# Application of Conceptual Model in Thematic Mapping: Representation of Relationships

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The paper addresses the general problem of visualization in thematic mapping. Thematic Web maps become more and more important in our life. Many opinions are formed and decisions made based on what maps the users see online in spatial information sites and portals. In case of maps that show variation of more than a few attributes, communicative quality of the map is very important for appropriate and efficient perception of the information. It is somewhat paradoxical that regardless of growing variety of available cartographical representation tools, same visualization errors are made repeatedly by the amateur cartographers as well as by experienced GIS users. Experiments performed in 2008-2013 showed that the students with some knowledge in cartography easily recognize a problematic map but usually encounter big difficulties with identifying and describing concrete faults. Even professional map makers sometimes make errors, mostly related with representation of series, structures, hierarchies and relationships. In order to improve the skills of the students related to the logical correctness of cartographic sign systems, we introduced two applications based on conceptual modeling technique: (a) for systematic design of conventional signs and (b) for reverse engineering of the model for the subsequent map quality assessment. Both these techniques are used for teaching thematic cartography in Cartography Master study program at Vilnius University, Lithuania.

Entity-relationship modeling is a database modeling method, used to produce a conceptual schema or a semantic data model of a system, often a relational database. We have demonstrated that ER/UML models can be successfully used for the design of a logically consistent system of map signs and for evaluation of correctness of existing sign systems. Current research in this field is carried out with the purpose of refining the proposed algorithm in order to encompass more complex situations, namely, structures, relationships between entities. In the paper, we demonstrate how relation-

ICA European Symposium on CARTOGRAPHY
VIENNA, 10–12 NOVEMBER 2015

Published in "Proceedings of the 1st ICA European Symposium on Cartography", edited by Georg Gartner and Haosheng Huang, EuroCarto 2015, 10-12 November 2015, Vienna, Austria

ships of different cardinality and modality could be represented using this method.

Representation of class hierarchies is based on the set of inherited attributes that is common for all the subclasses and is represented by a set of graphical elements. Correspondingly, signs that represent subordinated and coordinated entities share a subset of graphical elements. Representation of compositional hierarchies is similar to representation of structured attributes of a single entity, only the requirements for the visual structure of a compound sign are looser. Other one-to-many relationships often represent some kind of movement or a link in the space and require resolution of the relationship that is not common in other applications. In this case, individual signs for each relationship entity (link entity) are designed. Changes in time are more diverse and difficult to represent – mainly by compound or structural signs. Many-to-many relationships are resolved and relationship entities created, with corresponding graphical signs. Dependent entities that rely upon the existence of other entities are in the most of cases converted into link entities. If the relationship has the modality of zero, linking graphical entities must have an attribute of obligatoriness.

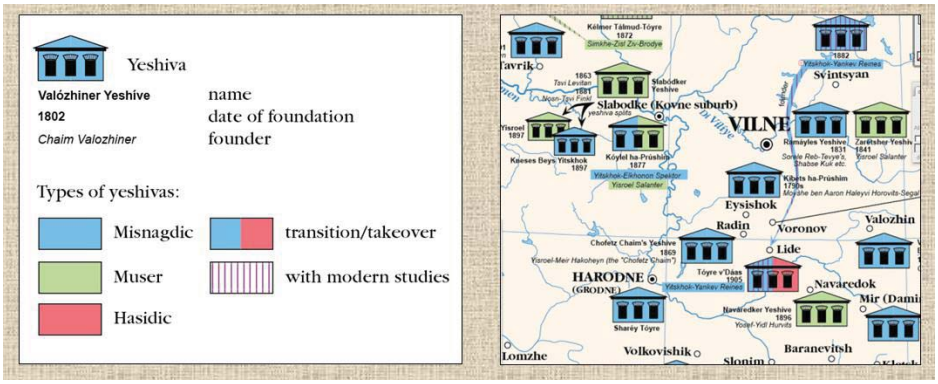


**Figure 1.** Representation of changes in space and time. Source: Katz D. (2014). Lithuanian Jewish Culture. Baltos lankos, Vilnius: 147.

The same task to design cartographic signs for representation of relationships was given to 20 students – 10 familiar with the described technique and 10 to whom the method was unknown. Comparison of the results supports the hypothesis that explicit use of a conceptual model results in better control over all visualization decisions and consequently more consistent representation of information.