{D\}$  and  $\{D\} \rightarrow \{C\}$ . Is the table **student** still in BCNF? Is it in 3NF?

## References

- [1] S. Bressan and B. Catania. *Introduction to Database Systems*. McGraw-Hill Education, 2006. ISBN: 9780071246507.
- [2] Hector Garcia-Molina, Jeffrey D. Ullman, and Jennifer Widom. *Database Systems: The Complete Book*. 2nd ed. Prentice Hall Press, 2008. ISBN: 9780131873254.
- [3] Raghu Ramakrishnan and Johannes Gehrke. *Database Management Systems*. 2nd. USA: McGraw-Hill, Inc., 2000. ISBN: 0072440422.

<sup>1</sup>Although it is a *synthesis* algorithm, the process is still decomposition.