

## **A Conceptual Model for Web-Based Heterogeneous GIS**

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The exponential network growth and the global connectivity reached in the last few years have had a great impact on the requirements of contemporary and next-generation information systems. Fundamental characteristics include efficient data access, delivery over the World Wide Web, heterogeneity, and interoperability.

Within this framework, we develop a conceptual model for the realization of a web-based GIS incorporating heterogeneous data (e.g., in raster, vector, and textual format) retrieved from different sources. The efficient organization of the underlying databases into structured digital libraries plays a central role in this project.

An essential requirement is fast data exchange. This problem involves two different aspects: (1) interoperability and (2) efficient data access and delivery. Interoperability refers to the capability of autonomous systems to exchange data and to handle processing requests by means of a common understanding of data and requests (Sondheim *et al.* 1999). In GIS, data modeling is an important issue within the context of interoperability, since agreement at the representation level is essential for exchanging geographic data. Specifications on the conceptualization of geographical entities and the space/time reference systems they reside have been provided by the OpenGIS Consortium (OGC 1996a, 1996b). The design of our Internet-based archive will meet interoperability and standardization requirements.

The capability of accessing and delivering data efficiently can be achieved by enabling the system to transmit data progressively. Progressive transmission of raster images over the World Wide Web has been successfully applied to provide the user with coarser

versions of data before downloading a complete image. This process is particularly useful when trying to access large amounts of data remotely through a slow communication link (e.g., a modem). Although communication lines (e.g., fiber optic cable) are getting faster, the current technology still does not adequately support wireless communication. Transmission of large amounts of data across mobile devices will continue to be an impediment for the foreseeable future; therefore, geographers and surveyors who want to access map data of a given area, while performing data collection directly in the field, will certainly benefit from the prompt availability of a coarser version of the map. In this way they will be able to perform initial operations while waiting for the fully detailed file to be accessible.

Current implementations include tools for progressive transmission of raster images and triangular meshes (Bajaj *et al.* 1999; Davis and Nosratinia 1998; Fisher 1995; Junger and Snoeyink 1998). So far, the progressive transmission of vector maps has not been extensively investigated as it presents some inherent challenges. Increasing the level of detail of a vector dataset is a complex and time-consuming process. As a consequence the transmission of vector map data is generally done by means of a one-step long process.

The solution we propose relies on a distributed, client-server architecture. A sequence of generalized representations of a map, each corresponding to a different level of detail, is pre-computed on the basis of sound cartographic principles and stored on the server (Bertolotto and Egenhofer 1999). When the user at the client site attempts to access a vector map, its coarser versions are transmitted progressively, i.e., in the order of increasing detail. Besides being provided with temporary versions of the data on which to perform preliminary operations, the user can decide during the transmission whether the detail of the current representation is good enough for his or her purpose and, if so, decide to interrupt the downloading process.

Finally, our project includes the organization of the system databases into digital libraries of generalized data for fast and efficient use. Different formats of the same data should automatically be chosen by the system to perform different tasks on the basis of efficiency. For example, rasterized (scanned) versions of maps could be provided to the

user for mainly visual purposes while the corresponding vector versions will be progressively transmitted if actual object manipulation is required.

## References

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