GIS FOR THE NEXT CENTURY

Aleš Limpouch
Help Service Mapping Ltd.
Brdičkova 1916, 155 00 Praha 5
Czech Republic
limpouch@cs.felk.cvut.cz

Commission III, Working Group IV

KEY WORDS: GIS, Software, Design, Model, Future Information Systems, Object-Oriented Data Organization, Hypermap Multimedia Environment

ABSTRACT

Computers have introduced geographic information systems (GIS) and digital map production in remote-sensing and photogrammetry. Modern GIS systems should not give only digital forms of maps, but they should provide powerful information systems for retrieval and analyses of spatial data. In this paper, we would like to show the impact of current modern computer technologies, such as object-oriented design, computer networks, object-oriented database management systems and multimedia on future GIS systems and outline our view of advanced GIS systems for the 21st century.

1 Main features of future GIS

Traditional common GIS systems support usually wide range of functionality for the manipulation of vector and raster data as well as for analyses of descriptive information attached to data in databases. This functionality provides only common procedures for data manipulation, access and analyses, which are necessary for users to achieve their goals. Functional orientation of traditional systems provide users with limited support for task-oriented technologies. This is the main reason for the common consideration that GIS is specific professional tool which is hard to use.

Future GIS system should provide users with functionality for processing georeferenced information in user-oriented manner. Information should be accessed in easy-to-use framework which enable users to navigate within increasing amount of information and to find answers to their questions. Open user-oriented GIS systems should help users with management and control of the society and environment in the future.

At present, we can see the first efforts to shift the view of GIS systems from traditional common systems to user-oriented information systems. Modern GIS systems should address user needs more clearly and provide tools for easier adoption of extensions to achieve user goals. Future GIS systems should also support new methods of data organization and data access which enable users to maintain their data in the same way independently of their graphical representation and location in computer networks.

2 Structure of future GIS systems

Sophisticated GIS systems will provide an open object-oriented environment for the development of particular GIS applications and information system for geographical data processing within distributed heterogeneous computer networks. New object-oriented data organization will enable users to access their data in more user-oriented way. Advanced GIS systems will allow to combine vector and raster data and handle these data in combined analyses. A quite new kind of user interface will make full use of the object-oriented system features truly possible. Powerful visual programming languages will give users the possibility to adjust the system to their needs.

Open object-oriented environment based on client-server architecture can be treated as construction kit which will facilitate the development of customized user-oriented GIS applications. GIS server will provide basic functionality for data access and handling and special modules will add more sophisticated functionality for data transformation, processing, man-

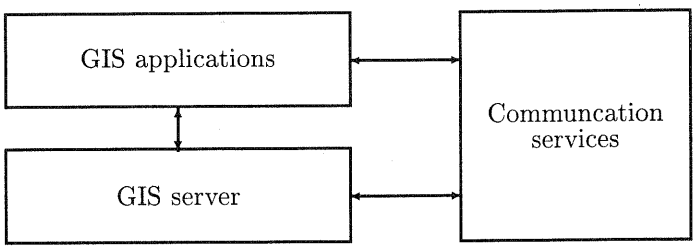

Figure 1: Client-server architecture for future GIS systems.

agement, analyses, modelling and output. Object-oriented organization, client-server architecture and effective development environments enable developers to supply GIS applications (clients) in optimal structure and extent. These applications will have user interface tuned for particular study field, technologies and data.

Correct data exchange and communication with other systems (such as office software) is also necessary. For this reason open data and communication standard are created. The development of GIS system architecture standard is currently done within the Open GIS project. Common standards for data exchange and program communications are developed in computer industry. The most important project seems to be effort of the Object Management Group in the project for access to object data and services within Common Object Request Broker Architecture (CORBA) framework. First experimental implementations of this architecture was created and new revisions of this standard are improved with help of experience from the existing prototypes.

3 Object-oriented data organization

Data are the most critical and important part of GIS technology. Systems based on traditional topologic and topographic data organization are considered to be "real GIS" systems. But classical data organization centered around geometrical objects imposes several limitations on data organization. Such a system should be labelled like *Gis* systems as their are concentrated on geometrical and geographical view at the expense of information and descriptive part.

Future data organization will shift from traditional view based on geometrical objects (points, lines and areas) and layers to user-oriented view based on thematic objects and geographical blocks. Thematic objects encapsulate a complete entity, which contains information attributes, executable methods as well as set of spatially referenced geometrical elements in both vector and raster form. Encapsulated pictures, sound and video clips introduce new media to form sophisticated multimedia GIS systems. These objects provide users with access to essential information to complete their tasks and achieve necessary results.

This information era creates unlimited amount of information data and future developments should create tools for management and access of these data. Spatial catalogues and hypermaps might be solutions for future organization of georeferenced data. Future GIS servers will provide tools for registration of data in spatial catalogues. This catalogues provide users with easier access to large data sources based on their spatial locations. Efficient data query tools should be developed for simplification of data access. Notion of hypermaps with links between objects, blocks and catalogues creates structured framework for data access.

Data exchange within large network environments should be also facilitated with GIS data definition language and format description. These tools should ensure data compatibility for future data access and provide easy way for extension adoption during the future developments. Canadian standard SAIF is the first attempt to create object-oriented data standard with data description language. This standard has also influenced developments within Open GIS project.

Data organization described above require modern computer technologies for data store and access. The development of modern object-oriented database systems enable GIS developers to store GIS data with object organization in natural way. This database systems should be amended with spatial indexing mechanism for data spatial sorting. There are also efforts for specification of common spatial query languages, which provide tool for quick georeferenced data access and analyses of positional relations within GIS systems.

Sophisticated data organization and computer technologies should enable developers to create generic **Geographical Information Management Systems (GIMS)** which will form future generation of GIS systems. Object-oriented extensible data organization and open development environment for the creation of GIS applications based on client-server architecture provide the required base for the effective development of user-oriented GIS applications.

4 Sophisticated multimedia systems

From the point of view of computer technologies the last decade of this century can be considered like

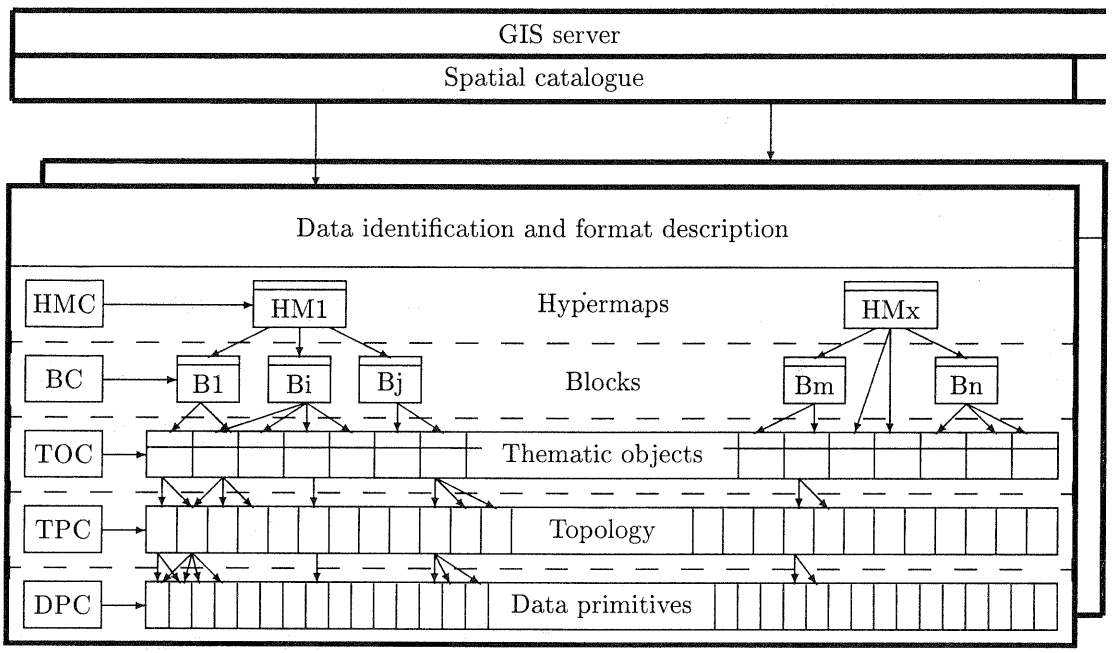

Figure 2: Simplified model of future data organization.

era of multimedia. Multimedia systems spreads into all computer environments and applications. Their use ranges from encyclopedia publishing, education and entertainment to production process monitoring and control. Multimedia technologies can be easily adopted into GIS systems. But the most important problem of current sophisticated multimedia technologies is lack of proper metaphors for their use.

Future GIS systems should solve two main task: adoption of multimedia for the use in GIS applications as well as supply of GIS services for other multimedia applications. But the solution of these problems need not be limited to technological part, but it should be concentrated on questions:

- Why use multimedia in GIS?
- How should be multimedia used in GIS?
- How should be digital map used in other multimedia applications?

It is quite clear that new media (photographs, sound, video, etc.) can increase information value of GIS data. These media are in many cases the most natural way of communicating information. Multimedia enables people to accept various information (e.g. music, actions) in its natural state and in familiar manner. But large amount of information increase potential danger of perception, mind and memory overloading. Multimedia information in GIS systems should be structured and presented very carefully with the help of user-oriented and thematically-oriented data organization.

On the other side adoption of digital maps like new media in common multimedia applications can increase their quality and potential. It is quite clear that people are used to describe positional relations on Earth by maps and in this way maps represents natural media for communication positional information. We can found maps incorporated in many current multimedia applications (such as encyclopedia). For example, they provides information about states which includes not only statistical data, but also simple maps. But these maps are usually closed into this application and cannot be linked with data in other systems. Methods for data exchange and creation of new links to data outside of application (e.g. economic or environmental databases) are important tasks which should be solved in future GIS systems.

5 Hypermap environments

Current era of information technologies has also introduced notion of hypertext and hyperlinked information within large data structures. World Wide Web (WWW) represents a real hit in network environment which provides easy-to-use access to large information databases and big amount of information, data, software and media resources within world-wide Internet network system. This technology brings unconceivable amount of information to screens of computer users. But new methods for information access, search and queries should be introduced to improve these environments, as mind and perception overloading is imminent.

This technology allows to incorporate images (such as maps) into documents. It is also includes simple

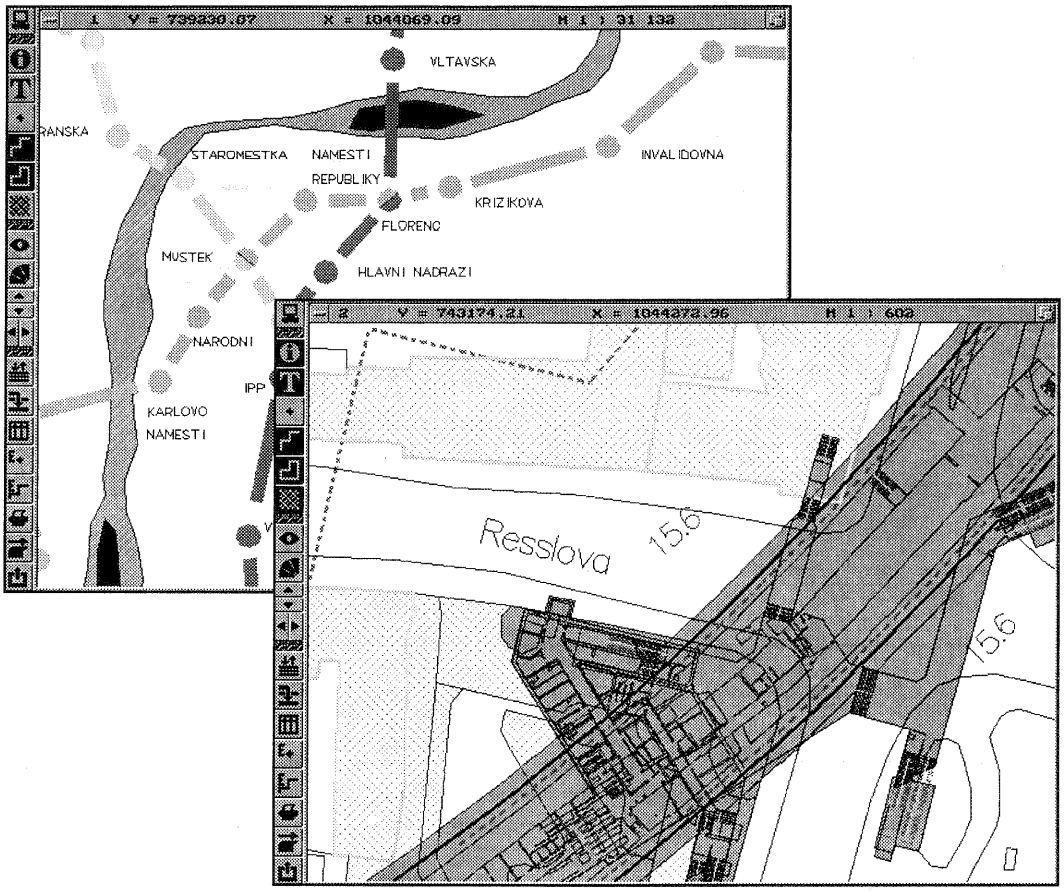

Figure 3: Graphical documentation of Prague underground is organized into simple hyperenvironment according stations and their connections (topoSkop viewer).

methods for definition of links within picture, which enable hypertext document developer to create "sensitive map". This mechanism is very limited and are not appointed for true relations between GIS data. It does not provide any spatial query mechanism for the creation of hyperlinked documents. It seems to be helpful for hyperlink databases (such as WWW) to incorporate some basic GIS technology to provide more sophisticated spatial-oriented data access.

On the other side it should be useful to provide some methods for the creation of hyperenvironment within GIS systems and applications. Live true links between thematic objects, geographical blocks and spatial catalogues create unique notion of hypermap environment which will make future access to necessary details of information easier and more extensive.

The most simple solution provides data link between reference areas and groups of layers. We used this data organization for archive of graphical documentation of Prague underground (see Figure 3) as well as for data resources of several civil councils (district Chrudim, Czech Republic). From experience with our customers, this method provides quite effective tool for access within larger collection of data layers which can be easily divided according to spatial position as well as data use or application.

REFERENCES

[1] Bouille, F. 1994. Towards 2000: The actual main trends in future GIS. Proceedings of Europe in Transition: The Context of GIS, Brno'94, pp. K-13–K-27, MU Brno.

[2] Charvát, K., Limpouch, A. 1995. Quo Vadis GIS: From GIS and GIMS to Open GIS. Proceedings of SOFSEM'95, LNCS 1012, invited paper, pp.334-349, Springer-Verlag, Berlin.

[3] Kubo, S. 1994. GIS for the Twenty-One Century. Proceedings of Europe in Transition: The Context of GIS, Brno'94, pp. K-2–K-5, MU Brno.

[4] OGIS Project Members, 1994. The Open Geodata Interoperability Specification. Draft Base Document – OGIS Project Document 94-0251R1, OGIS Ltd., Wayland, USA.

[5] Spatial Archive Interchange Format: Formal Definition. Release 3.1, April 1994, Surveys and Resource Mapping Branch, Ministry of Environment, Lands and Parks, Province of British Columbia, Canada.