Derivation of Digital Vector Models - Project DRIVE

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Research and development project DRIVE

A joint project between Department of Geography from University of Zurich and Axes of system AG aimed to transfer scientific and research knowledge to practical applications. The project promoted by the commission for technology and innovation (KTI) Swiss Federal Office for Professional Education and Technology (OPET). The motto of KTI is "Science ton Market". The aim is the rapid conversion of state-of-the-art laboratory findings to marketable products. With this goal the KTI promotes research and development projects between universities and enterprises.

The emphasis of the project lies in the extension of the *axpand* system, in order to be able to accomplish the necessary automated steps for the production of topographic maps from digital vector models (including geometrical and cartographic generalization, symbolization, placement), in an integrated development environment. Research-relevant questions focus on linkage of digital vector models in different scales using multi-representation databases (MRDB), as well as the use of these linkages for the automatic update. A goal is to reduce the workload for actualization and data update across related scales.

A second main focus concerns the research and development of generalization operators, deep examination of these operators under consideration of “neighborhood” relationships, as well as the use of suitable data structures. In addition, the parameters and controlling of the generalization operators are to be improved. The goal is to replace static sequential batch methods of operation by dynamic Workflows. The sequence of generalization operators used should be specified and defined situation-dependent. This should be achieved when the selection of generalization operators is shifted from the level of the object class on the level of the individual object. This requires a prior automatic conflict analysis.

Existing digital vector models in various scales from official national and state/land survey authorities will be used for the project (survey, cadastral data, VECTOR25, basis DLM, DLM50). A further use of the data takes place via the linkage with specialized information systems.

The cartographic production system “*axpand*”

The company Axes System, supplier of spatial data technologies, develops systems to administer, visualize, utilize and distribute spatial data. These technologies are developed and marketed under the product name *axpand*. Main users are the official city, state/land and national survey authorities, as well as map (cartography) publishing companies.

For the purpose of distribution and use of spatial data in public authorities, a describing data structure is preferably used in order to precisely define and describe geographical data. In Switzerland the format "INTERLIS", in Germany the "ATKIS/EDBS" - model is used country-wide. The data is described as carriers of spatial information based on Digital Landscape Models (DLM) are updated in pre-defined cycles and are widely used for the generation of official maps. After symbolization, geometrical and cartographic generalization and placement of graphic visualization objects (texts, symbols, etc.) of the terrestrial objects, Digital Cartographic Models (DCM) are generated from Digital Landscape Models. These can be printed out as paper maps or be exported for the further use in digital (structured) format.

a) Multi-Resolution Data Management

The multi-resolution data management enables the efficient administration and representation of geographical data in various scales. In the center is the geographical object, which is clearly identifiable and which clearly represents a real-world object (e.g. a particular building) or situation (e.g. a plot boundary, a border-line). This geographical object can be represented in different scales differently (type of geometry, representation, symbolization) or even suppressed. Currently only very elementary functions for multi-scale data management are available in GIS- and cartography systems. The identification takes place mostly over simple attributes (e.g. same object number). This requires managing different data sets (databases) for different scales of data representation. Disadvantages are clearly in the forced data redundancy, which manifests itself in the following shortcomings:

- large data volumes
- high data redundancy leading to high data management costs
- high cost of actualization requiring manual repetition of update process on each scale dataset

In contrast to this, individual object in a multi-resolution database behaves in the following way:

- once in a resolution (e.g. basis model 10'000), an object is instantly available in other scales (e.g. cartographic model 1:25'000)
- a deletion in the basis model leads to a deletion in all connected resolution stages increasing data integrity
- when once changes take place in the basis model, individual adjustments (generalization, suppression) in the other scales can be propagated instantly

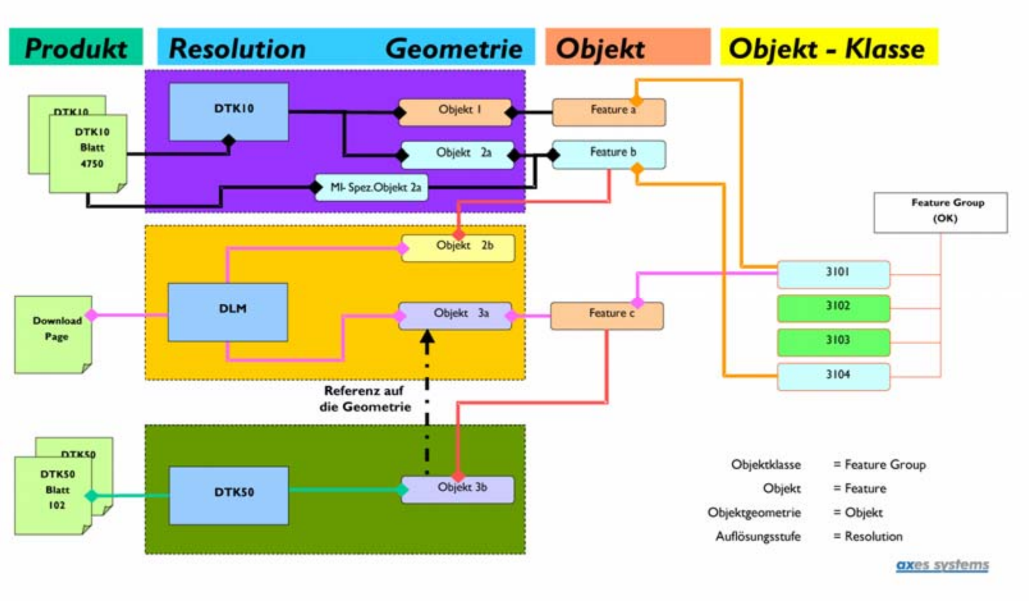


Figure 1: Multi-resolution *axpand*-Data architecture

The use of multi-resolution data architecture enables seamless and uniform data management across all resolution stages, ensures high data recency due to simplified and automated updates, as well as an integrated solution with high level of automation in all work-processes.

b) Production of digital topographic maps in different scales

A Digital Landscape Model essentially differs from a Digital Cartorgraphic Model in the following ways:

- no symbolic representation (no cartographic generalization)
- no text placement

Various full-scale maps are generated within the *axpand* environment using the appropriate DLM's. The evaluation and/or transformation of the DLM information (statistic data and object attributes) done automated:

- leveraging DLM's and appropriate statistic data, generation of the cartographic objects, as well as appropriate object parts in a seamless geographical database using defined symbolic representation
- adjustment of the map elements (symbol placement and text assignment and/or placement)
- automated cartographic generalization (among other things surfaces, line and symbol displacement, line and surface simplification, surface scaling, surface and line merge)

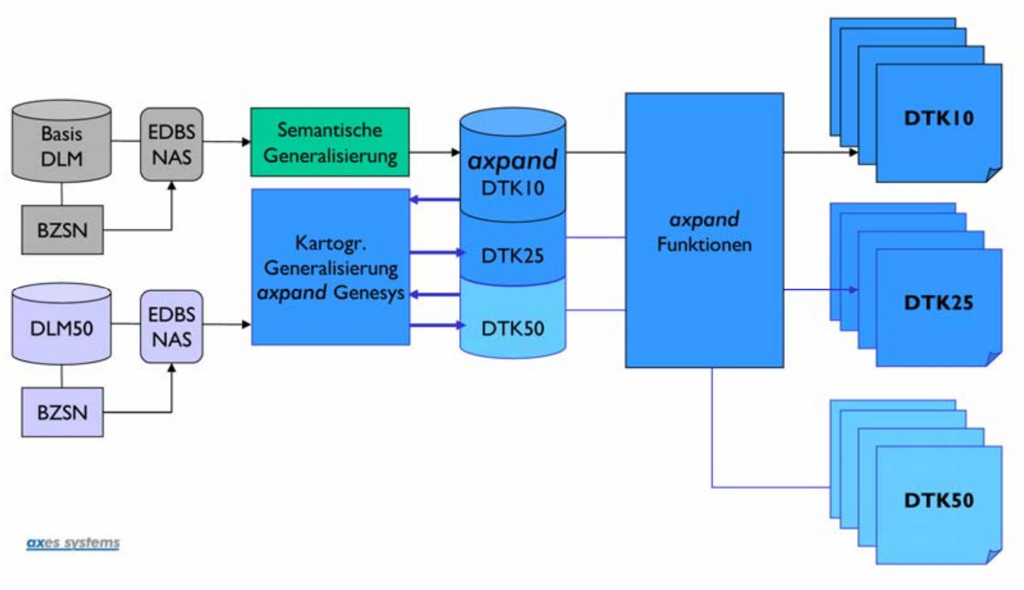


Figure 2: Integrated use of data and products

During the geometrical changes, the topology must be retained so far as possible. Various map sheets and data products can be generated based on the cartographic generalized data. The national mapping agencies of Thuringia (Figure 3) and Saxonia-Anhalt (Figure 4) produce its digital topographic maps DTK10 and DTK25 successfully with *axpand*. In the following some examples are documented.

Figure 3: Basis-DLM to DTK10 – Example of DTK10 produced with *axpand* from national mapping agency of Thuringia.

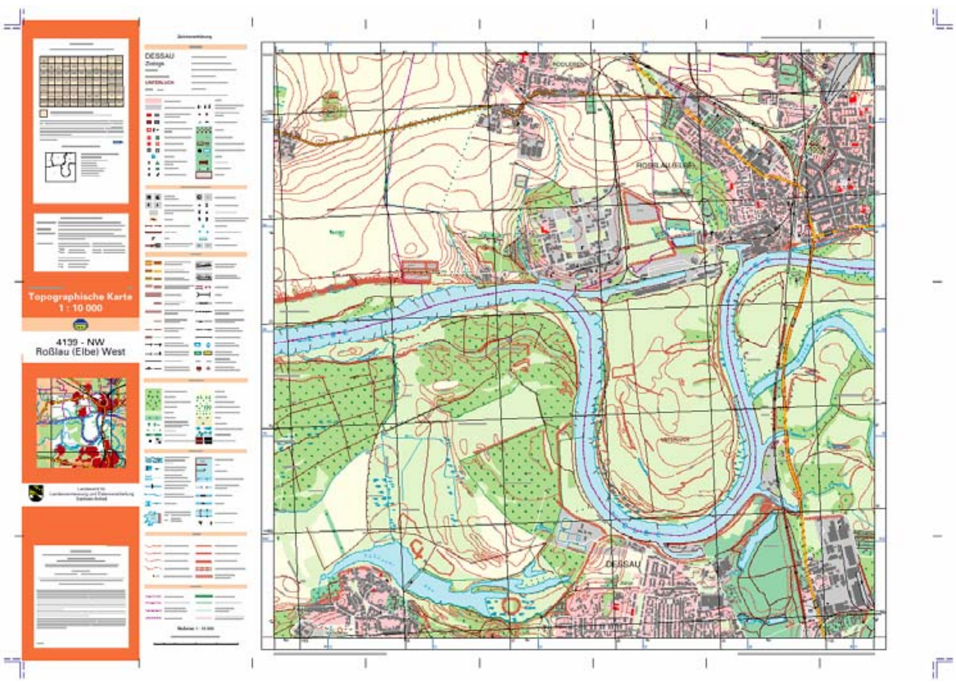


Figure 4: Basis-DLM to DTK10 – Example of DTK10 including legend and title produced with *axpand* from national mapping agency of Saxonia-Anhalt .

Current work at DRIVE project

The current work in the drive project concerns itself with the extension of *axpand* system architecture for binding the generalization components which will be developed in the project. The interface was realized by means of XML RPC (remote Procedure Calling), which specifies also the *axpand* standard for using system functionality from outside by researchers and application developers.

1. Standard based extension of the architecture (Figure 5)

   - binding of the generalization component
   - system opening for research and application development

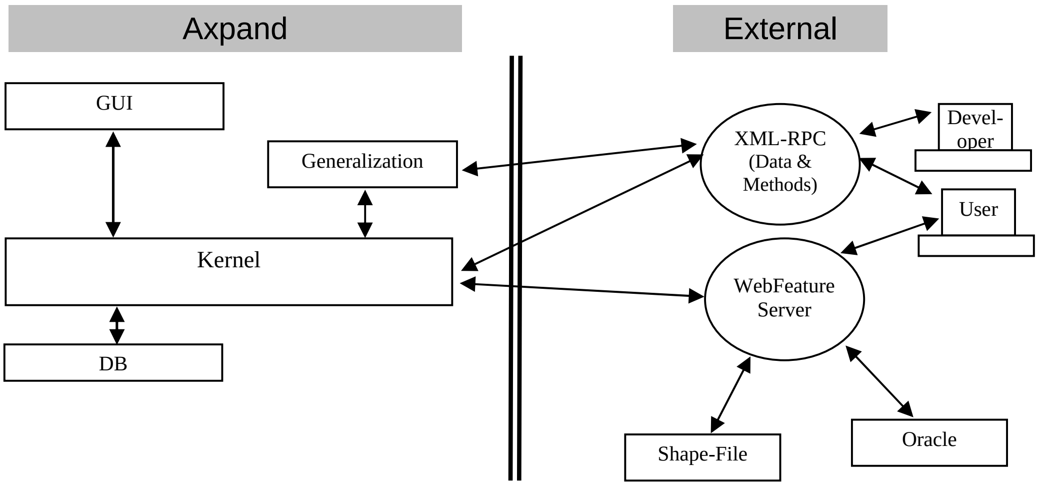
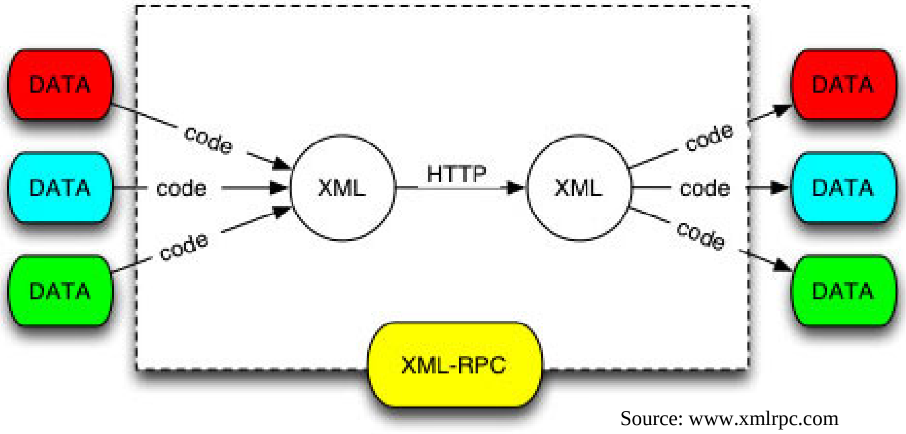


Figure 5: Extension of *axpand* system architecture

2. XML RPC interface

   - XML-RPC is a Remote Procedure Calling protocol that works over the Internet. An XML-RPC message is an HTTP-POST request. The body of the request is in XML. A procedure executes on the server and the value it returns is also formatted in XML (Figure 6). Procedure parameters can be scalars, numbers, strings, dates, etc.; and can also be complex record and list structures.
   - support of GML (Geography Markup LANGUAGE), for exchange of geographic data
   - block-by-block data communication, whose granularity can be to object level



Source: www.xmlrpc.com

Figure 6: XML-RPC interface; standard protocol RPC (Remote Procedure Calling) uses HTTP for transport protocol and XML for encoding

3. Development data model for generalization and updating

- standard-based linkage of derivations using IDs of objects from different scales
- introduction of a relations class, which contains generalization-specific information (Figure 7)

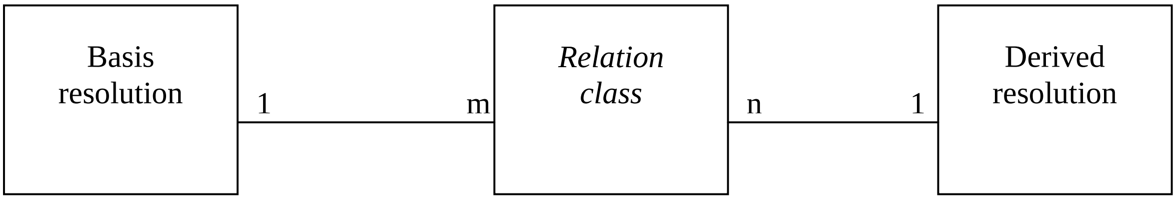


Figure 7: Relation class between objects in original and derived resolution

The following information can be held by the relations class:

- whether derived object was produced interactively or automatically
- whether assigned basis object possesses identical update state
- which generalization operators with which parameters were used
- which objects were involved in the generalization
- date of the last change

Conclusion

A practically oriented generalization project between industry and university was presented. The goal is to extend the generalization functionality of the *axpand*–system and identify relevant research questions. Using such a commercial system saves time on one side while having functionality of map production available and costs time on the other side because a development of interfaces is necessary to connect with the system. The developed interface based on XML-RPC opened the system for other developers and users.

The project will focus on two main research areas. The first part deals with the extension of multi-resolution data architecture to make the update process more efficient. The idea is to have a relation class associated with derived objects to store generalization relevant information. The second part will be used to develop generalization algorithms, especially for groups of objects and to improve the orchestration of generalization operators.

Thanking
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