MULTIPLE REPRESENTATION DATABASE
AS BASIS FOR
TOPOGRAPHIC MAPS

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Introduction:

Many new products have entered the market since the replacement of traditional cartography by digital technology. Topographic 3-D height models are available as well as maps in raster and vector formats. Digital maps are popular as a reference for customized thematic information added by graphic software whereas georeferenced data is used for analyses and visualizations with GIS. To preserve the value of the data acquisition and modelling, the updating issue gains interest.

In the diploma thesis written at the Institute of Cartography at the Swiss Federal Institute of Technology Zurich, the role of a Multiple Representation Database (MRDB) for a national mapping agency is discussed. The MRDB's purpose is to serve as a common basis of topographic data in various resolutions for all derivatives, i.e., maps, reference data or landscape models. The updating is done exclusively in the MRDB in order to avoid parallel updates and therefore data inconsistency.

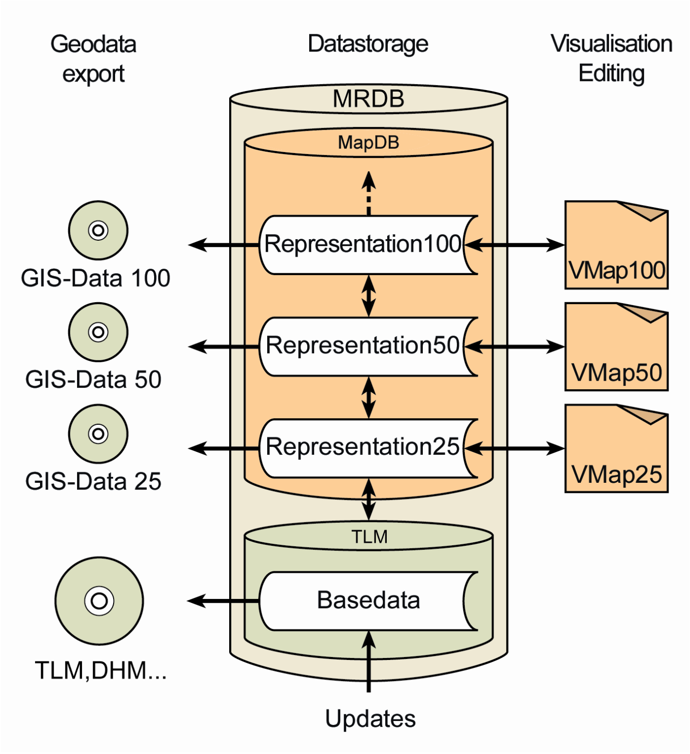
Goals:

The theoretical chapters of the paper focus on the examination of the components of an MRDB with respect to the demands for the generation and updating of topographic maps. Following these academic thoughts, a simple prototype shall be constructed using instruments and methods that suit the development of large-scale systems.

Multiple Representation Database:

All representations in an MRDB rely on a Topographic Landscape Model (TLM) which serves as the basis of the system. The TLM contains data in the highest needed resolution and may not be compromised by cartographic generalization. All updates are entered on the TLM level and propagated from there step by step through the different representations. Therefore, the TLM consists of the most accurate and up-to-date data in primary geometry that suits the needs for precise GIS data.

Based on the TLM, a sequence of cartographically generalized representations is overlaid. These representations fulfill all requirements in order to be automatically symbolized to vector maps. In these vector maps, updates are edited and the changes are saved in the representation. Prerequisite for this step is a capable interface between the representation managed in a GIS environment and the graphic software because the data must not only be visualized, but also efficiently edited in the symbolized illustration.



MRDB Schema.
The TLM serves as the basis for all the scaled representations in the MapDatabase. The representations can be used to derive maps as well as GIS- data.

In order to assist the cartographer in the updating process, the MRDB propagates update objects from one representation to another, possibly even using generalization algorithms. The cartographer may accept the automatic proposal of the system or make further changes on the update elements, which are visually distinguishable from the previous status.

The main focus was laid on the linkage between the different representations. Limited to a road network, different conceptual variants of object relationships have been evaluated. A road network was modelled using the object-oriented Unified Modelling Language (UML). The model considered different street classifications and additional traffic significance. Known approaches for the automated linkage of corresponding objects in different representations were mentioned.

Data model:

Cartographic generalization includes not only the selection of certain objects, but also a change in geometry caused by simplification, displacement or merging. Therefore, a separate data model needs to be stored for every representation. The question is how corresponding objects in different representations can be linked together. After comparing an area in different map scales, it was obvious that features must be linked with a many-many relationship. UML relationship classes were used to connect object classes of different representations.

Implementation:

The relationship model was implemented in an ESRI ArcGIS geodatabase for testing. The first step was to embed the UML model of the road networks in the ESRI UML environment using the computer-aided software engineering tool MS Visio. Restraints caused by the relational geodatabase forced minor changes of the logical model, which was designed in two variants. The specification of the road network into the different street classifications was modeled using either subclasses or subtypes. Subtypes had the advantage of being easier to overview, but could not be linked properly to other object classes. Using subclasses was a bit more complex. The geodatabase allows relationship classes only among object classes that have no subclasses themselves. The linkage on the most detailed level in the model caused a large number of relationship classes.

The export into the MS Repository transformed the graphic object-oriented UML presentation into a relational database. At this time a semantic check of the model could be automatically executed. After all conflicts were solved the schema wizard was used to import the geodatabase schema from the repository in ArcGIS. Since the data import of geometric networks was not possible, it was necessary to delete all networks and feature relationships. Sample data of actual road networks in two different scales were loaded into the empty tables of the geodatabase. Afterwards the geometric networks were re-established by a wizard. The reapplication of the schema wizard included all the previously deleted relationships again and completed this interoperable workflow. The object relationships were added manually.

Discussion:

Even though object-oriented databases are not yet widely spread in the GIS industry, the object-oriented database design has various advantages over the traditional entity relationship model. Object-oriented models with their hierarchies and associations are closer to human thinking and are therefore easier to understand for professional experts such as cartographers who have little knowledge of data modelling. The UML also eases the communication with software programmers who develop customized tools and applications, since it shares terms and concepts with the modern programming languages. The automatic workflow from the UML model to a GIS database has great potential, especially for designing large systems from scratch. The work flow makes it possible to take advantage of the modern modelling techniques as well as of splendidly constructed relational GIS.

Unfortunately, the visualization packages of GIS are not as far evolved as the modeling capabilities. To meet cartographic requirements, GIS visualization either needs to be enhanced with additional tools, or bi-directional interfaces to proven graphic software need to be established. A professional solution where maps can be displayed and edited with standard desktop publishing software and where all data is organized in a database could not be tested, but is available on the market.

Conclusion and Outlook:

For mapping agencies that are responsible for updating topographic data, an MRDB is the necessary investment to allow integrated processing of spatial data. Parallel updating is inefficient and intolerable over a long period of time. The technology for the database design is available today. Procedures for matching corresponding objects and constructing relationships between them are being developed. Focus for future studies needs to be laid on the automated production of missing data sets in various scales and the linking of objects more complex than linear features.

Literature:

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