

MAPS AND THE INTERNET 2002

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Foreword

The International Cartographic Association (ICA) is the world authoritative body for cartography, the discipline dealing with the conception, production, dissemination and study of maps. The mission of the ICA is to promote the discipline and profession of cartography in an international context. The International Cartographic Association exists:

- to contribute to the understanding and solution of world-wide problems through the use of cartography in decision-making processes;
- to foster the international dissemination of environmental, economic, social and spatial information through mapping;
- to provide a global forum for discussion of the role and status of cartography;
- to facilitate the transfer of new cartographic technology and knowledge between nations, especially to the developing nations;
- to carry out or to promote multi-national cartographic research in order to solve scientific and applied problems;
- to enhance cartographic education in the broadest sense through publications, seminars and conferences;
- to promote the use of professional and technical standards in cartography.

In 1999, recognizing the influence of the Internet on cartography, the ICA formed the "Maps and the Internet" commission. Commissions of the ICA bring together cartographic researchers from throughout the world to address specific problems facing the discipline. At the meeting in Ottawa, Canada, the commission adopted the following terms of reference:

- Focus attention on disseminating maps and spatial data through distributed electronic networks.
- Examine Internet map usage and project future areas of growth.
- Examine web map user issues to better serve user needs. Promote the exchange of information about effective Internet mapping for an international audience. Collaboration / coordination with the ICA commission on visualization and virtual environments.
- Improve user access to maps by examining the potential of Internet map metadata.
- Promote instruction on Internet mapping through collaboration /coordination with other ICA commissions.

The commission held its first international meeting in Knoxville, Tennessee, in October of 2000. The one day symposium was sponsored by the commission and the North American Cartographic Information Society (NACIS). A "Maps and the Internet Workshop" was held in Guangzhou, China, July 31 - Aug. 2, 2001. Co-sponsored by the Guangdong Academy of Science and South China Normal University, the workshop was attended by nearly 100 participants from 11 different countries. These proceedings, published by the Institute of Cartography and Geomedia Technique at the Vienna University of Technology in Austria, are from the third formal meeting of the Maps and the Internet commission.

The rapid growth in the use of the Internet over the past decade has been astounding. Most of this growth can be attributed to the World Wide Web. Conceived at the European Particle Physics Laboratory (CERN) in Switzerland, the WWW introduced the principle of "universal readership," a concept that networked information should be accessible from any type of computer in any country with a single program. In June of 1993 there were only 130 web servers. By mid-1995 there were 23,500 web servers and this had grown to 230,000 by 1996 and 2.4 million by 1998. By 1999, the web generated 68% of all Internet traffic while e-mail and FTP each had about 11%. The Web now dominates the Internet.

As the web has become increasingly commercialized, a considerable amount of data has been collected on web usage. The number of Internet users is growing rapidly. According to the Computer Industry Almanac, there were over 533 million regular Internet users worldwide at year-end 2001 or about 8.7% of the world's population (www.c-i-a.com). This is up from 200 million users at year-end 1998. At current growth rates, it is expected that this figure will reach 945 million by 2004, 1 billion by 2005 and 1.46 billion by 2007.

Examining how maps are distributed and used is important in understanding trends affecting cartography. Through the web, a new generation of map users is interacting with maps in an entirely different way. The traditional

cartographic products may have little meaning to these "new" map users once they have been exposed to interactive mapping through the web.

More than any other technological development in the past century, the web forces us to examine the purpose of cartography and our means of map distribution. For many applications, the web may serve as the best medium to communicate spatial information in an economical and efficient manner. Or, perhaps, the web will generate greater interest in maps of all kinds. As cartographers, it is important for us to understand changing use and attitudes about maps.

Michael P. Peterson
Chair
ICA Commission on Maps and the Internet
Omaha, Nebraska

Foreword

The Annual Meeting of the ICA Commission on Maps and the Internet 2002 is taking place at Karlsruhe, Germany and is organized by the Institute of Cartography and Geomedia Technique of the Vienna University of Technology in Cooperation with the University of Applied Sciences Karlsruhe.

Annually the Commission activities are culminating in the Commission Meetings where the intention of bringing together international specialists in the field of Internet Mapping and to disseminate information to a broader audience on new developments and major areas of research is pursued. Therefore it has been a common interest, to have - after meetings in Ottawa (Canada 1999), Knoxville (USA 2000) and Guangzhou (China 2001) - a meeting 2002 in Europe.

The location "Karlsruhe" has been chosen mainly due to two reasons: central location from a European point of view; and optional connection to a regional Internet Cartography Symposium. The organizers of the annual german speaking "Web.Mapping" - Symposium, namely Prof. C. Herrmann from the Karlsruhe University of Applied Sciences and Prof. H. Asche from the Potsdam University, have agreed on the idea, to hold the ICA Commission Annual Meeting 2002 in conjunction with their Symposium at Karlsruhe, Germany.

The resulting program includes various topics, covering all fields of the Commission's Terms of Reference. Contributors from thirteen different countries prove that the actuality and importance of Internet Mapping is still increasing and the location Karlsruhe meets the interest of the Commission Members.

This issue of the "Geowissenschaftlichen Mitteilungen", a joined Journal of the Departments of Geosciences at the Vienna University of Technology, is therefore especially dedicated to the contributors of the 2002 Meeting of the ICA Commission on Maps and the Internet.

For the help with organizing the meeting and publishing this journal I would like to thank the Karlsruhe Organisation Team, namely Prof. C. Herrmann, Prof. H. Asche, Prof. P. Freckmann and Mr. O. Kovac, and the Vienna Organisation Team, namely DI Susanne Uhlirz.

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Theory and Research in Maps and the Internet

The Development of Research in Maps and the Internet

Michael P. PETERSON

1 Introduction

Within a span of less than a decade, the Internet has become a major medium for cartography. Millions of maps are now transmitted through the Internet every hour; many more maps than are printed on paper. Cartographers have responded to this new medium by exploring the potential and limits of the Internet for map distribution. As we embark on a new area of research, it is important that we understand related areas of research in cartography, the importance of theory and the nature of science.

Research related to the distribution of maps through the Internet has been based mostly on developments in technology. To a large degree, research in the area has concentrated on adapting the needs of cartography to the new tools (Java, JavaScript, SVG, etc.). While this approach keeps cartographers from “falling behind” in terms of technology, it limits the development of underlying theories that can guide developments in the area. Rather than relying on theory to guide research, researchers in cartography are put in the position of constantly chasing technological developments. The purpose here is to establish a theoretical foundation for research related to the distribution of maps through the Internet. Research in this area has its basis in at least five theoretical developments in cartography.

The future development of cartography is based on the Internet. The future of cartography is largely tied to this new medium. This chapter reviews research in cartography, past and present, and relates them to the emerging area of Internet Cartography.

Scientific and technological developments are based a common understanding of an underlying set of principles among a group of researchers. Research by one group is related to past research conducted by other groups in the discipline. At least five areas of research can be identified in cartography over the past half-century. These areas of inquiry will have a strong influence on future research conducted in cartography. The five areas identified here are *cartographic communication*, *analytical cartography*, *cartographic visualization*, *multimedia*, and *the power of maps*. Before we examine these related areas of research, it is important that we understand the nature of scientific inquiry.

2 Theory and Paradigms in Cartography

A word *theory* is used to refer to a concept that has not been verified but that if true would explain certain facts or phenomena. It is commonly interpreted as an organized system of accepted knowledge that applies in a variety of circumstances to explain a specific set of phenomena. In science, the word is synonymous with hypothesis, and hypothesis is commonly used as another term for conjecture. The terms *theory* and *theoretical* are sometimes used in opposition to the terms *practice* and *practical*.

The primary task of scientists is to bring the accepted theory and fact into closer agreement. Thomas Kuhn popularized the term paradigm, which he described as essentially a collection of beliefs shared by scientists – a set of agreements about how problems are to be understood. According to Kuhn, paradigms are essential to scientific inquiry, for “no natural history can be interpreted in the absence of at least some implicit body of intertwined theoretical and methodological belief that permits selection, evaluation, and criticism” (KUHN 1962, p. 6). Indeed, a paradigm guides the research efforts of scientific communities, and it is this criterion that most clearly identifies a field as a science.

A fundamental theme of Kuhn’s argument is that the typical developmental pattern of a mature science is the successive transition from one paradigm to another through a process of revolution. When a paradigm shift takes

place, "a scientist's world is qualitatively transformed [and] quantitatively enriched by fundamental novelties of either fact or theory." As a consequence, scientists tend to ignore developments in technology that might threaten the existing paradigm and trigger the development of a new and competing paradigm. For example, Ptolemy popularized the notion that the sun revolves around the earth, and this view was defended for centuries even in the face of conflicting evidence (KUHN 1962).

Kuhn argues that science is not a steady, cumulative acquisition of knowledge. Instead, science can be characterized as peaceful interludes punctuated by intellectual revolutions which he described as "the tradition-shattering complements to the tradition-bound activity of normal science" (p. 6). After such revolutions, one conceptual world view is replaced by another.

The problem is that many of Kuhn's ideas have become part of the postmodernist paradigm. According to postmodernism, Western science is hardly neutral and objective. Instead it is full of unexamined prejudices and preferences and presumptions. Kuhn also gives the process of paradigm shift an authoritarian cast, comparing scientific groups to the ruling classes of Orwell's "1984." Anybody who disagrees with the dominant scientific paradigm, he said, is "read out of the profession." In fact, Kuhn suggests, it is only when there is unanimity about a paradigm that science comes to believe it is progressing.

PETERSON (1999) argues that the concepts of paradigm and paradigm-shift are germane to changes brought about by the Internet in cartography (p. 34). Similar to Kuhn's paradigm shift, the Internet has introduced a rapid, discontinuous change in cartography. The frightening aspect of Kuhn's paradigm shift is that, like a revolution, it obviates all prior work. In cartography, this would mean that all work related to the print medium – essentially everything we know about maps and their construction – would need to be thrown out. This prior knowledge would simply no longer be valid. Further, by keeping any of it, we would be corrupting our ability to use the new medium.

Researchers are guided by paradigms. Researchers in cartography, over the past half-century, have been influenced by at least five major paradigms. All of these areas of research have an influence on the development of cartographic research related to the Internet.

3 Paradigms in Cartography

A paradigm is a common core of beliefs about what represents a valid area of research. Four paradigms can be loosely identified within cartography:

3.1 Cartographic Communication

The theoretical basis for the cartographic communication paradigm began in the 1950s with the work of ROBINSON (1951). Influenced by communication theory, cartographers began to view the cartographic communication process as a series of steps. Each connection between the stages of the "cartographers mind" and the "map users mind" as shown in Figure 1 represents a potential for a loss information. In other words, maps transmit messages encoded using a graphical language that is subsequently decoded by the reader. This encoding and decoding process is not without error.

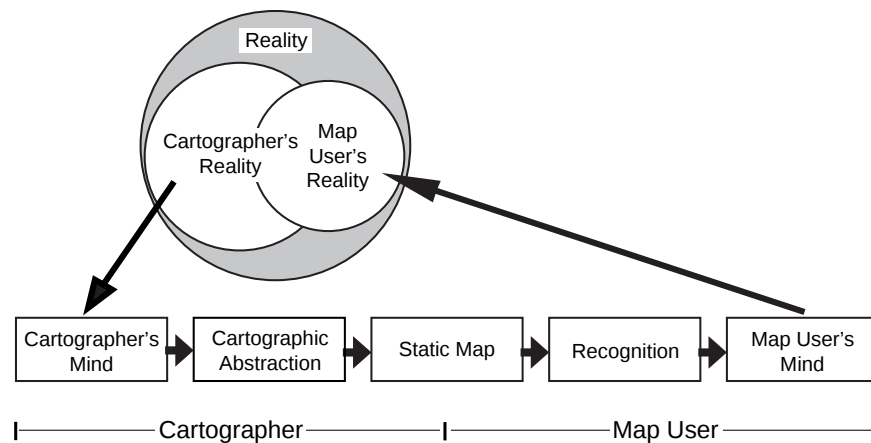


Fig. 1: The Cartographic Communication Model

Cartographers borrowed research methodologies from psychology, particularly psychophysics and cognition, in an attempt to improve the design of maps from a more scientific perspective. The underlying theory of this research was that maps were composed of elements that communicate information. Improving the design of these elements through scientific methods would improve the communication potential of the map. Research in psychophysics related to the scaling of symbols was later discredited because different research designs led to different results (CHANG 1979). Research into the cognitive aspects of maps is ongoing but is done more from the perspective of how humans process spatial information – rather than with the intent of improving the design of maps.

By the 1990s, interest in research related to cartographic communication had faded. PETERSON (1994, p. 27) points out that the introduction of the PC in the 1980s had redirected the attention of cartographers to this new tool. For whatever reason, the paradigm had faded and cartographers became less concerned with altruistic goals of cartographic communication. The research direction had a long-term influence on cartography because it had led to an increased understanding and interest in the discipline about communication with maps.

3.2 Analytical Cartography

Analytical cartography is most closely associated with Prof. Waldo Tobler and his students at the University of Michigan in early 1970s. The analytical approach focuses on transformations of information inherent in cartographic procedures. It was in contradiction to the “communication school” because the procedures were more central than the map product, or its use.

MOELLERING (2000) states that analytical cartography had grown from Tobler's concept of “solving cartographic problems” into a broader and deeper scientific specialization that includes the development and expansion of analytical/mathematical spatial theory and model building. A primary goal is to expand the mathematical/analytical theory of spatial data analysis, and theory building and analytical visualization. Applications of analytical cartography include terrain visibility (including visibility indices, viewsheds, and inter-visibility), map overlay (including solving round-off errors with C++ class libraries and computing polygon areas from incomplete information), mobility, and interpolation and approximation of curves and of terrain (including curves and surfaces in CAD/CAM, smoothing terrains with over-determined systems of equations, and drainage patterns). A concern in this analysis is simplicity, robustness, and the tradeoff between different data types (FRANKLIN 2000).

Analytical cartography may be best viewed as a “mathematical cartography,” having its lineage in the very mathematical work of map projections (an early interest of Tobler’s). Students of cartography, mostly geographers, who were initially attracted by the graphical nature of the discipline, never adapted well to the mathematical character of research in analytical cartography. The goals of analytical cartography, which could be as mechanistic as improving the efficiency of a certain algorithm, were no match for the broader and more noble goal of improving the map as a form of communication. As a result, interest in the area of research remained limited.

3.3 Cartographic Visualization

The idea of cartographic visualization was initially expressed through a graph by DiBiase, since referred to as the “swoopy” diagram (see Figure 2a). In this graph, cartography is defined into two fundamental activities: visual thinking and visual communication. Visual thinking occurs in the private realm and consists of the activities of exploration and confirmation. Visual communication, the public realm of cartography, involves synthesis and presentation. MACEACHREN (1994) introduced the visualization cube (see Figure 2b) that added the two dimension of human-map interaction and the presenting knowns / revealing unknowns. Visualization, it is argued, takes place in the high interaction–private–revealing unknowns part of the cube.

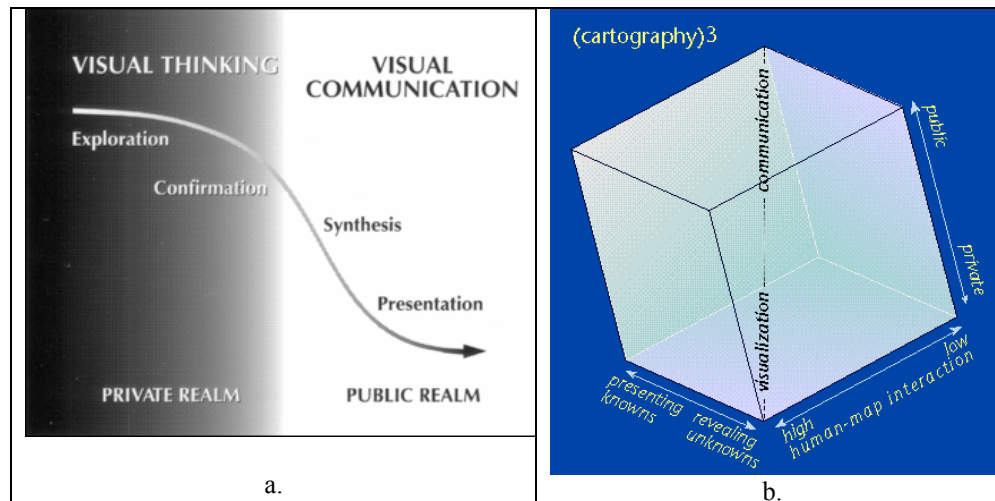


Fig. 2a: The visual thinking/visual communication curve referred to as “swoopy” developed by DiBiase (1990).

Fig. 2b: The visualization cube developed by MACEACHREN (1994).

The focus of current research is developing human-centered methods and technologies that make it possible for scientists and decision makers to solve scientific, social, and environmental problems through computer-supported, visually-enabled analysis of the growing wealth of geospatial data. Current research foci within geovisualization emphasize four interconnected themes: (i) Integrated methods for knowledge construction, (ii) Geocollaboration, (iii) Human understanding of and interaction with geospatial information and (iv) Decision support and risk management.

The distinction between maps for presentation and maps for exploration may be an artificial one (PETERSON 1996, 1999). Every map is used for analysis, even those supposedly made for presentation. Everyone who uses a map engages in the process of cartographic visualization. As portrayed, cartographic visualization seems to suggest a “higher form” of map use usable by only an elite “few.” The elitist aspect of cartographic visualization is related to the tradition of exploratory data analysis in statistics. Here, the emphasis is on the use of graphics in the development of ideas, not merely the use of graphics in their presentation (UNWIN 1994, 517). But, the distinction between analysis and presentation with any type of graphic display is a tenuous one, especially in cartography. Map use is by definition an inquisitive and analytical process. Every map can be used for analysis, even maps on paper that are designed for ‘presentation.’

The “maps for the few” notion that underlies geovisualization is an outgrowth of Geographic Information Systems, which are so complicated to use that they can only be operated by a limited number of highly trained individuals. If such systems exist that are only meant for the few, then it is naturally easier to put maps in this context as well. It should be remembered that maps can help everyone to understand the world and can provide information to make important decisions. A research emphasis that is designed to help only the elite few will not gain the support of a significant group of researchers.

3.4 Power of Maps

The role of cartographers as "neutral presenters of information" was brought into question in a post-modernist research agenda that emerged in the late 1980s. This movement is most often associated with a book entitled *The Power of Maps* by Denis WOOD (1992). He argues that maps are an instrument of the nation-state to wage war, to assess taxes, and to exploit strategic resources (p.43). The nation-state is mostly interested in stability and longevity. To this end, cartography is "primarily a form of political discourse concerned with the acquisition and maintenance of power" (WOOD 1992, 43). Wood argues that ethical considerations in cartography concerning accuracy and communication may not be as important as serving the needs of the nation-state.

The beginnings of this critical analysis of the foundations of modern cartography can be traced to Brian HARLEY (1990). Harvey was influenced by the ideas of constructionism, the theoretical formulation of post-modernism. Modernity, or logical positivism, attempted to describe the world in rational, empirical and objective terms. It assumed that there was a truth to be uncovered, a way of obtaining answers to the question posed by the human condition. Post-modernism questions this confidence. Logic and reason are viewed as historical artifacts, as parochial as the ancient explanations of the universe in terms of Gods (JENCKS 1996). From this viewpoint, Harley showed how maps are made to appear as unbiased reference objects, though they actually depict a subjective point of view. He discusses the signs and myths inherent in maps and suggests ways to decode the interests implicit in their representation. Harley writes:

Pick a printed map or manuscript map from the drawer almost at random and what stands out is the unflinching way its text is as much a commentary on the social structure of a particular nation or place as it is on its topography. The map-maker is often as busy recording the contours of feudalism, the shape of a religious hierarchy, or the steps in the tiers of a social class, as the topography of the physical and human landscape. (HARLEY 1989, p. 6)

He goes on to write:

Power is exerted *on* cartography. Behind most cartographers there is a patron; in innumerable instances the makers of cartographic texts were responding to external needs. Power is also exercised *with* cartography. Monarchs, ministers, state institutions, the Church, have all initiated programs of mapping for their own ends. In modern Western society maps quickly became crucial to the maintenance of state power -- to its boundaries, to its commerce, to its internal administration, to the control of populations, and to its military strength. (HARLEY 1989, p. 12)

The Power of Maps movement attempted to unmask the map for what it is: a communication tool imbedded in culture, history, selected perspectives that led to bias. Even the most simple map is a highly selected, generalized, and symbolized picture of something the mapmaker wishes to communicate. In keeping with this, HARLEY (1990) argues that the technological dimension cartography has managed to overwhelmingly dominate the discourse in the field. He argues that this technological dimension did not only become the one new shape of medium for our knowledge, but truly "the message." Harley makes such a reference to the ideas of McLuhan in order to specify that, under the influence of the computer, cartographers are more interested in technological questions rather than in the social consequences of what they represent.

4 Maps and the Internet

A major research interest in maps and the Internet has only developed since about 1995 and was strongly associated with the growth of the World Wide Web. CRAMPTON (1995) looked at the potential of the web for map distribution.

A basis for much of the development of maps and the Internet is the underlying notion that while an individual map distributed through the Internet may not by itself communicate as much as the corresponding map on paper (because of limitations in the resolution of the computer screen), the Internet makes it possible to distribute the map to many more people. Therefore, the sum total of map communication across all individuals is greater with the Internet.

Examining the “sum total of map communication” is closely related to research in map use. In fact, much of the early research associated with maps and the Internet concerned the number of maps being distributed through the Internet. The underlying goal of this research was to show that there was a fundamental shift in the way people accessed maps, and that this could be assessed in some way by looking at . However, the theory of map use was never as developed as cartographic communication – and never really separated completed from it.

A third area concerns media theory. Although new to cartography, the area of research is best represented by research in ‘multimedia cartography’ (CARTWRIGHT, PETERSON, GARTNER 1999) The goal of this research is to examine the incorporation of multiple forms of media with maps. Bordering on virtual reality, multimedia cartography intends to both convey a better and truer image of the reality than can be depicted by the map itself, and create a more conducive map use environment that will attract people who normally do not use maps on paper.

The fourth theoretical development related to the distribution of maps through the Internet is the general area of map ethics and map power. Although sometimes associated with post-modernism, this area of research presents a number of ideas that influence our research.

5 Conclusion

PETERSON (1999) argues that the concepts of paradigm and paradigm-shift are germane to changes brought about by the Internet in cartography (p. 34). Similar to Kuhn’s paradigm shift, the Internet has introduced a rapid, discontinuous change in cartography. The frightening aspect of Kuhn’s paradigm shift, like a revolution, obviates all prior work. In cartography, this would mean that all work related to the print medium – essentially everything we know about maps and their construction – would need to be thrown out. It would simply no longer be valid. Further, by keeping any of it, we would be corrupting our ability to use the new medium.

The distribution of maps through the Internet will continue to grow and expand. The development of theory to guide research in cartography is important for the discipline to properly incorporate this new medium.

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Dissemination of Census and other Statistical Data through Web Maps

Corné P. J. M. van ELZAKKER and Ferjan ORMELING, Barend J. KÖBBEN, Daisy REDIDO-CUSI

Extended abstract

A Census is usually understood as the process of collecting information on the official count of the human population of a specific area of interest or country as a whole. Such a survey, that has become one of the Government's mandates in many countries, is often conducted every 5 or 10 years by some kind of national statistical organization (NSO). Census data are collected at the household level, enumerating its individual members, as well as the respective housing conditions. As, in principle, every household is enumerated, the result is the most complete and accurate demographic and socio-economic dataset of a particular territory you can think of. However, Censuses are not taken in every country in the World. In the Netherlands, for instance, the Census has stopped, in order to protect the privacy of the individual citizens. In countries without a Census, the necessary statistical data on the population are collected by NSO's in various other ways. Use can be made of municipal registries or of sample surveying techniques. In this way, almost every country in the World -whether it conducts a Census or not- has some kind of NSO that collects statistical data and also makes these data available to their users. These users may be government officials, scientists, planners or, for instance, private companies looking for markets.

Until recently, Census and other statistical data were only disseminated on paper and mostly in textual or tabular form. Quite often the help of an official of the NSO was required to find the data the user needed. Since a number of years, however, the data can also be made available in digital form, i.e. on diskette, CD-ROM or other data carrier. The obvious advantage to the users is that they may import the data directly into a computer environment for analysis and, with the help of interactive search facilities, it may be easier to find the data required. However, problems that remained were the necessity to contact the NSO's to identify and order the data products and, most importantly, the fact that the time-lag between the collection of the statistical data and their publication could still be considerable.

In this respect, the recent rise of the World Wide Web (WWW) as a possible means for data dissemination has two very big advantages over other electronic means like diskettes or CD-ROMs. These advantages may be summarized under the headings accessibility and actuality. Accessibility means convenience in accessing the whole lot of data anytime and from anywhere (as long as there is Internet access). Actuality refers to the potential of making the data available to the user immediately after their collection. That is why many NSO's are now making serious use (or are planning to make use) of the WWW as a means of statistical data dissemination.

As said, Census data are collected at the household level. One attribute of each household is its address, or location in geographical space. Normally, because of reasons of privacy, data are not made available for individual households. The data can be made available for enumeration areas (in which a number of households are living together) and for several higher levels of aggregation, up to the national level. In countries without a Census, demographic and socio-economic statistical data are often also made available for administrative units at various levels of aggregation. However, in these countries the geographical level of detail is often less than that in countries with a Census. But in both cases the statistical data do have a clear geographic component. And this makes it possible for Census geographers to analyze spatial patterns, trends and anomalies. In this process maps have always been and still are invaluable tools to get insight into and overview of the statistical data. In the past, maps could not be used to their full potential in Census geography. It was not so easy and very time-consuming to produce paper maps and hence they were quickly outdated or gave a wrong impression to the user. Therefore, Census data were not often disseminated in the form of paper maps and the statistical reports mainly contained text and tables. But because of the development of more and more user-friendly GIS and cartographic software statistical maps can now be generated much more easily and quickly. And, for analysis and presentation, many of the statistical data that are acquired in digital form (e.g. on diskette or on CD-ROM) are imported directly into this kind of software that is installed on the computers of the users. Nowadays, data can also be downloaded from the Internet for this purpose.

But users do not necessarily have to install the GIS or cartographic software themselves. They may also get access to, insight in and overview of geostatistical data through Web maps, i.e. maps that are displayed, generated or disseminated through the WWW. Traditional and new functions of map displays, coupled with the advantages of accessibility and actuality of the Web, make them very powerful tools indeed for on-line Census and other geostatistical data analysis. An illustration of this potential was provided in the Netherlands in May 2002 when a cartographic representation of the results of the elections (another kind of statistical data) was adjusted and immediately disseminated through the WWW as soon as the results from the individual municipalities were gradually made available during the evening of the election day. And, besides actuality, one aspect of the accessibility of Web maps -as compared to e.g. paper maps- are the costs of dissemination: once the hard- and software configuration and the Internet connection are there, it is much cheaper to use the WWW. As an illustration, the printing costs for a recently published paper colour atlas of 66 pages of Census data for Omaha (USA) were over US\$ 70, excluding labour and distribution.

The core of this paper deals with the roles Web maps may play in the dissemination of Census and other statistical data. These roles will be summarized under the headings:

- Web maps as geographical interfaces for finding and retrieving Census and other statistical data
- Web maps as a means of presentation
- Web maps for on-line analysis and exploration

These functions are illustrated with examples from the Netherlands and the Philippines. But, before that, a worldwide inventory is presented of the currently existing websites of NSO's and their functionalities and characteristics, including their cartographic aspects. A final section deals with the peculiarities of the hard- and software requirements for making it possible for Web maps to function in the various ways presented.

Note:

The full text of this paper will be published as a Chapter in PETERSON, M.P. (Ed.) (2002), *Maps and the Internet*. Amsterdam: Elsevier Science (forthcoming)

Modelling the Visualization of Internet-Maps and its Post Processing - The Making of a Map for Logistic and Travel Planning

Lars BRODERSEN and Marlene MEYER

1 Introduction

National Survey and Cadastre Denmark has developed a new map for Internet based travel planning. The development of the map has been supported by a method ensuring that all aspects are analysed in the correct sequence, and that work processes take account of the logical consequences of this. The result of the project will be discussed as well as to which extend the method has been followed and to which extend the method is applicable to the project.

2 Method

A method (BRODERSEN 2001) has been developed to bridge the gap between the traditional knowledge 'how to make a map' (usually topographic maps) and the new infrastructure originated demands of ability to produce all sorts of maps and graphic presentations of geodata. The purpose of the method is to guide the involved people through the necessary (mental) aspects of the project in the right order, and to force them to draw the logical consequences.

According to that method a map is produced because someone has decided that there is a need for information to be transmitted (a communication). Nothing comes into existence by itself.

The tasks of the commissioning (usually the customer) party are to describe:

1. The purpose: Why is the map to be produced?
2. The target group: Who is to use the map?
3. The aim: What should the format be – and when?

The producer's (the cartographer) task is to describe:

4. Use model including what questions are the users going to ask?
5. Modelling of the information contained in the map?
6. Appearance of graphics?

When talking about communication the word quality should be understood as 'the properties of a communication'. The ultimate aim for the cartographer is that his map offers the user the possibility of *quickly* and *in a safe manner* getting *correct* answers to relevant *questions*.

The production of a map is a lengthy process, which involves various disciplines. The project has to be initiated, the aims have to be formulated and a target group defined, data sources have to be defined, the data has to be modelled and generalized, the manner of graphic presentation has to be decided upon, various editing procedures etc. has to be carried out, implementation of the map into the software and the Internet portal has to be done and finally there is the promotion and dissemination.

2.1 Purpose

The first job of the *commissioning party* is to find out *why* the map is to be produced (the purpose). Is it to raise support for a better political understanding of the regions transportation structure? Is it in order to make money?

Will the map serve as an advertisement for a particular transportation company? Will the map serve as a mean to change people's transportation behaviour from private to public transportation? Why are we getting under way?

2.2 Target Group

Secondly, the commissioning party must think about who is going to be the user of the map. There is a big difference between making a map for a family's bank holiday jaunt, everyday commuters, tourists, or a battalion of soldiers advancing in the field.

2.3 Aim

Thirdly, the commissioning party must (possibly in cooperation with the cartographer) decide on the general appearance of the map and the deadline, so that it will effectively serve its purpose (the aim). The aim describes the result of the project. Further should be considered what the criterions of success are: A map that results in 20% more customers in the next three weeks at this particular transportation company? Or, so that the guests to a confirmation party can find their way to the church hall with the help of the travel planning service and the map and without having to ask for directions?

2.4 Use Model

When the commissioning party has formulated the purpose, target group and aim, the cartographer takes over the task and determines what information is to be transmitted in order to fulfil the purpose, activate the target group and meet the aims.

The context of use must be described. How is the map to be used? What information is to be gained from the map? Is the map to be used on a properly lit desk or is it to be used at night out of doors? Is it to be used as the basis of a discussion or as an illustration at an exhibition?

The cartographer must study the context of use thoroughly and simulate the customer's use of the map. Only in this way the cartographer will get an insight into how the user will interpret and use the map. Only then will the cartographer be able to tailor make the map and avoid misinterpretation. In practice this means that the cartographer must play the role of the user as completely as possible.

2.5 Information Model

The user comes with a whole flurry of questions when he is to use a map. It is the commissioning party's and the cartographer's job together, to anticipate these questions. On the basis of these supposed future questions the commissioning party and the cartographer must define what questions the map should allow and what information the map should contain. The questions can localize the target group's needs.

When the information has been selected, there is no advantage in just throwing it onto the map haphazardly. If there is coherence between information, if there are groups or rank order or important variation then these must be shown on the map. Thus the cartographer sort and filter the information so that variation, rank order, groups and size can be expressed. Sorting and filtration take place as another logical conclusion of the expected use of the map. The organized data is deployed in the cartographer's final task.

2.6 Appearance of Graphics

The selected information can be presented with colour, form, size, pattern etc. These cartographic means of presentation (or the 'graphic variables') have particular characteristics, which have to be taken into account when they are applied to the data in order to achieve the desired interpretation by the user.

3 Case

3.1 Initiation of Project

The customer or the commissioning part is a co-operation of public transportation companies in Denmark offering a nationwide Internet based travel planner (the 'Travel Planner') for users of public transportation. In 1999 KMS produced a web map for the web service covering greater Copenhagen. In 2001 the co-operation wished to improve the functionality of the applications as well as extend the map to cover the entire country and KMS started the development, which was set up as a KMS project.

KMS expected an increasing interest in Internet maps and therefore decided to develop a standard web product which at first hand should be aimed at and produced for the co-operation, but which could be used in a wider context in the travel and logistics line of business.

3.2 Identity

On the basis of the commissioning party's request the following was defined:

Purpose of the map is to offer a standard map product to providers of Internet services, primarily within the logistics and travel line of business.

However, throughout the project it was not quite clear whether the project was dealing with a solution to a commissioned task or dealing with the creation of a new product for KMS's product line for general sale and use. One example of this confusion was that the project-name was 'The Travel Planner', whereas the product was called 'the standard product'. Further the project plan did not place the responsibilities for future, further development of 'the standard product' after production and delivery to the customer. Questions concerning the general design of the standard product were therefore left unanswered.

Target group of the map is primarily a costumer using the 'Travel Planner' when planning travel and transportation. Secondly 'the standard product' should be used by employees in organizations using route planning as a tool for optimising company logistics. Likewise the purpose of the map, the definition of the target group was duplicated throughout the project.

The aim (for 'the standard product') was to produce a web map with national coverage, based on the national topographic database in the scale of 1:10 000. The map should enable seamless zoom from street to national level. Further, it was the aim to produce a web map of considerable higher cartographic quality than similar products on the marked including the previous deliverance to the 'Travel Planner'.

The product consists of a map canvas and an underlying network consisting of traffic network (roads and transportation routes) as well as addresses on 'doorstep level'.

It was the aim (for 'the standard product') to produce a map that could be used by a wide range of users, independent of GIS-platform. The product itself contains therefore no GIS functionality such as zoom, pan, map tips and search facilities.

3.3 Use Model

As mentioned above the aim of the standard product is quite wide and therefore not well defined. The following use model is, however, aimed at the 'Travel Planner' exclusively.

The typical use case for the 'Travel Planner' describes a user intending to plan a journey using public transportation not knowing schedules, routes and connections etc. The user will most likely access the application on the Internet through a private computer.

When using the travel planner the user indicates starting point and destination by typing in street name and street number along with a desired schedule for either departure or arrival. The ‘Travel Planner’ returns with an itinerary including directions for that part of the travel, which has to be covered by foot, the locations of bus and train stops, route numbers and train lines, as well as arrival and departure times for all connections. As a supplement to the itinerary some users may print out the map. The map shows either the walking route or the entire travel depending of the length and complexity of the travel.

As the application is covering all public transportation in Denmark, it may be used for travels of various length, from short in-town journeys to long travels going from one end of the country to the other,

As an addition to the itinerary the map should provide the following information:

- Distance and routing of the walk from starting point to first bus stop or train station, as well as from last bus stop or train station to destination. Important are street names, distances and other geo-referenced landmarks (e.g. named buildings) on the route if any.
- Distance and routing of the journey by public transportation including transfer bus stops and train stations. Important are street names, location and names of bus stops and train stations as well as for regional travels the names of town in which transfers will take place.
- Distance and routing of the entire travel. Important is that the map gives an overview of the travel including locations of bus stops and stations, as well as for regional travels the names of town in which transfers will take place.

As mentioned, the standard product was defined to be application independent, and the customer had therefore contracted with a software company to develop the functionality of the new version of ‘Travel Planner’. This application was not available during development of the map. There where thus a number of uncertainties during the development, not only concerning functionality but also with regard to size and number of map windows. In praxis the map developers worked on the assumption, that the use model for this new version would be similar to the old version of the ‘Travel Planner’.

If both map developers and application developers had been working on the basis of one and the same use model, uncertainties etc. could have been brought into consideration during the development process and solutions could have been found for both parties

3.4 Information Model

From the above use model it can be extracted what information is needed. First of all the transportation network is needed, consisting of roads, bus lines, railways, bus stops and train stations. Street names are needed in large and intermediate scales. In small scales are names of towns and other place names needed. Secondly, geo-referenced landmarks are needed. These were, for the large scales, chosen to be buildings, and in open land also tall features such as forest, towers etc. For small scales were chosen towns, prominent lakes and rivers.

It should be discussed to what extend users utilize geo-referenced landmarks for their orientation? Use of landmarks for orientation requires that the map is portable (i.e. printed), which normally it not the case for Internet maps.

In this case, it has been chosen to use non-georeferenced landmarks such as forest, lakes and rivers. As forests normally don’t carry a visible geo-reference (e.g. a name) it’s questionable to what extend ordinary users are able in a safe manner to link the green colour on a map (the forest) with the right forest in reality? One could suspect that parts of the content tend to be chosen because of habits. The reason why these non-georeferenced landmarks are present in the map might be a result of conservatism and aversion against removing these standard objects from ‘a map.

3.5 Appearance of Graphics

The first version of the map in the ‘Travel Planner’ did cover greater Copenhagen only, and no small-scale maps were available. When developing the new version small scale maps were therefore added. It was the overall intention to develop a new, improved map with respect to clarity and simplicity.

As the map is presented without legend the symbols have to be self-explanatory. Therefore the design was chosen to be with colours similar to city maps and topographic maps, as it is expected that most users will be familiar with these.

It's notable that the choice of colours is linked with tradition as well as expectations to the user's stipulated familiarity with different map types, instead of argued for on the basis of an analysis of the use model.

3.6 Discussion

When reviewing the process of the entire project it seems relevant to discuss the following issues: What was the result of the project? Was the method followed? Was the presented method beneficial to the project?

What was the result of the project? The customer finds the new version of the map a considerable improvement compared to the previous version. Among the cartographers in KMS the design itself is considered a step backward compared to the traditional paper map production. The question is, whether a comparison with paper maps is the best way to assess a web map, or the quality of any map should be measured through a real-life use?

Was the method followed? It was followed to some extend but not consequently. Especially the use model was incomplete. One reason for this was the unknown functionality of the Travel Planner application as well as the missing identity of the standard product. The standard product was developed with a general use and application independency in mind. However, this idea of general independency makes it impossible to create a use model.

The 10 000 dollars question is, if it's possible at all to develop a 'standard map product' to the Internet considering the characteristics of the Internet, which are the immense number of functionalities and end user applications.

Was the method beneficial for the project? It appears that if the described method had been implemented in the organisation and followed during the project, the uncertainties concerning aim, target group and use model could have been addressed on an early state of the project. This project is an example showing how things get difficult when a project is not being guided consequently by a method, difficult in respect of targeting, identity, explainability, productivity, clarity and consensus for all involved parties. Methods should be followed, not for the sake of their existence, but for the sake of documentation, repeatability, information to third parties etc.

If 'habits' is the main driver through greater parts of such a project, what can be done to make it more attractive to follow a methodological approach? How can new methods be introduced and integrated into organizations?

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Using the Internet to Deliver Customisable Map-based Educational Experiences

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1 Background and Motivation

Within the Higher Education community the current increase in the provision of maps and data presents both challenges and opportunities. In the UK, these are being met and fulfilled by the EDINA Digimap service, which provides on-line access to a vast range of Ordnance Survey digital topographic map data. Currently, such access yields user-defined maps (in terms of scale, content and coverage) on screen and as downloaded data files for import into users' GIS software. Remarkably successful, the Digimap service is now subscribed to by 70 educational establishments, resulting in access to Ordnance Survey (OS) data by potentially hundreds of thousands of students and staff in higher education. Further details of the service are given in MEDYCKYJ-SCOTT ET AL. (2002).

2 Development

In order to fully utilise the flexibility of the Internet as the dissemination medium for such data, and to promote the use of Digimap within Higher Education, the e-MapScholar project has been initiated. This project will support multidisciplinary applications of map data, highlight case studies, and allow tutors to customise their own environment within which to educate their classes.

Because a large proportion of the users of Digimap are not experienced or trained geographers or spatial scientists, there is a need for introductory and developmental learning material to ensure confident use of the OS data. The use of this data by students of urban planning, architectural design, civil engineering, forestry, archaeology and environmental science, many of whom will be unfamiliar with the nature of OS mapping and most of whom will be accessing the data for subject-specific practical exercise work, suggests that a guidance or tutorial system is necessary.

3 Innovation

The task of creating and developing this system, entitled e-MapScholar, is being undertaken by a range of researchers as indicated in the authorship of this paper. This paper concentrates on the deliverables supplied by the team, in particular

- The range of material and educational concepts covered by the project;
- The creation of practical tools to support the data handling, investigation and learning assessment within the project;
- The system for managing the content and customising the Internet session.

4 Material

The material which is handled and delivered by the e-MapScholar system is hierarchically divided into resources (intended to cover a range of mapping related topics), coherent units addressing particular concepts within these topics and individual screens (generally one 'page' of material covering individual points, usually with some form of self-assessment). These are held and delivered as XML documents. Currently, three main domains are being addressed: Working with digital map data; Data integration; and Data visualisation.

The framework of the learning resources developed has been assisted by the team-wide adoption of ‘mind maps’ to ensure coherent and complete coverage of the subject-matter of each domain (PURVES ET AL. 2002) and the inclusion of an experienced evaluation panel which ensures the effectiveness of the learning materials created.

Each page is constructed from a number of ‘learning objects’: these will generally include some text – introductory, descriptive, explanatory – and some images – usually static raster maps or diagrams. In addition, there is likely to be some formative self-assessment to test knowledge of the material presented and there may be interactive, practical exercises embedded into the page. Both of the latter have required the creation of a set of web-based data handling tools, described in the next section.

The creation of the web pages to hold and disseminate these learning units has relied on the construction of XML documents consisting of text blocks, images and tools. Uniform DTD blueprints have been developed and commonly agreed to define the content model as appropriate. These define the logical structure and the legal building blocks which ensure XML document conformance. The users view of the XML content is governed by XSL stylesheets and can result in:

- different views of the data (it is possible to choose to browse the material as one long file, divided into screen-based pages, or formatted for printing);
- different levels of the data hierarchy (for example as a complete resource, as individual units, or as learning objects);
- different calls to component tools (for example, to pass required parameters).

Common DTDs are used for validation of the constructed XML documents ensuring that the content is appropriate and correctly formatted (Fig. 1). This includes checking the logical structure and the validity of the elements and associated attributes. The DTDs also ensure consistent data exchange among the different e-MapScholar development teams.

```
<Page id="2">
  <text>
    <plainText>There are 3 types of graphical feature used on a map to represent objects in the
    real world: points, lines and areas. For point objects, their locations are recorded
    by one coordinate pair. For line objects, a sequence of coordinate pairs defines
    the representation on the map.
    </plainText>
    <plainText>
    Area objects are defined by a sequence of coordinate pairs, with the requirement
    that the first coordinate pair is identical to the last, thus forming a closed zone.
    To be absolutely certain which area is being referred to, it may be necessary to add
    a further point object (defined by a coordinate pair) within the area symbol.
    This is sometimes called a 'seed point'.
    </plainText>
  </text>
  <question ww="505" h="150">
    <q>How many coordinate pairs are needed to create a straight line feature?</q>
    <a>Two.</a>
  </question>
  <figure>
    <graphic name="coordinate_geometry.gif" width="400" height="575"/>
    <caption>Points, Lines and Polygons are defined by coordinate pairs</caption>
  </figure>
</Page>
```

Fig. 1: Extract from learning material showing XML tree structure for a sample page

Once stored, XML files can be called from the Content Management System (CMS, discussed later) which is used to initiate and develop the particular materials requested for each session on e-MapScholar.

5 Tools

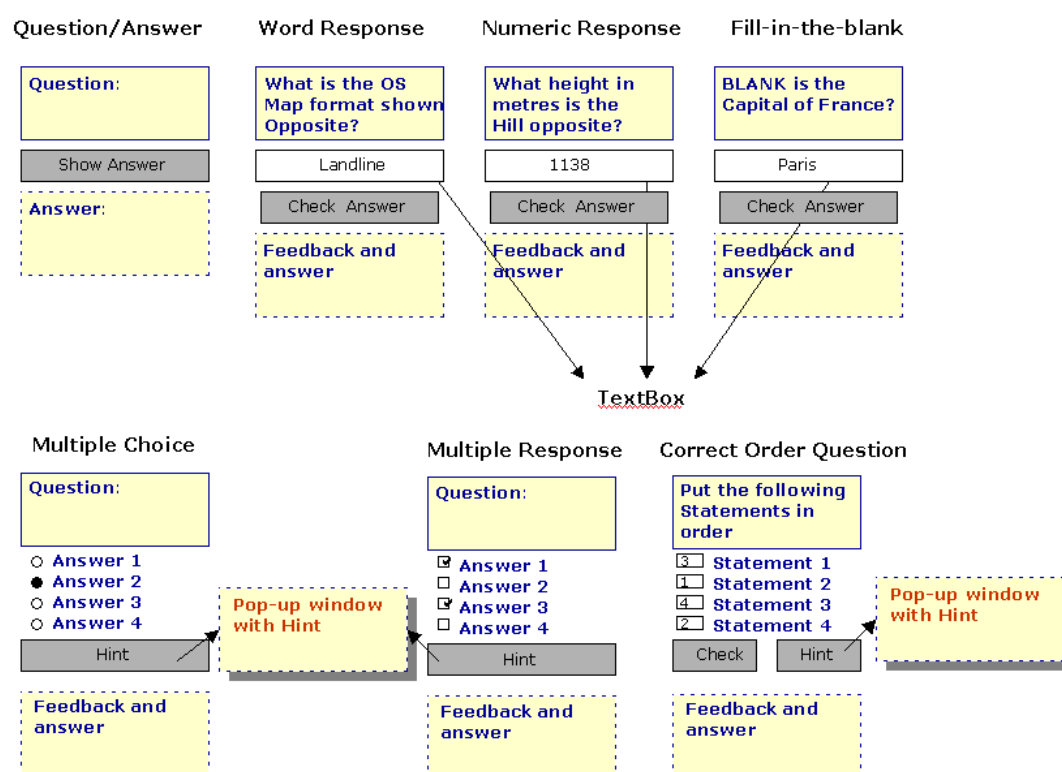


Fig. 2: Graphical display of the functions available in the self-assessment tool

The e-MapScholar project relies, as does the Digimap service, on web-based delivery using standard browsers to access, display and disseminate Ordnance Survey data in graphical and digital form. In addition to standard browser functionality, a number of specific web-compatible tools have been written to enhance both the demonstration and the student-performed practical tasks. By introducing certain concepts and functions these tools improve the utility of the on-line learning process for students. Although many of these tools are extensive and stand-alone, capable of being run as separate applications, they have been incorporated as applets within the web material delivered by e-MapScholar. Written in Java™, such tools have been developed to address requirements in a number of areas. The self-assessment tool has already been mentioned: this incorporates a range of different functions, from relatively straightforward question and answer boxes, to more complex multiple choice or extensive descriptive answers (Fig. 2). In many cases an explanation of the reasons for the answer must also be included.

Other tools which have been created perform other functions such as accessing and presenting graphic data, explaining concepts and introducing working practices. Many of them have a requirement for interactivity. In addition, there is the need to customise the content of the tool. For example, a lecturer using e-MapScholar to introduce topics to her class might need to ask specific questions, may want to illustrate concepts with maps pertaining to the location of the college, or may wish to demonstrate alternative presentations. In each case the tool and/or the other learning objects may need to be customised: this is discussed further in the next section. A full list of tools specifically created for e-MapScholar is given in Fig. 3, alongside a preview example of one of them.

Tools are used to assess (e.g. Question and Answer tool), to assist in data creating (e.g. Digitising and Map/Image Overlay tools), to enhance visualisation (e.g. Design and Terrain Viewing tools), to manipulate maps (e.g. Zooming and Querying tools) and to modify the display (e.g. Layering and Bounding Box tools).

The example of the Data Creation tool is taken here to demonstrate the nature of the development process, to show how tools are integrated into the learning units and to illustrate the particular use of OGC protocols in handling data in the web environment.

Within the Data integration strand of e-MapScholar, it was felt that the potential learner needed to have some introduction to methods of data collection and also needed to be able to practice with and use (within the e-MapScholar session) a prototype tool, enabling them to confidently add some of their own data to the map data served. An example digitising tool has been created to address this need.

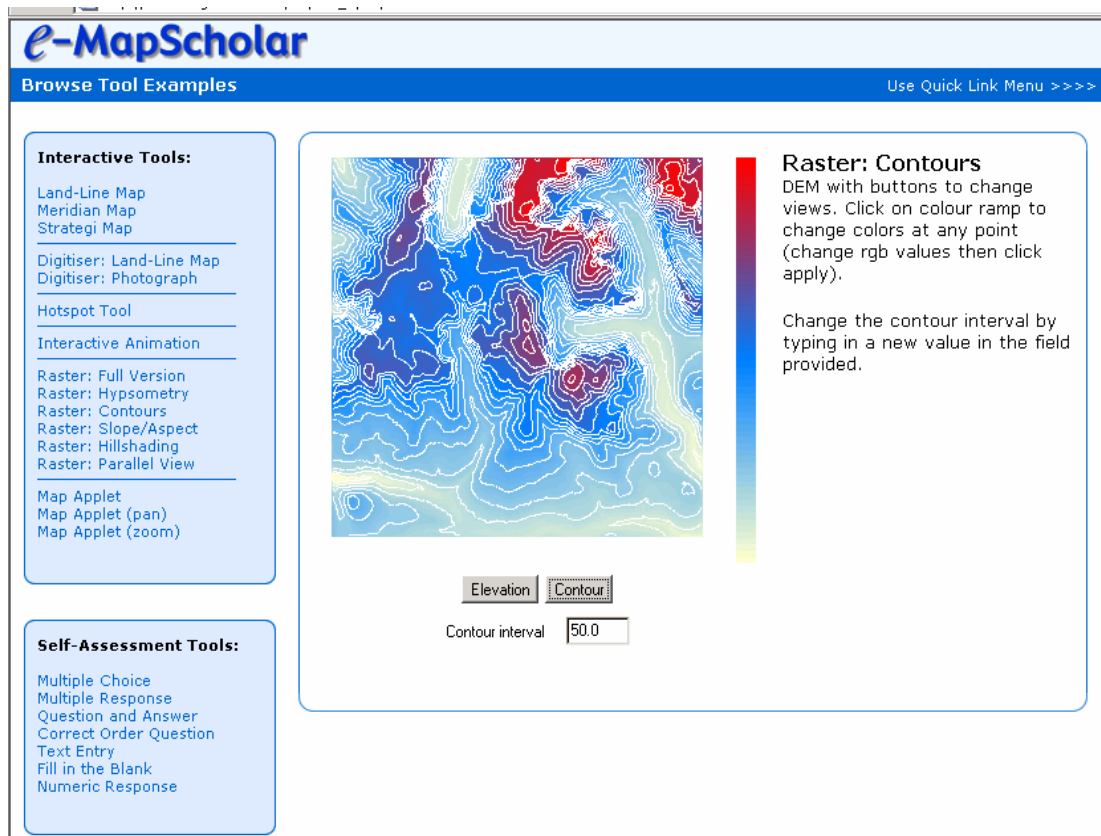


Fig. 3: Listing of the tools developed within e-MapScholar with an example of one tool, inside the browser display

The Digitiser tool is a JavaTM applet, consisting of class files, image files and data elements. It incorporates considerable functionality, although it is not intended as a 'production tool'. Sensitive buttons provide significant interactivity and the interface is intended to be intuitive. Figure 4 shows the appearance of the tool and how it is incorporated into the web pages within e-MapScholar. Primarily, the tool is used to exemplify the descriptive written material which explains the concepts of data collection by digitising from paper and digital screen-displayed maps. The distinction between the capture of point, line and area features is stressed and the students are given the opportunity to test their digitising skills within the web page.

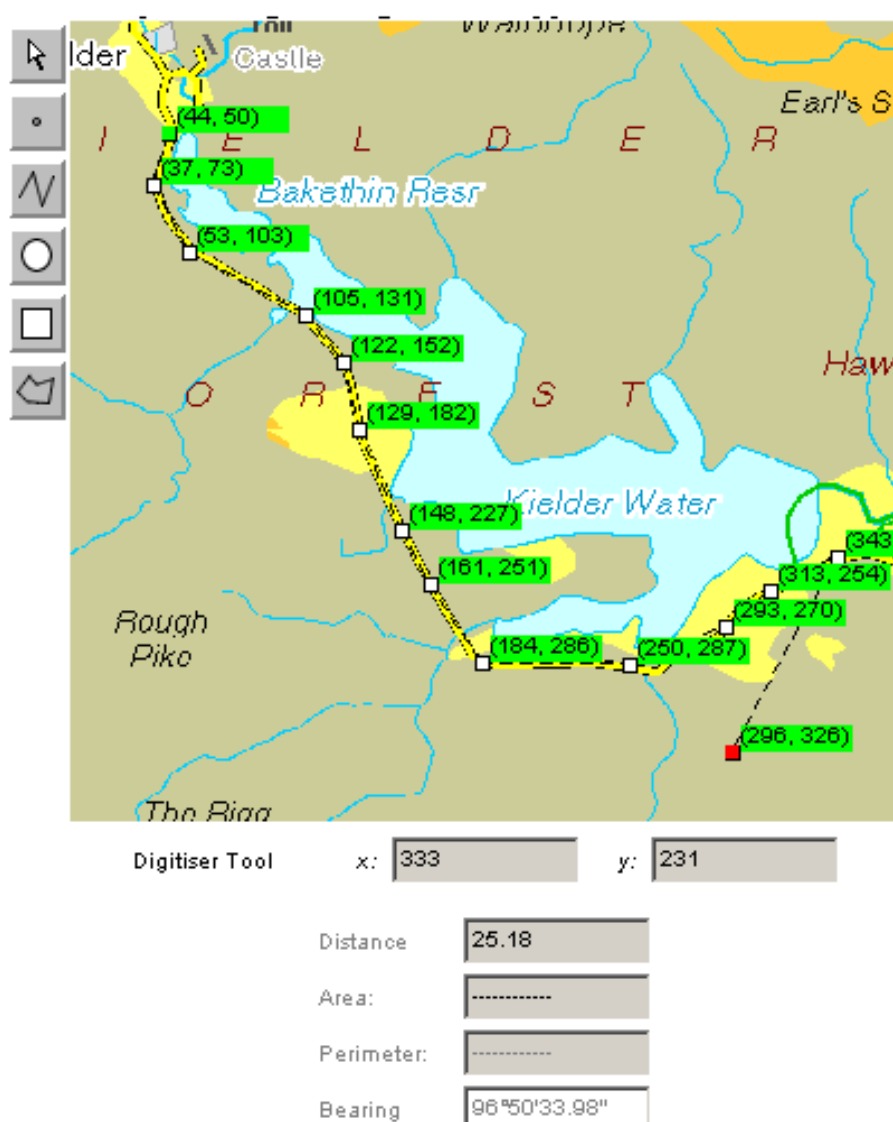


Fig. 4: Using the digitiser tool to capture a line feature from backdrop OS mapping

As with most of the tools created within e-MapScholar, the Digitiser tool can be customised. This can be done by enabling/disabling the buttons. In addition, it is possible to vary the map image incorporated into the active area of the tool. It might be appropriate for a lecturer to present the tool with a map backdrop showing a familiar local area, rather than a default.

The use of OGC Web Mapping technologies allows for this customisation. In fact, map backdrops, whether the default or a customised choice, must be specified using calls to the OGC WebMap Server hosted at the EDINA site. The OGC specifications allow geospatial data in a variety of formats to be delivered, for interpretation at the client side (for example, the OGC WebCoverage server and the OGC WebFeature Server) or for image files to be created at the server side and then delivered (for example, the OGC WebMap Server).

The OGC calls made to the server in order to specify the particular map backdrop required are in the form of a string embedded in an http request (Fig. 5). A number of standard OGC parameters are passed to indicate which OS product is needed (e.g. 1:250,000 dataset), bounding box (in National Grid coordinates), scale, reference system, width and height of display, layers, style etc. These parameters are used by the server to create an image file (in .GIF or another format) from the data held on the EDINA server. This image is then embedded as a static image into the HTML document served to the client, or possibly as an element within an applet.

```

<PARAM NAME="x" VALUE="539135" />
<PARAM NAME="y" VALUE="180125" />
<PARAM NAME="scale" VALUE="2400" />
<PARAM NAME="map.server" VALUE="http://minto.
    ucs.ed.ac.uk:44000/opengis/
    wms/landline/WebMapService" />
<PARAM NAME="map.server.version" VALUE="1.1.0" />
<PARAM NAME="layer.names" VALUE="Landline" />
<PARAM NAME="layer.styles" VALUE="default" />

```

Fig. 5: Example of the parameter listing which forms the basis of an OGC request string

6 Content Management

Customisation by the lecturer to provide examples and learning resources tailored to a particular subject area is seen as a key feature. An interactive Content Management System is being developed which will allow a number of different approaches to be taken to providing bespoke teaching materials at unit or resource level. Resources are published using the CMS and accessible for re-use by other lecturers. Certain elements of the content can be customised - for example local sites and illustrations can be presented to the students; material can be combined by lecturers in their own way; and new material can be submitted and existing material can be edited, saved and re-used by the whole community subsequently.

The standard function of the CMS is to act as a portal between the user and the e-MapScholar content. The customisation process involves calling the XML files as appropriate, linking with the relevant DTDs (e.g. for specific view, for specific browser, for specific content) and validating the XML as a whole. The task of creating a system which can address all these requirements is noteworthy: in effect a new approach to managing learning environments, such as e-MapScholar, will be the result.

7 Summary

The e-MapScholar project addresses aspects of Internet-based learning using spatial data. Its innovation and practical delivery to the wide-ranging UK Higher Education community make it an ideal example and novel use of Internet mapping.

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Multimedia, Maps and the Internet

New Media Visualizations and Visualising Geography

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Abstract

A research programme is currently underway to construct and evaluate a 'different way' of providing geographical teaching/learning elements with multimedia cartography – the use of a GeoExploratorium. Providing a new way of 'seeing' geographical information by providing different viewpoints and therefore, hopefully, ensuring that the 'voids of geographical understanding' are filled with information gathered from other perspectives and used to assemble a more complete picture of reality. The question that this research is addressing is: do the 'tools' for geographical visualization change the viewpoint of space or place and therefore, if so, is a 'jaundiced' view of (geographical) reality provided which aids in the construction of a particular mental map and thus an individual's perception of place and space. What does this mean for the providers of tools to visualise geography?

This paper addresses the questions: Does the way of 'seeing' influence the way of knowing? What is the most appropriate pedagogy for using New Media technologies for providing visualizations to assist users to understand geography? How do humans learn about geographical information, and how does this learning vary as a function of the medium through which it occurs (direct experience, maps, descriptions, virtual systems, etc.)?

1 Introduction

When we now consider the World Wide Web and what it means to cartographers and consumers of their products it is obvious that a revolution has occurred in cartographic design, map production, map 'delivery' and map consumption (or use). For cartographers it means that almost (within reason) any idea for an interactive multimedia can be realised as a digital product. The plethora of multimedia software tools for graphics production, image manipulation and product authoring enables design to be transformed into interactive maps, enabled to be delivered on discrete media, through intranets and on the Internet. Maps can be delivered 'on-demand' and composed dynamically. Maps can almost be built and delivered in tandem to the data being collected. And, for users not just one map is available, but many, from worldwide resources, in many cases for free or at minimal cost. We can design, produce and use maps freely and liberally, globally.

However, in the haste to develop and use on-line interactive multimedia products perhaps we have overlooked one important consideration. Do these new tools for geographical exploration and discovery always show the same 'view' of geography, or do different (digital) tools provide different 'windows' into reality. In the past different paper thematic maps were designed to illustrate specific information, where cartographers had control over the choice of data, its generalisation and depiction. When we produce interactive multimedia tools we can pass-over this control to users, whose use and interpretation skills are, in most cases, unknown. We have lost control about what they do with our products and how they view reality. It is argued that research is necessary to ascertain whether the cartographic tools of Interactive multimedia provide specific 'windows' into geography and whether different interactive multimedia visualization tools in fact provide different views into reality. Therefore users may build different mental maps of the world when particular tools are utilised.

This paper explores some of the ideas behind how we are presented with information about reality, focusing on popular media, how consumers of media interpret and build their own realities through popular media use and how this impacts on understanding geography when these same consumers use Web-delivered interactive multimedia products in the same manner as consumer media.

2 New Media, Popular Media and the Provision of Artefacts for Understanding Geography

Seymour PAPERT (1993), looking at the way in which 'different' educational processes come about when students are allowed to be educated according to Instructionism and Constructionism, argued that the computer age and associated dynamic media has changed the dominance of information from textual sources, especially print, to other information sources. He saw that the access to many kinds of knowledge available from computer-based systems allow a personal style of learning to take place, as described by Sherry Turkle in her book *The Second Self* (1984). Perhaps, as digital information media becomes more 'conglomerate', composed of interwoven entertainment, education, commercial, governmental and informational 'nodes' the traditional elements that made our once unique will disappear and they will be used/consumed as any other popular medium. And, the user requirements for 'good' map use, those that ensure that users know of the shortfalls of map design, might also disappear, leaving our products as things that entertain.

BANCHOFF AND BRANNON (1998) argued that over the past several decades that even the geographic sciences have been slowly disassociating themselves from maps towards other means of geographical visualization. This has been supported by reports (op cit.) that since 1996 the requests for paper route maps from the American Automobile Association have dropped by 7% (however, this should really not be considered to support this argument, as maps per se are still being made available, albeit not as paper products, but maps are still being requested and used).

About New Media and its impact on how information is disseminated has been commented-upon by BANCHOFF AND BRANNON (1998 p. 6). They said: The overwhelming effect of this live, in-your-face media coverage is that we have become generally desensitised by varying degrees, not only to disasters, but to geography itself. Maps do not matter any more because seeing an event as it happens puts us right on the spot; we have travelled around the globe in an instant, the television or computer monitor has become our virtual transportation device. We are right there ... wherever there might be. Turn off the sound, take away the captions, and we might be looking at generic, archival footage taken from the media vaults." He considers that when the geography of news becomes irrelevant to society, so to do maps.

This effect that Banchoff and Brannon discussed has been called the 'CNN Effect' by some American social psychologists. And to support this, they (op cit.) note that during the Balkan conflict of 1999, President Clinton urged Americans to get out their atlases to discover where Kosovo was, rather than think about why they (the US forces) should be there at all. Of this he said "It was a defacto admission that Homo sapiens are becoming increasingly spatially dysfunctional".

3 Reality and Non-Realistic Maps

To be effective communicators of geographical information maps do have to lie. Mark MONMONIER (1991) in his classic book *How to Lie With Maps* explained comprehensively the theory and practice that illustrates this. Consider Charles Joseph Minard's depiction of Napoleon's Russian Campaign, produced in 1861. Geographical reality is discarded completely to produce what Edward TUFTE (1990) has described as "arguably the best statistical graphic ever drawn". This example is shown in figure 1.

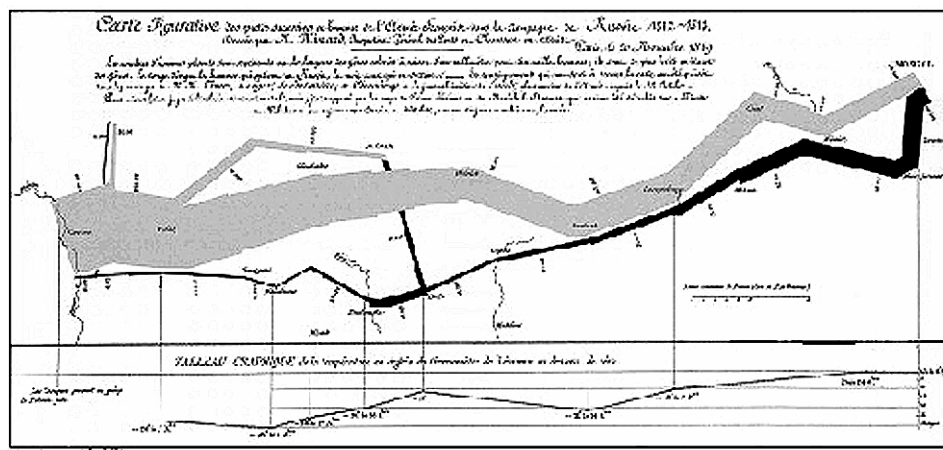


Fig. 1: Minard's depiction of Napoleon's Russian Campaign. Source: TUFTE 1983

A more recent example is one of the most widely used maps by inhabitants and visitors to London – The London Underground map. By distorting geography the designer, Beck, made the map more usable and an effective communicator about how to move about London. His original design moved away from the concept that the maps had to follow the actual geographical route of the lines, like the pre-Beck map shown in figure 2. By replacing the strict geographically imposed demands that required that representations be placed exactly where they were located with a regular pattern of generally horizontal, vertical or diagonal lines his new 'diagram' showed more clearly the relative locations of the different lines and the sequence of stations. What were critical to Beck's design were connections: the interchanges between the various lines. It is these connections and the simple information graphics that make the map 'work', irrespective of whether the user is a seasoned London commuter or a tourist arriving at the capital for the first time. Beck's first design is shown in figure 3.

This example illustrates how reality is sometimes depicted better if non-realistic maps are used in preference to geographically-correct maps. But, for the first-time visitor to London, and perhaps also for some long-time London dwellers, what is the composite mental map of London?

And even the 'maps' of board games have confused matters. The popular game Monopoly, by Parker Brothers, 'located' one version of it in London. Whilst the places are actual locations in London are real, the juxtaposition of each square on the board has been done to satisfy the demands of the game, rather than allowing a true picture of the capital to be shown. Does this 'map' of parts of London confuse the real geography of the city? See figure 4 for a 'slice' of the game board.

Can the user 'fuse' together an image of the entire city, and how it works, from this type of map and, is that fused mapping a true and accurate image of the city? Such problems did not stop at Beck's depiction of the city, as many new graphic designs have been proposed as replacements to his map. One such design from MetroPlanet is illustrated in figure 5.

Do, as it is argued when using interactive multimedia maps, these 'simple', but effective, graphic communication devices provide just one window into reality? And, do naive users of these products, when using them like any other New Media product, compose an image of the world when using this graphic window that is not a true image of reality?

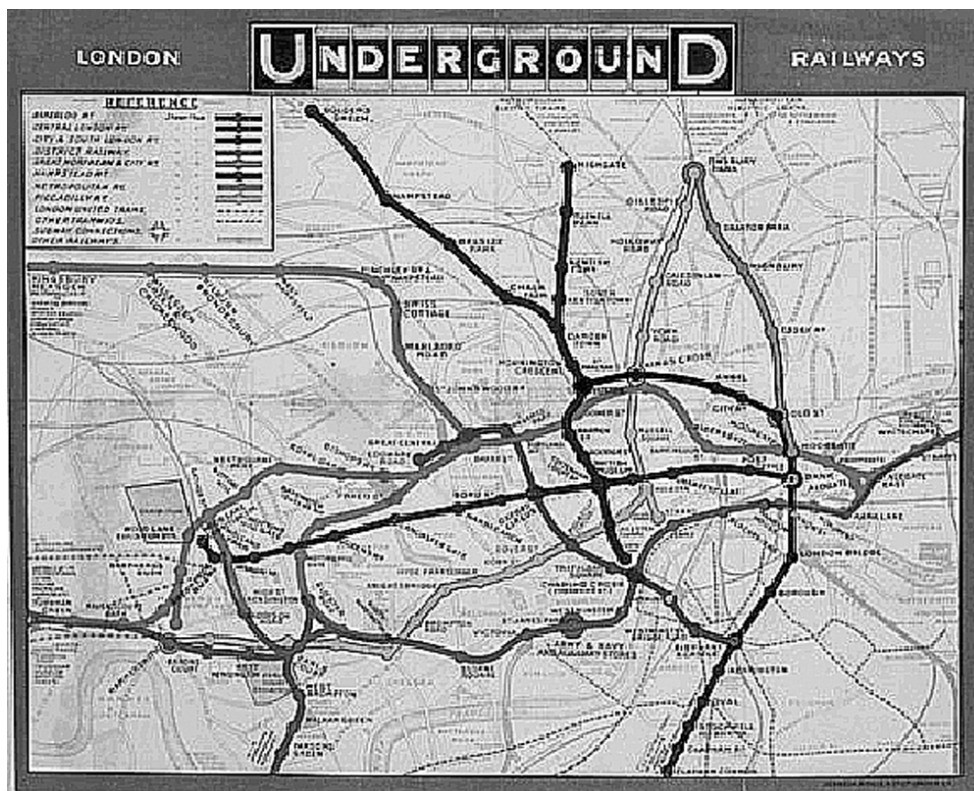


Fig. 2: Pre-Beck map of the London Underground rail system, 1908.
Source: <http://www.ltmuseum.co.uk/omnibus/pg/1919b.htm>

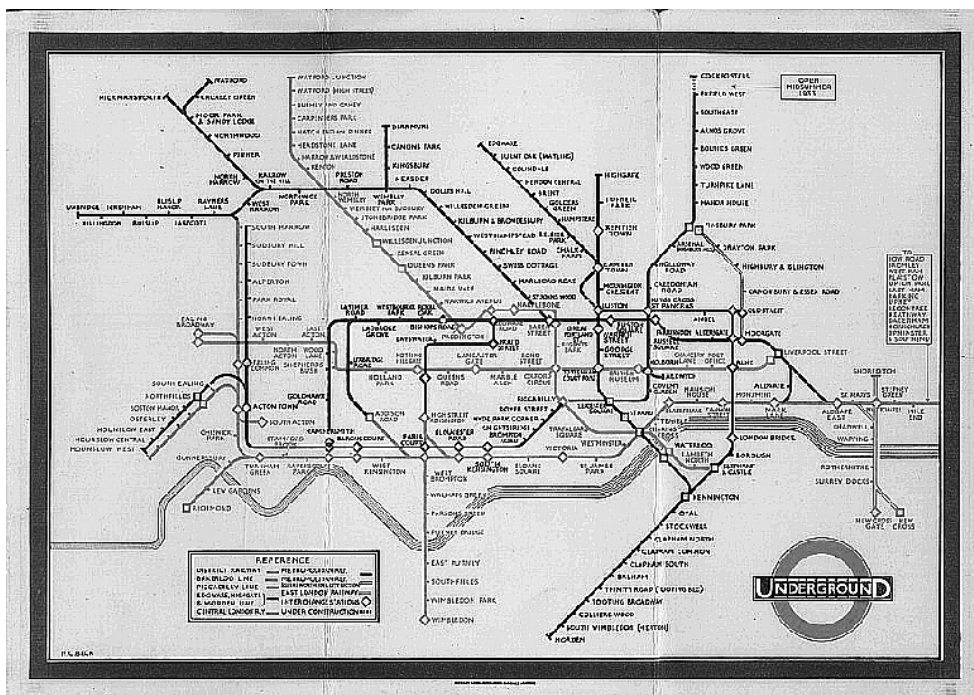
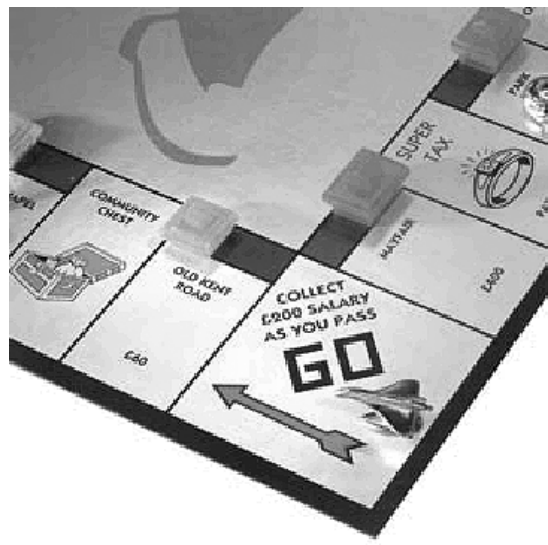


Fig. 3: Beck's map – first edition, 1933.
Source: <http://www.ltmuseum.co.uk/omnibus/pg/1919b.htm#>



4 Non-reality and Maps

If the users of cartographic products can be confused by simple imagery that depicts an element of reality, then how do they handle maps about non-reality? Many maps have been produced that depict worlds of fantasy or worlds created by books, film and television. Book readers, viewers of television and movies, and even radio listeners have created their own mental maps of places that have never existed. Yes, this is what authors and film directors want us to do, to create images from their written or image 'cues. But, is reality confused with non-reality?

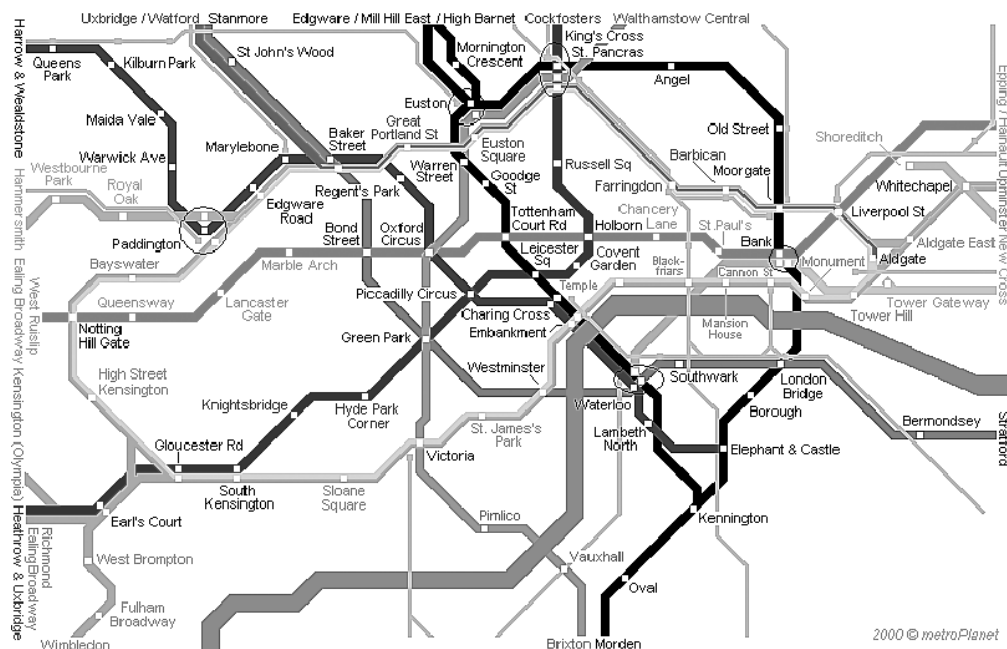


Fig. 5: MetroPlanet's LUG mp design, 2000
Source: <http://www.metropla.net/eu/lon/london.htm#20>

We read novels, watch television and movies and listen to radio. Images of fictitious locations are built as mental maps and they become real ‘places’ in our minds. Maps of these imaginary places have been produced to evoke ‘naturalness’ or to facilitate a ‘realness’ factor that did not exist. We can use these images to study the intimate details of the area or region, like maps of the Middle Earth (figure 6), or to appreciate how a town ‘works’, like maps of *Twin Peaks* (figure 7) or *Peyton Place* (figure 8) or *Oz* (figure 9), or to overview an ‘event’, like the radio spoof of *War of the Worlds* (figure 10).

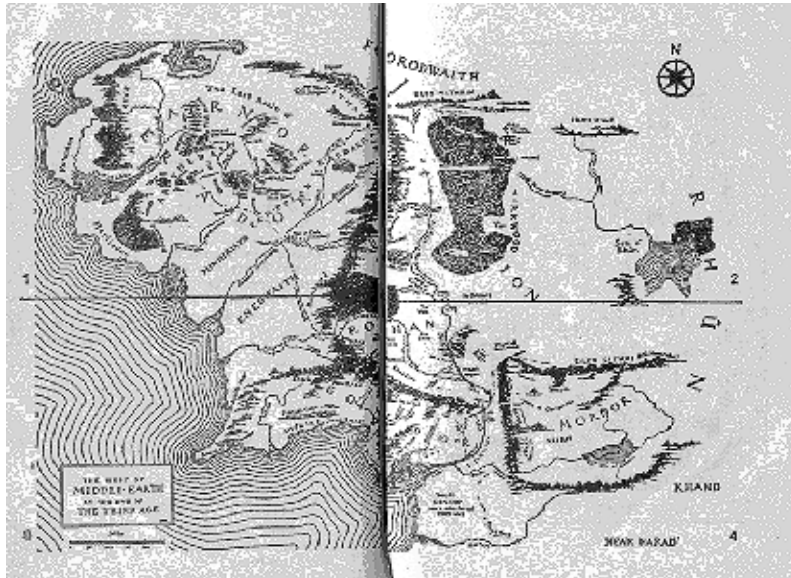


Fig. 6: Map of the Middle Earth. Source: *The Fellowship of the Ring*, Ace Books
Source: <http://www.isildur.com/tolkien/maps/fullmap.gif>

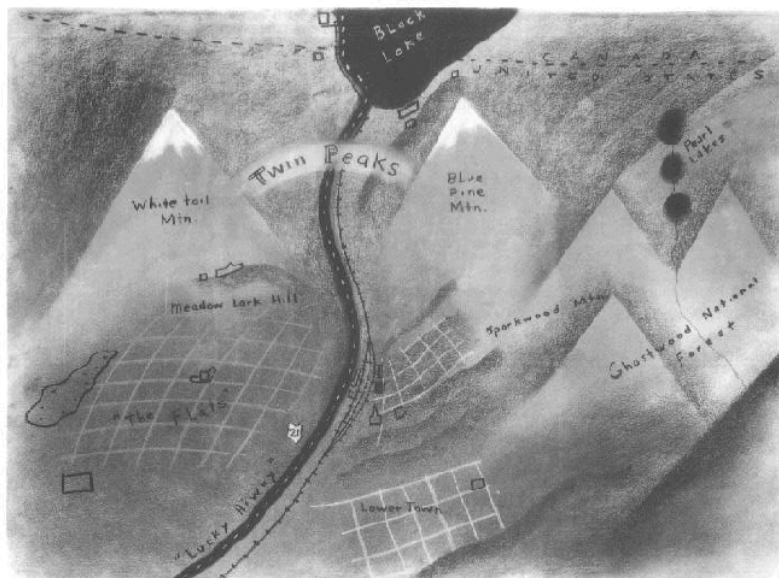


Fig. 7: Director's impression of Twin Peaks

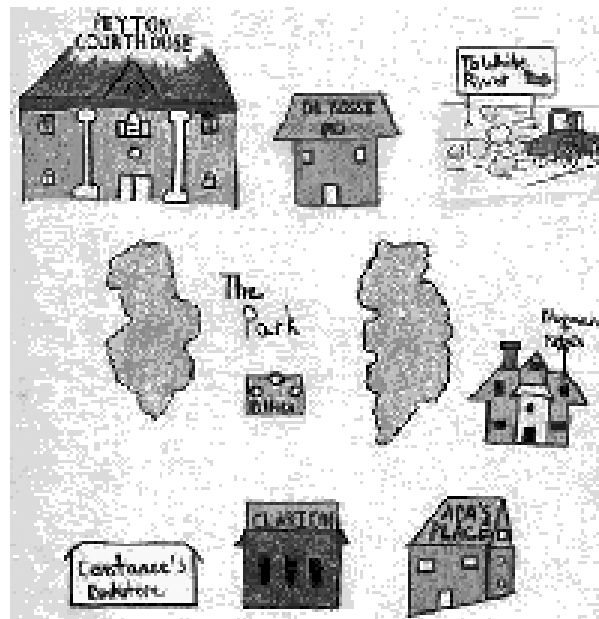


Fig. 8: Map Peyton Place. Source: <http://members.aol.com/AlisnRod/>

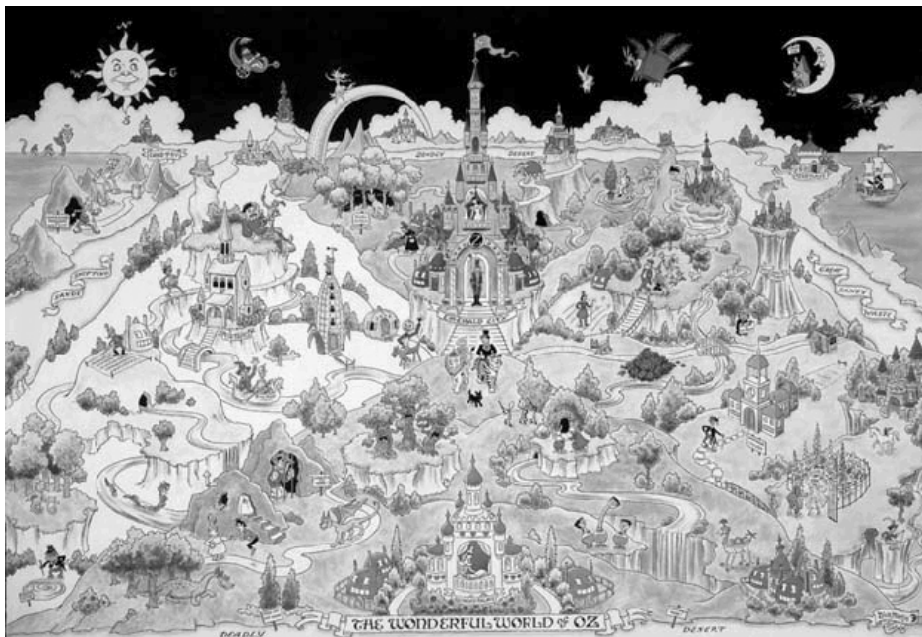


Fig. 9: Map showing the Land of Oz was created by DICK MARTIN (1927-1990), who illustrated a number of Oz-related books. Source: <http://www.loc.gov/exhibits/oz/images/vc66.jpg>

Radio has also acted as a catalyst for creating an artificial world that is the site of an annual pilgrimage. ORSON WELLS'S *The War of the Worlds* radio was broadcast on Halloween night 1938 on WABC, in New York. The radio play was broadcast from the Mercury Theater as a dramatization of H.G. Wells's *War of the Worlds*. The play gave details of a Martian invasion of the Earth. And, the play informed viewers that an alien object had landed in Grover's Mill, New Jersey. Thousands of listeners who tuned in late believed the Earth was being invaded by aliens, leading to panic. The New York Times reported this occasion on its front page (figure 10).



Fig. 10: The New York Times headline of October 1938

Source: <http://www.phy.syr.edu/courses/modules/SETI/HISTORY/wells.html>

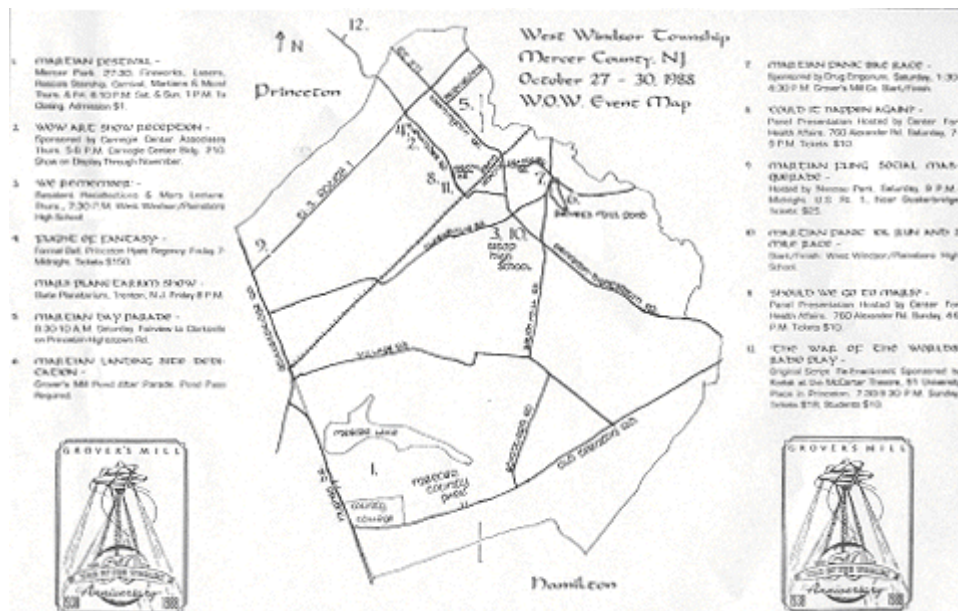


Fig. 11: Grover's Mill 50th Anniversary celebration map

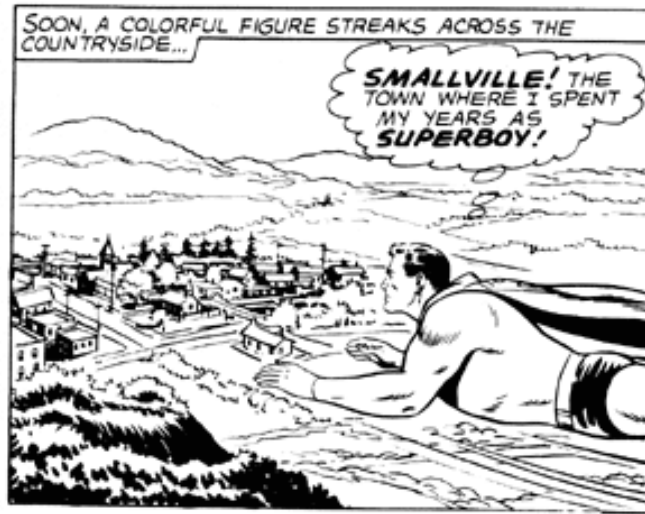
Source: <http://www.jd.gosling.btinternet.co.uk/wotw/50thmap.htm>

Each year devotees congregate at Grover's Mill to celebrate the anniversary of the broadcast. A map was produced for the 50th Anniversary celebration (figure 11).

Similarly, in September of 1996 hundreds of people in Madrid, Spain were panicked by television 'news' broadcasts depicting giant saucers hovering over United States landmarks. The segments turned out to be advertisements for a new alien invasion movie, *Independence Day*. See: <http://www.unmuseum.org/wow.htm>.

Comics also can create places, and their publishers also provide selected maps of locations (real and non-real) that are shown in the comics. As well as the towns created by comics, like Superboy's Smallville (figure 12), comic publishers have also produced maps that depict features of their worlds. Marvel comics have published *The Official*

Handbook of the Marvel Comics map of Manhattan (c. 1986) (figure 13), DC Comics have produced their *Atlas of its cities of the Eastern US Seaboard* and locations in Batman's Gotham City have been pinpointed (figure 14).



Superman approaches Smallville, 1963

Fig. 12: Superman comics – Smallville

Source: <http://theAges.superman.ws/Encyclopaedia/smallville.php>

Television programs have also created 'realities', for example the *Ponderosa* ranch in Nevada, a real operating 'dude ranch' established after the success of the television series *Bonanza*. In 1959 the National Broadcasting Company (NBC) introduced this western series. Part of the opening scene of the movie was a map that showed the location of the ranch, between Virginia and Lake Tahoe, Nevada (figure 15). The first episode was televised on September 12, 1959 and was followed by 431 more one-hour shows over the next 14 seasons. 500 million viewers in 86 countries and in 12 languages saw the series. The worldwide popularity of the program, and its success in the USA promoted the idea of establishing a ranch in the area described by the television map. This was done in 1967 and, as they say (in the movies) the rest is history. Over 300,000 people visit the ranch each year. It is located between Reno and Lake Tahoe (figure 16). The non-real created the real. (See <http://www.tahoevacationguide.com/Activities/pointsofinterest.html> for details). Note: The television series has now begun a new life, with a new series filmed in Australia. Australian bush becomes American frontier!

Finally, linking books, built real sites of the non- real and maps. Disneyland, in Los Angeles USA created *Tom Sawyer Island* as a 'real' place that their visitors could see and experience. To enable visitors to explore the island a map was created (figure 17) and until the mid 1970's were handed out free at *Tom Sawyer Island* Disneyland. It contained illustrated text describing the island's main attractions: Tom and Huck's Tree House; The Old Mill; Injun Joe's Cave; Pontoon and Suspension Bridges; Castle; Rock Ridge; and Fort Wilderness. Location in a book, actual 'built' world and a map of that world.



Fig. 15: Ponderosa ranch map from the television series Bonanza

Source: <http://www.yesterdayland.com/popopedia/shows/primetime/pt1272.php>



Fig. 16: Ponderosa ranch map – location of the ‘physical’ ranch

Source: <http://www.jd.gosling.btinternet.co.uk/wotw/50thmap.htm>

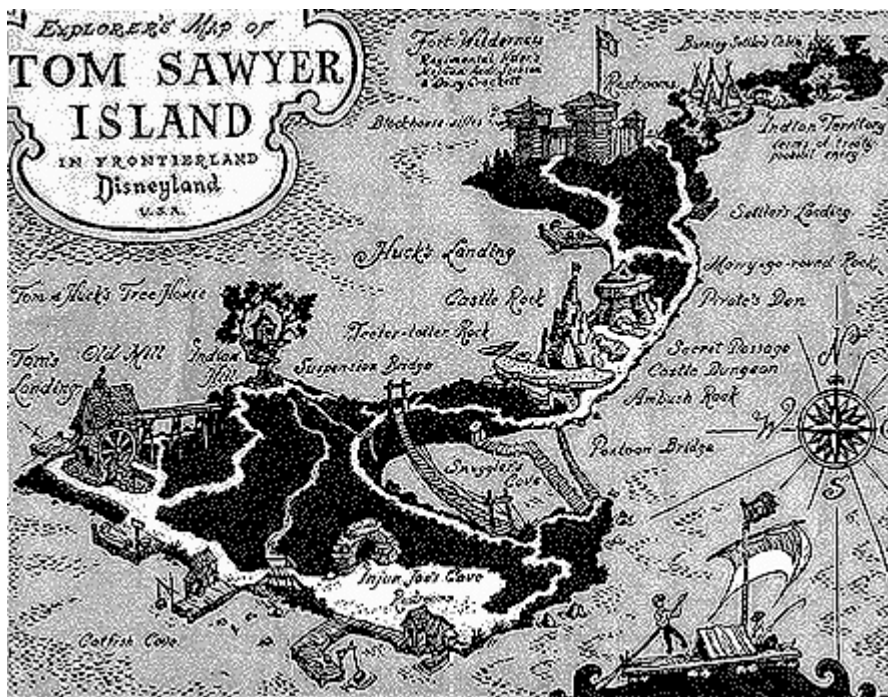


Fig. 17: Map of Tom Sawyer Island

Source: <http://home.earthlink.net/~cstrodder/Disneymap.html>

5 Reality or Non-Reality and Multimedia Maps

The use of New Media, as previously stated, allows users to explore, locate and use a myriad of geospatial visualization products. This has the potential to cause some problems if sufficient care is not taken. CARTWRIGHT commented upon this in 1997:

“However, as users adapt to using things like multimedia maps and maps via the Internet there is a need to re-assess how the user ‘sees’ reality and how the use of new (electronic) media may present something that bears no resemblance to reality at all, mapping what MACEACHREN (1995) calls ‘not-Reality’ “ (CARTWRIGHT 1997).

6 Different Realities with Multimedia Maps

If it can be assumed that the Web also modifies geography by creating new geographies by linking people and services and, also do the maps and that are delivered via the Web, then there is a need to consider some elements related to both the designer and the design of Web mapping products. The Web mapping designer is restricted by reality: real reality and the reality that the user considers to be real.

So, which reality to work with? And how do we get information about the user’s reality? This reality can be considered to be in three areas:

- Geographical – the users’ perception about geography, related to experience in things geographical and how the elements of geography can be transmitted via maps (digital or otherwise);
- Usage – how the user actually uses the Web and how they feel comfortable with accessing geospatial information on the Web; and
- Knowledge about the way in which the Web works, how to work with maps delivered via this medium and the general distortions of geographical information when it is transmitted through maps

Distortion of reality may be related to the 'viewing media', and this is one aspect of the delivery (Web) process map authors have little control over. To this can be added the uncertainty, or, better still, lack of knowledge about whether different viewpoints, and therefore different realities, can be associated with the use of different viewing 'portholes'.

There are many issues related to how New Media is applied to the delivery and portrayal of geospatial information. (see CARTWRIGHT 2002 for a treatment on this subject). Also, there are a number of Issues related to design of multimedia maps. Areas needing research are related to:

- The general public is generally inexperienced users of New Media as delivery mechanisms of information;
- How to eliminate the 'gloss of the new' when evaluating the effectiveness of our products and delivery strategies;
- The general impact of interactive multimedia and its effect on changing geographical realities;
- The general public's confidence in information delivered by popular media;
- Confusion between real and non-real;
- Fusion of real and non-real;
- The fact that there is no real 'groundtruth' for quality/accuracy of information (see CARTWRIGHT 1997 for a discussion on groundtruth); and
- The overwhelming power of this (multi) medium.

7 What does this mean for our Web Cartography Design Process?

Getting visualizations of reality right, and making them work is a difficult task. Sometimes we undertake the design and production of visualisations, and the appropriate access/interaction components somewhat remotely from the user. Getting this 'right' takes much time and effort and if users are to appreciate geography, and the elements of geography displayed in visualizations, we need to incorporate their understanding of geography into the products we design and develop. This is not a new phenomenon. For example, as HAFT (1999) illustrated in her discussion about Don Gutteridge's *My Story: Maps* that focuses on the Lamberton County verbal map. She said "a map, and the information form that map only becomes memorable when a person discovers how to read his own experience from it" (HAFT 1999, p. 41). How do we make users of geographical visualizations achieve this?

NEVILLE (1993) has said that there is no 'prescribed' way to use New Media, but something that allows browsing, exploring, experimenting and users are able to build their own applications is a reasonable starting point. Users can have their own personal 'trips' in personal computing, allowing for a much greater opportunity than what appears 'on the surface'. But, in providing user control we must ensure that how they will use our information 'appliances' is considered in design and development exercises. And, the pitfalls of viewing geography through machine-imposed windows need to be known. Information about this must be transmitted to users and product designs should be made with these considerations addressed. Products and interfaces are needed that reverse the effect of 'dumbing down' or 'de-geographing' information that may be provided by popular (New Media) information sources.

8 Research

Currently a research program has begun to address the question of different realities being built with interactive multimedia. The fundamental question that this research is addressing is: does interactive multimedia cartography provide a new way of 'seeing' geographical information by providing different viewpoints for different types of users, ensuring that the 'voids of geographical understanding' are filled with information gathered from other perspectives and used to assemble a more complete picture of reality?

Do the 'tools' for geographical visualization change the viewpoint of space or place and therefore, if so, is a 'jaundiced' view of (geographical) reality provided which aids in the construction of a particular mental map and thus an individual's perception of geography. What does this mean for the providers of tools to assist in understanding geography?

9 Conclusion

Perhaps we need to go back to the methods of Socrates, Plato and Aristotle and end-up with the (digital) delivery of artefacts that are developed and ‘draped’ around appropriate metaphors – what we use in providing artefacts for exploration, discovery and exploitation of geospatial data / information. This could ensure that ‘best-fit’ products are delivered. It might be argued that if we were to make a film about contemporary media, and its delivery on resources like the Web that we could name this movie “*The Machines Take Over the Workshop*”, somewhat like the movie *The Inmates Take Over the Asylum*. Machine-delivered products do need human/designer inputs. Has the focus on the ‘Machine’ of Cartography taken over the humanistic (and art) element of cartography? And, how, if this is so, do we ensure that effective designs are made and appropriate products delivered?

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Cartography, Virtual Reality and the Internet

Rex G. CAMMACK

1 Introduction

The complexity of the map model has been tied to the media on which it has been expressed. Digital technology is a new media for maps. Cartographers are adding new media elements such as sound and animation to the map. When new media elements are combined with a map, cartographers can create a multimedia map. CARTWRIGHT & PETERSON (1999) label this method of modeling reality as “multimedia cartography.” In multimedia cartography, the cartographer uses digital media technologies to create a richer perceptual experience for the map-reader.

CARTWRIGHT et. al. (2001) and SLOCUM et al. (2001) identify the principle research issues regarding map visualization. Many of the issues address by CARTWRIGHT et al. (2001) and SLOCUM et al. (2001) are also important in multimedia cartography. There are significant differences between multimedia cartography developed for public communication and geovisualization models (MACEACHREN & KRAAK 2001) for private data exploration and discovery. Yet the core issues are the same for geovisualization and multimedia cartography.

SLOCUM et al. (2001) defined a set of research themes for “cognitive and usability issues in geovisualization.” The first of these themes is “geospatial virtual environments” (SLOCUM et al. 2001). A proposed taxonomy for virtual environments in geovisualization consists of immersion, interactivity, information intensity, and intelligent objects (MACEACHREN et al. 1999A, MACEACHREN et al. 1999B, AND HEIM 1998). For virtual environments to work, the users’ perceptual system must be stimulated in a manner similar to the real world. A successful stimulus will create a sense of immersion for the user. New developments in technology are more palatable for the user. John Hanke was quoted as saying “We’re moving the map from an abstract representation of reality to one that is interactive and realistic” (O’BRIEN 2002). Indeed it is important to make a more realistic model of reality for virtual reality, but at what point does one lose the focused message a map provides.

One of the main advantages of the map has been its’ abstract model of reality. This abstract model provides a focused message to the map-reader and removes unneeded details. One might characterize the map as a precise analytical tool that geographers, planners, military leaders, etc., use to understand space and force their control on it. MACEACHREN & KRAAK (2001) “Map Use Cube” (see MACEACHREN & KRAAK 2001 Fig 1 p 5) points out that map use is a continuum depending on the audience, amount of interaction, and data relations. MACEACHREN & KRAAK (2001) use the Map Use Cube as a framework for understanding the many nuances of map use but doesn’t address the issue of abstraction verses reality.

DYKES et al. (1999) (see FAIRBAIRN et al. 2001 Fig 2 p. 18) show how representation of space is defined based on a continuum of abstraction. Some representation of spatial information may be extremely abstract such as Chernoff faces (CHERNOFF 1973), while others may be nearly realistic. (IMHOFF 1982). A spatial representation can fall anywhere along the abstraction continuum. A relationship between abstraction and map use exists. One aspect of this relationship is that spatial representation at different levels of abstraction can have the same map use. Using multiple maps with varying levels of abstraction may improve the map-readers experience.

A case study was undertaken to create an integrated map and virtual reality perceptual experience. As the system was being developed, multimedia and geovisualization were incorporated. This multimedia cartography experience was intended to improve environmental understanding for a small drainage basin.

The following case studies evaluate several technologies for delivering multimedia cartography over the Internet that include interactive mapping and virtual reality technologies. The intent of the multimedia cartography system is to use the multiple levels of abstraction within the system to improve the perceptual experience of map-readers.

2 Case Study

2.1 Study Site

The study area is the Little Sac River Basin. The Little Sac River Basin is located in the southwestern part of the state of Missouri in the United States of America. The geographic area of the Little Sac River Basin is 1,010 km². The Little Sac River Basin is a Karst landform region with numerous caves, sinkholes, and losing streams. The majority of the basin is a rural landscape with small family farms and single-family houses. The southern part of the basin contains part of the urbanized area of the city of Springfield.

Several environmental groups are concerned about the water quality of the river. A principle reason for their concern comes from the fact that the Little Sac River is one of the drinking water sources for the city of Springfield. Springfield provides drinking water to an estimated population of 450,000 people. The environmental groups defending the Little Sac River Basin want to educate the public about a number of environmental issues including chemical and nutrient contamination, stream form deterioration and riparian corridor damage.

2.2 Multimedia Maps

The environmental groups and scientists concerned about the Little Sac River Basin had collected and archived a significant amount of data reading the issues of water and environmental quality. The primary means of getting this information to the public was through the journalistic media. Some of the scientists working on the Little Sac River Basin wanted to find an alternative path for getting their results to the public (CAMMACK & PAVLOWSKY 2001). By creating a direct flow of information between the stakeholders and the scientific communities, an unfiltered communication network could lead to improved decision-making regarding environmental issues.

PETERSON (1995) identified a set of interactive tools such as pan, zoom, identity, selection, and queries for interactive maps. These interactive tools allow the user to create a customized map reading experience that suits their needs. MILLER (1999) defined this type of interaction as marginalia to use the margins of the map to communicate with the map-reader. MILLER (1999) categorized marginalia into three types: spatial, manipulation and navigational (see MILLER 1996 for a detail description). In the context of the study marginalia interactions were used to show aspatial research results such bibliographic references, channel cross-sections, water chemistry graphs, and virtual reality views of the landscape.

2.3 Virtual Reality

The key aspect of this case study is joining the multimedia map and virtual reality technology. For the virtual reality part of this case study, several virtual reality technologies were available. Since the primary goal of the project was to connect environmental groups, scientists and community stakeholders together into an educated community, a simple low cost virtual reality solution was needed. Cartographic and virtual reality researchers have developed numerous technologies for creating immersive geospatial experiences (MACEACHREN et al. 1999a, MACEACHREN et al. 1999b, FAIRBAIRN et al. 2001, and CARTWRIGHT et al. 2001). Many of the hardware technologies such as CAVE, immersive workbenches, and Power Walls allow improved immersion techniques but are out of the scope of the public user. It was decided to use an existing data format that would be easy to gather data and pass it to the public. Several choices of data formats are available: VRML OpenGL, Java 3D and GeoVRML. For this research a common format was chosen. The virtual data format used was Quicktime Virtual Reality (QTVR) developed by Apple computer. Since QTVR is a photographic based solution, it is important to understand how digital photographs can be converted into a 3 dimensional virtual environment.

2.4 Digital Photographic Panorama Virtual Reality

CARTWRIGHT (1999), BUZIEK (1999), & DYKES (1999) all discussed the use of QTVR for multimedia cartography. The following section is a brief explanation on how to collect and build a QTVR environment for this case study (see APPLE COMPUTER INC. 2000 for a more detailed description). The QTVR were used to help the public understand the base geomorphologic structure of the Little Sac River. Three locations were selected for data collection. The sites chosen all showed several important geomorphologic structures.

The following equipment is needed in the field for collecting a series of overlapping photographs: tripod, camera, and panoramic tripod mount. Fig. 1 shows the tripod and panoramic tripod mount used for the data collection. Either a film or digital camera can be used. A digital camera was used to eliminate the scanning of photographs.

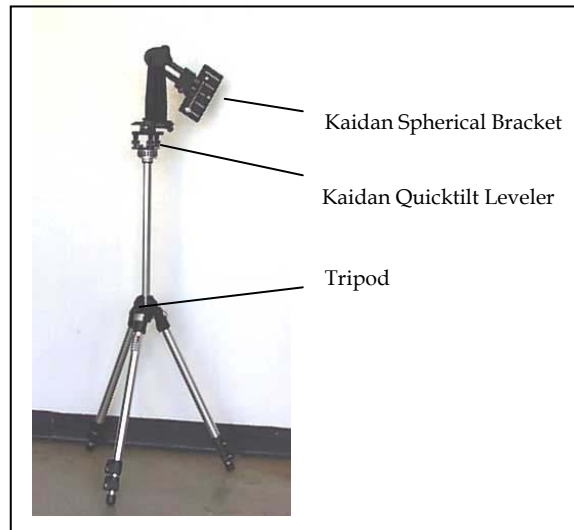


Fig. 1: The photograph shows the digital camera mounted on the Kaidan Spherical+ Bracket and Tripod.

Once the camera was in place, a series of overlapping photographs are taken. For this research the camera was rotated into the portrait orientation and the camera was rotated 18 degrees between each photograph. The camera was then rotated 35 degrees down from vertical and another row of 20 photographs were taken. The camera was then rotated 35 degrees up from vertical and a final row of 20 photographs were collected. Once the 60 photographs were collected, they were stitched together.

In this case study a set of multi-row cylindrical QTVR were developed. It was decided to use the cylindrical format to save file size for data transfer performance issues. To create the multi-row cylindrical QTVR file a stitching program was used. We used Stitcher 3 from REALVIZ but there are several programs available, see <http://www.iqtv.org>. The stitching process combines overlapping images into a single photographic image (Fig. 2). The resulting image is then projected on the cylinder by the QTVR software (Fig. 3). One of the primary issues to overcome with digital panorama stitching is brightness balancing. Most of the stitching programs have algorithms to balance the images.

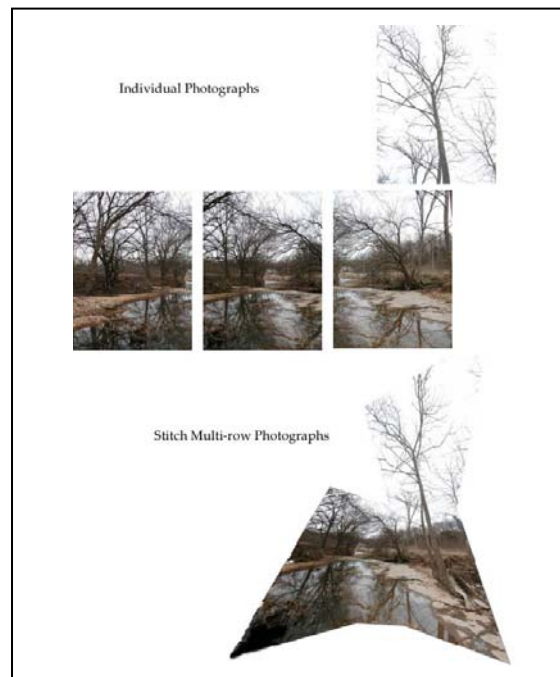


Fig. 2: The figure shows several of the photographs before and after digital stitching and rendering to a cylindrical QTVR model.



Fig. 3: The illustration shows a cylindrical QVTR in the QTVR player software.

3 Augmenting Virtual Reality

In the QTVR scenes all the geomorphic forms were identified. The map-reader has trouble seeing the geomorphic form within the near-realistic representation. The QTVR scenes were augmented (SLOCUM et al. 2001 and FEINER et al. 1997). By augmenting the QTVR scenes the cartographer can focus attention on particular information obscured by the complexity of the virtual reality representation. In the case study, three types of augmentation were implemented: rollover annotation, feature delineation and hyperlinks. Rollover interaction is a common multimedia cartography device (SWANSON 1997, and CAMMACK 1999). The QTVR interface has a display label area. The display label area shows the annotated label of a hotspot in the QTVR scene. When the cursor moves over the

hotspot, the label is annotated in the display label area. In Fig: 4 the curser was positioned over the gravel bar and in Fig: 5 the curser was located over the cut bank feature.

The second type of augmentation used was the area delineation feature. This augmentation utilizes the hotspot feature of QTVR. To add a hotspot to the QTVR scene the VR WORX 2.0 software was used. QTVR support polygon shaped hotspots. In a graphical sense the hotspots can be points, lines, or areas. The QTVR player can also show the hotspot areas within the scene. By turning on the hotspots outline within the scene a cartographer can highlight specific content within the scene. In the case study the geomorphic forms were delineated as hotspots. In Fig: 5 the scene has a cut bank and a ruffle pool delineated with the curser over the cut bank and the cut bank annotation shows in the display label area.



Fig. 4: The illustration shows a QTVR scene with a rollover annotation type of augmentation.

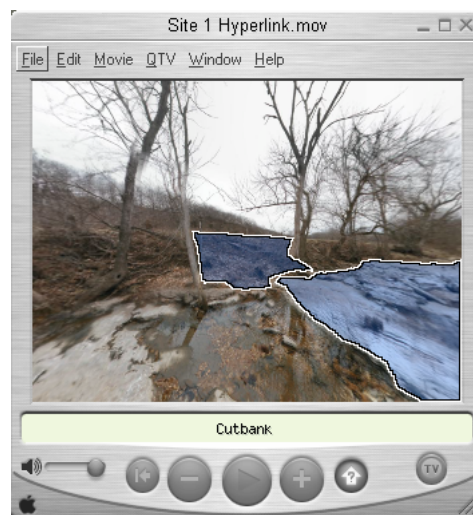


Fig. 5: The augmented virtual reality shows a delineated cut bank and a ruffle pool. The cut bank is also a hyperlink to another web page providing additional information.

The final augmentation to the virtual reality scene was to add hyperlinks to the scenes. In this case study the hyperlink moves the map-reader to more detailed information regarding the geomorphic feature. The hyperlink interactive device can alter the content of the QT player by moving to another QTVR scene or displaying another graphic, i.e. graph, chart, stream cross section, or photograph. The hyperlink device could close the QTRV player

and alter the associated map. In the case study several different hyperlink functions were incorporated: navigation, link to graphic and closing the QTVR player. By augmenting the QTVR scene the map-reader gets access to focused information within the virtual reality.

4 Integrating Maps, Virtual Reality and the Internet

Within this case study a set of interactive maps and augmented QTVR scenes were integrated together. In order to deliver this multimedia cartography system to a map-reader efficiently several methods were considered. A CD-ROM or DVD kiosk method has several advantages: data volume, controlled user environment, and known hardware environment. The method does however have several disadvantages: limited public access, multi-site maintenance, and cost for a kiosk system.

Another alternative was developing an Internet distributed system. The use of the Internet to distribute maps has grown dramatically (PETERSON 1997). Technological developments have made it possible to deliver multimedia cartography systems (CARTWRIGHT 1999, CARTWRIGHT & PETERSON 1999, CAMMACK 1999 and GARTNER 1999). Unlike the kiosk method, the Internet method has a single system production and maintenance costs are lower. The Internet system distributes the multimedia maps and QTVR scenes within the project however the bandwidth limitation could make it impossible for individual Internet users to access the website (CAMMACK 1999). Other issues to consider are incompatible hardware and software configurations and server versus client processing (CAMMACK 1999). CAMMACK (1999) and GARTNER (1999) both suggest that pushing data to client side processor will increase the use-ability of mapping sites. Different operating systems and Web browsers may not support many of the client side solutions. In addition to this compatibility issue, technological development itself may render both the positive and negative of client side solutions obsolete.

In this case study the principle mapping technology was ESRI Internet Map Server. The Internet communication protocol used was JAVA. As discussed before, the virtual reality data structure chosen was QTVR. Figure 6 shows a snapshot of the multimedia site showing the interactive map with a popup window showing one of the QTVR scenes. The QTVR scenes are accessed through a hyper linked point symbol representing the location of a data collection site. Within the QTVR scene, annotation and hyper link data augments the map-reader experience to produce an enhanced multimedia mapping experience.

5 Conclusions

The goal of the project was to develop a multimedia environment that would help users better understand water quality issues for the greater Little Sac River Basin region. The multimedia cartography system developed was an Internet distributed interactive mapping website. The website included an integrated map and virtual reality component. The integrated map and virtual reality demonstrate how cartographers can use multiple levels of abstraction (FAIRBAIRN et al. 2001) with a common map use (MACEACHREN & KRAAK 2001). To achieve this integration, Apple QTVR scenes were fused with an interactive mapping site developed on ESRI's ArcIMS software.

Once the digital photographs are collected they must be digitally stitched together and rendered to a cylindrical model. One of the goals of the project was to augment the virtual reality scene (SLOCUM et al. 2001 and FEINER et al. 1997). The three types of virtual reality augmentation done were: rollover annotation, in scene feature delineation and object hyperlinks. All three types of augmentation are part of the QTVR data structure and are accessible through the QuickTime VR player.

During the process the multimedia cartography team has gotten some feedback from novice and expert map-readers. To improve this multimedia map system the next phase of this research must include a set of control user interaction experiences (FAIRBAIRN et al. 2001) and a better understanding of the cognitive processing used to integrated different level of abstraction for the same geographic area (SLOCUM et. al. 2001).

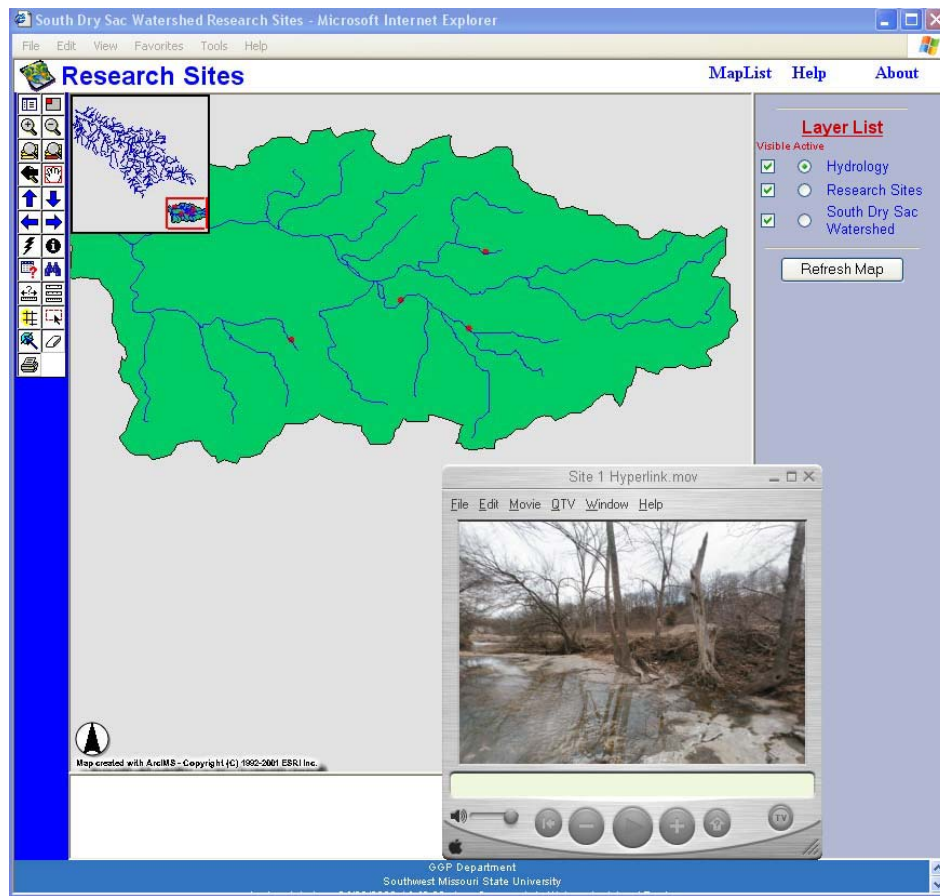


Fig. 6: Diagram showing how the map and QTVR are viewed together on the website. In this case the QTVR is a form of a marginalia (MILLER 1996 & MILLER 1999).

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Geo-Marketing and Internet Mapping – Requirements and Map Solutions

Peter FRECKMANN

1 Introduction

The importance of spatial analysis and planning activities in the field of Geo-Marketing increases rapidly in companies of all lines of business. But currently not all companies are profiting from Geographical Information Systems (GIS) to support their decisions with maps which are produced by GIS. There is still an important number of companies which are afraid of doing the use of complex GIS. They know the possibilities GIS can offer them only vague or they know nothing about these kinds of systems. With Internet based applications it is possible to get a much higher acceptance in the future for the use of spatial data in connection with effective maps for marketing and distribution problems.

This paper will give a general idea of the requirements and map solutions for Internet mapping to visualise spatial marketing and distribution data with maps in three ways:

- From the users point of view the design of the web pages and the comprehensibility of the maps are essential to get a high acceptance.
- From the cartographers point of view it is important to know which type of cartographic models are suitable and what kind of spatial data are available.
- From the programmers point of view it will be shown which tools are currently used for this type of Internet map solutions and which developments can be expected in the future.

2 The Principles of Geo-Marketing

2.1 What is Geo-Marketing

First of all the term Geo-Marketing should be defined. There is a big range of definitions in a wider or in a narrower sense. In the framework of this paper Geo-Marketing can be defined as business applications focus upon the use of geographic data to provide operational, tactical and strategic context to decisions that involve the fundamental question, where (LONGLEY et al. 1995). For example: where are my customers?

Typical applications in this field are:

- Visualisation of spatial data like customer addresses, service locations etc.
- Customer potential analysis
- Sales territory planning
- Retail store location planning
- Catchment demographics, store accessibility, competition or outlet characteristics.

Methods of Geo-Marketing are used in a wide range of lines of business for example consumer industry, retail, banking, telecommunications, publishing or insurance. Within a company typical methods are introduced not only in the distribution and marketing but also in customer services, public relations, management, controlling and market research.

Modern methods of Geo-Marketing offer companies competitive advantages, this means digital analysis and digital mapping are much more effective than the traditional methods. Especially for the background that approximately 80 – 85% of all company data has a spatial character. Because of the quantity and of the complexity these data can't be processed manual. There is not enough time for analysis and visualisation without GIS technology.

2.2 Geo-Marketing on the Internet

With the use of GIS most of the problems in the field of Geo-Marketing can be solved. But there are some important restrictions:

- Often GIS are complex systems which can only be used with special knowledge. But for the normal user it could be too much. For example small and medium companies don't have the possibility to entrust certain employees with the task using GIS for Geo-Marketing analysis and mapping as extra work, because they have many other things to do.
- The integration of all data into a GIS is often expensive because of different data formats various locations where the data are stored and the availability of current data.

In comparison with standard GIS a web based GIS solution offers the following advantages:

- The user works on a usual graphical user interface with menus or buttons for analysing and visualising functions which could be especially designed for his application.
- Availability of all relevant data at each working place, at every time, in the same version and relevance to the present. So analysis and mapping of the data is independent from locations or company divisions. Today real time data allow on-the-fly-mapping and maps-on-demand

So with Internet applications today the user is the cartographer and he is able to produce analysis and maps at any accuracy standard that satisfies him (MORRISON 1997). This leads to a kind of democratic process in creating and using maps also in Geo-Marketing

From this framework four typical application aspects results:

- A company can visualise his locations to offer the customers a better access. So the customers can find the nearest location, the best route to this location etc. This is what most of the companies do with maps on the Internet today.

But there are more possibilities, for example:

- A supplier of spatial market data can open up his spatial analysis services for the customers via the Internet world wide.
- A company can give the employees an access to the relevant spatial marketing and distribution data without the necessity that an employee must have knowledge to work with GIS.
- A company which deals with location based objects like real estates or advertising space in public areas can show the location of these objects in maps on the Internet combined with spatial data which are relevant for a potential customer to evaluate the offer of the company.

3 The User's Point of View

3.1 Graphical User Interface

First of all the user wants an easy to use graphical interface. Beside the well known functions of the usual Internet browsers he expects for analysing and mapping of spatial data the following points (FISCHER 2001):

- The dialog should support the user in the way that he can work effective. This means the navigation on the web pages should be optimized with an efficient information hierarchy and a clearly arranged menu structure.
- Menus and buttons should be self explanatory. This means the user finds that behind a link what he expects to find. Menus and buttons should have a pleasant design.
- All steps should correspond to the knowledge of the user. This means elements which are usual for the user should be as a standard, for example underlined words are hypertext-links etc.

- Mistakes should be corrected by the user in an easy way. This means little mistakes should be ignored and error messages should be clear formulated.
- The user should learn from the system. A step-by-step introduction or a sitemap supports him in this sense.

3.2 Basic Maps

The basic maps the system should offer the user depend of his tasks. In most of the cases he needs boundary maps like postcode or community boundaries to visualise area based data or to plan sales districts. Sometimes he needs house number ranges on a street segment or house number coordinates to locate addresses of customers or service points etc. In some cases road networks are necessary for example to plan catchment areas on the bases of road distances or drive times.

In principle all maps should return the kind of maps he is familiar to work with before he used GIS technology. This is very important to get a high acceptance of digital maps.

3.3 Market Data

Depending on the applications area or address based data form the basis of analysis and visualisation. These are external geodemographic data like inhabitants, income, employment, cars or internal customer data like turnover, sales volume, last visit etc.

3.4 Mapping Functions

The task of the user is to put the market data into a thematic map. For that he needs basic functions like zoom in and out, pan, identify and select objects. Further he needs functions to find locations and to present locations and market areas with symbols, colours and diagrams. Apart from the mapping functions analytical functions are necessary which correspond with the problems the user has to solve with the system for example statistics, classification, area aggregation or location allocation. But all results of analysis lead again to thematic maps.

4 The Cartographer's Point of View

4.1 Basic Maps

In principle vector maps have some advantages in comparison to raster maps for Internet applications like less storage space or zooming capability. Today vector maps in high quality are available on the market for example from TeleAtlas or Navigation Technology (Fig. 1). For planning of catchment areas on the basis of road distances and drive times vector maps are absolute necessary.

Depending on the application the basic maps have to consist of different layers like road networks, administrative or postcode boundaries. To locate customer or company locations detailed address databases with postcode, city name, street, house numbers and a coordinate which belongs to an address are necessary.

For a sufficient orientation on the map topographic information like land use have to complete the layers. In most of the cases in vector maps this kind of information is sufficient, if not topographic maps as raster based background maps can be used to give the user details of the spatial situation.

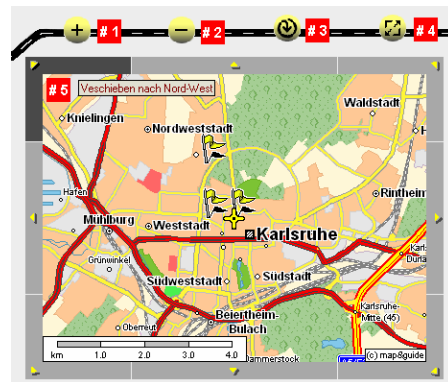


Fig. 1: Basic map prepared from NavTech data, Source: FISCHER 2001

4.2 Mapping Functions

Maps on the Internet are dynamic maps. Therefore functions like pop-up-information and mouse-over elements should be natural. Further a dynamic zoom capability to drilldown requires only one basic vector map because of the direct relation between scale and map content. The larger the scale the more information will be shown on the screen. In addition the cartographic presentation can change depending on the scale for example with a small scale a city can be a point, in a large scale an area. Legend can be visible on a mouse click, pop-up-legends will be presented when the user selects an object. Interactive legends allow the user to decide which content should be shown on the map or to classify the data. Referring to the use of colours it is important that the cartographer don't know how the map appears on the screen of the user. In many cases the "Web Safe Colour Palette" with 216 colours can be sufficient (WORM 2001).

4.3 Visualisation of Spatial Data with Cartographic Models

A map consists of points, lines and areas as three graphic elements and their combination in cartographic symbols. The cartographer has to take into consideration that normally the less resolution of Internet maps requires not very detailed signatures but signatures which are easy to perceive.

The system of cartographic signatures builds up various cartographic models to visualise spatial data for points and districts in the field of Geo-Marketing. The typical models referring to point related data are used in location maps. They allow to visualise qualitative data like A-, B-, C-customers, service points, points of interest etc. with different symbols or colours and to group them (Fig. 2a, Fig. 3). Quantitative absolute and relative data can be represented with proportional diagrams like circles (Fig. 2b, Fig. 4). These models are often used in maps to show number of inhabitants or customer data like turnover at a certain location. By creating segments in a pie chart different characteristics like age groups of inhabitants or turnover per product can be shown (Fig. 2c).

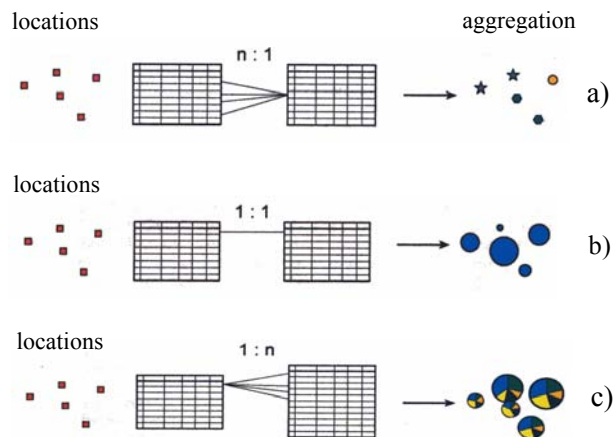


Fig. 2: Cartographic models for point related data. Design: H. MUSTAPIC

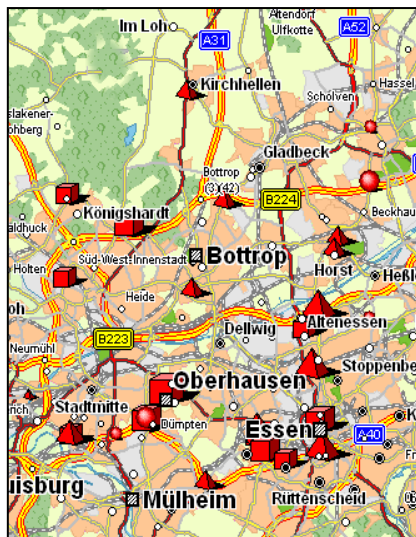


Fig. 3: Visualisation of various locations, Source: PTV AG

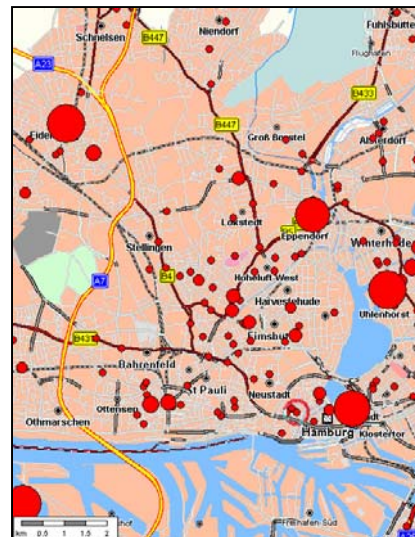


Fig. 4: Visualisation of different values of an attribute at certain locations, Source: PTV AG

In comparison to point related data area related data are used in area maps, choropleth maps and also in maps with proportional diagrams. Area maps show districts with different quality expressed in different colours like various sales territories which are aggregated from a more detailed district level (Fig. 5a, Fig. 6). Quantitative absolute data can also be represented with proportional circles for example to visualise the number of households in a certain district. Choropleth maps show relative data like population density in hue steps (Fig. 5b, Fig. 7). Different characteristics in absolute or relative data can also be presented with pie charts (Fig. 5c).

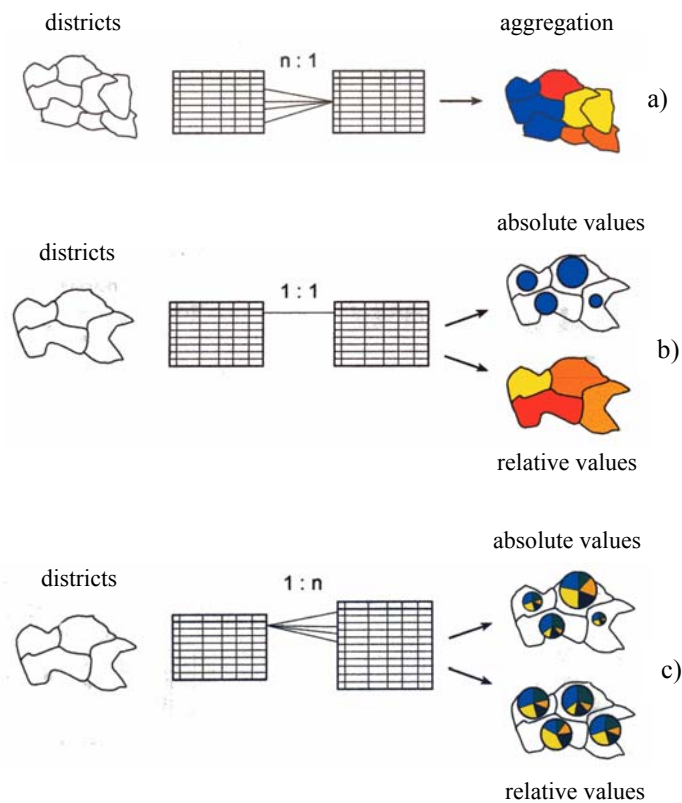


Fig. 5: Cartographic models for area related data. Design: H. MUSTAPIC



Fig. 6: Visualisation of various districts, Source: FISCHER, 2001

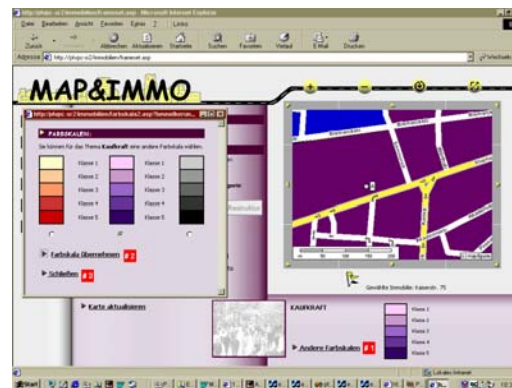


Fig. 7: Visualisation of different values of an attribute for each district, Source: FISCHER, 2001

5 The Programmer's Point of View

5.1 User Friendly Web Design

With the European standard "DIN EN ISO 9241" a catalogue of rules exists which helps the programmer to create an ergonomic user interfaces. These rules are related to the keywords:

- Input masks
- Reply messages
- Error management
- Status
- Online help and
- Dialogs

Independent from the content of the web pages a user friendly web design based on the general principles of this standard can support the user to solve his problems.

5.2 Elements of Web GIS Solutions for Geo-Marketing

Within the client-server-architecture for Internet applications a dynamic map browser is the suitable technology in the field of Geo-Marketing because the user have to create his individual maps. Every zoom into a map or pan of the map requires a new map sector. Often analysis steps have to be repeated because parameters changed. All interactions lead to a new map.

A standard configuration of a dynamic map browser is shown in Fig. 8. The information which is given from the client to the http-server sets off a calculation on the mapserver to generate the new map as GIF- or JPEG-file which gets back to the client.

A CGI-Programme (Common Gateway Interface) prepares the HTML-inquiry for the map server. Proprietary interface programmes like API (Application Programming Interface) or ASP (Active Server Pages) enable a faster process in connecting the map server. PHP (Hypertext Preprocessor) as a new technology supports a wide range of database systems like Oracle, MySQL, Informix or Access (DICKMANN 2001).

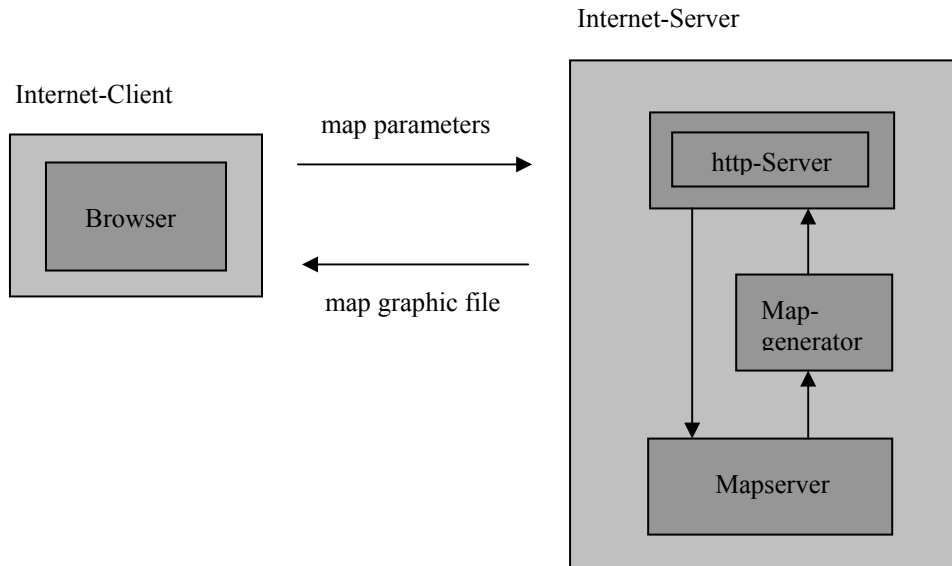


Fig. 8: Client-Server-Architecture, Source: FRECKMANN 2001

Creating maps means a high grade of interactivity. HTML itself and a server working at full capacity could be the bottle neck in the data exchange between client and server. So the client-server-architecture allows to transfer the work of the processor on the client side. For web mapping applications in the field of Geo-Marketing it is useful to put the centre of the work of the processor on the so called thick client. To extend the functionality of the client plug-ins and viewers are applied. Especially active-X components and Java-applets offer many possibilities to introduce more GIS functions on the client side.

In most of the cases GIF or JPEG raster maps are used on the web pages. But to get maps with a high quality like vector based maps the Scalable Vector Graphics- Format (SVG, recommended from the W3C) which use the new XML standard is introduced. In comparison to the GIF or JPEG formats within this format all graphical elements of a map are defined as mathematical objects (DICKMANN 2001). So the quality depends only on the screen solution. Maps can be zoomed in or out without loss of quality.

Further capabilities of the SVG standard are important for the conversion of cartographic models with symbols, diagrams and coloured districts into easy to use high quality thematic maps for Geo-Marketing, for example (Fig. 9):

- basic geometry like circles, rectangles, lines, polygons
- translation, rotation, scaling
- detailed hue steps
- colour transparency
- various line symbols

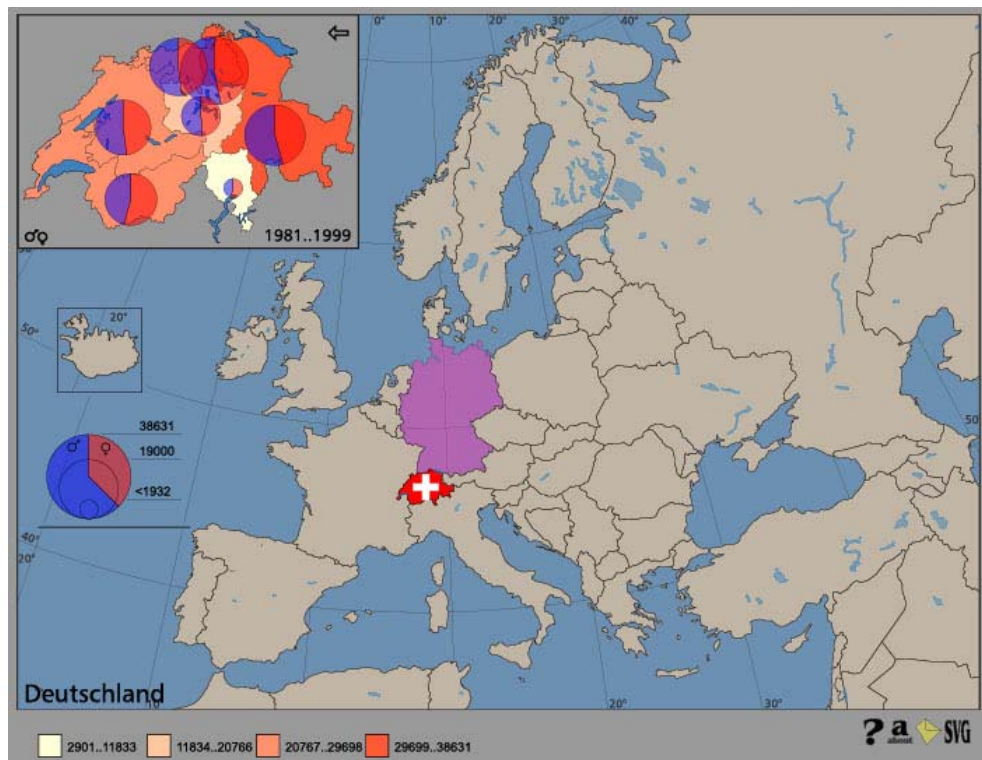


Fig. 9: International Migration 1981 – 1999 as interactive cartographic SVG application,
Source: http://www.karto.ethz.ch/teaching/dip_2001_joray/

6 Conclusion

The integration of the three points of view described above leads to the fourth point of view, "... a map should not only be functional but also be attractive from an aesthetic point of view. ... Combining functionality with a high level of visual attraction and a design that suits the medium should be a challenge for every web cartographer." (WORM 2001). In addition a user friendly design of the web pages and user friendly operations to create the maps will extend the acceptance of working with GIS in Geo-Marketing. This can be realised much more easier when a web based GIS is available.

In the future new XML based technologies like SMIL (Synchronized Multimedia Integration Language), X3D (3D-Graphik) or XHTML will offer new capabilities. Especially GML (Geography Markup Language) could be interesting for mapping application in the field of Geo-Marketing for example for address geocoding or to create new attributes for locations, districts and customers.

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Web Atlases

Swedish Webatlas goes Interactive

Mathias CRAMÉR

1 Background – The National Atlas of Sweden

1.1 Printed Edition

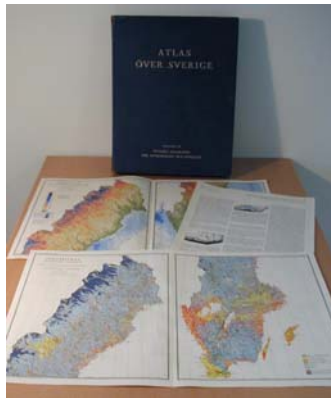


Fig. 1: The preceding “Atlas över Sverige” 1951-1973



Fig. 2: The National Atlas of Sweden (1990-)

The National Atlas of Sweden (Sveriges NationalAtlas, SNA), has been for a number of years one of the largest and most well spread national atlases in the world. It covers 16 national topics and includes over 3,000 map illustrations.

On behalf of the Swedish Parliament, the Atlas is governed by the National Land Survey. The total yearly budget is approx. 400,000 Euro. Regional atlases, as part of the SNA, are being financed externally.

Book sales have been quite successful with 15,000-20,000 copies each. The book Map and Mapping has sold about 80,000 copies. Most books are available in English.

Although the original plan was to publish only 17 books there is now a total of 19, including one regional atlas and a national summary. At the moment another regional atlas is being produced and topics for new books have been suggested. Previously published books are continuously being reprinted or revised.

The SNA collection is very popular at comprehensive schools and many of the thematic atlases are being used as work of reference at high schools and universities.

1.2 Computer Versions

Also the ArcView-based “PC-Atlas GIS” is frequently used as an educational tool at Swedish schools. It contains over 1,000 map views, using a variety of GIS map techniques (thematic maps, lines, polygons, raster images, charts etc).

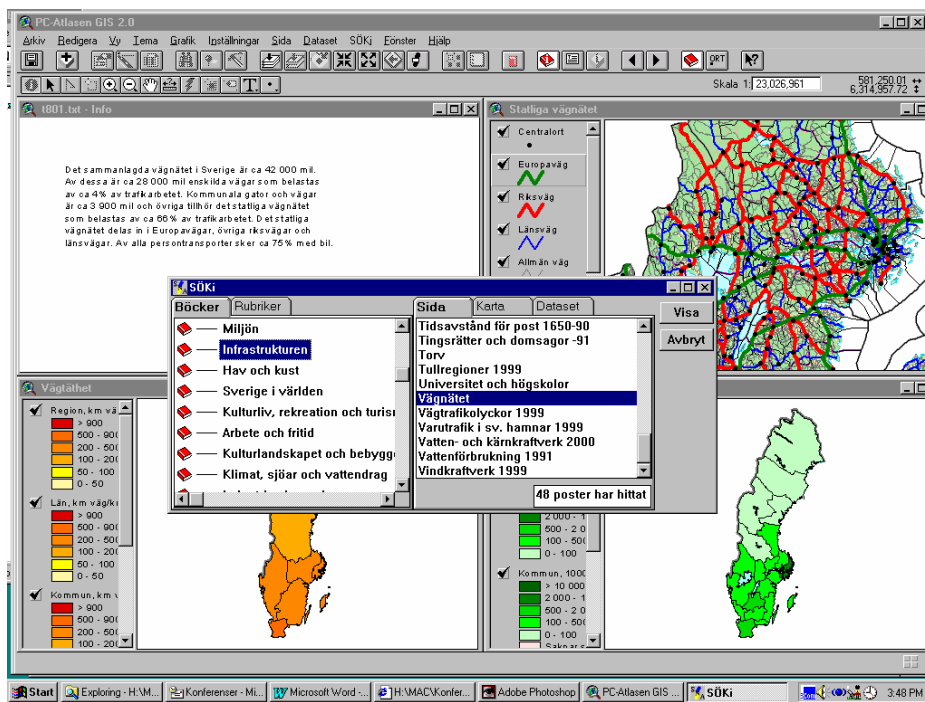


Fig. 3: The ArcView based PC-Atlas GIS. Example, describing aspects of the Swedish road infrastructure.

The PC-Atlas was originally distributed on floppy discs but nowadays it comes on CD-ROM. Updated versions have generally been published once a year.



Non-interactive GIF-images have been available on the Internet since 2000. The set is referred to as the SNA Webatlas, as part of the homepage.

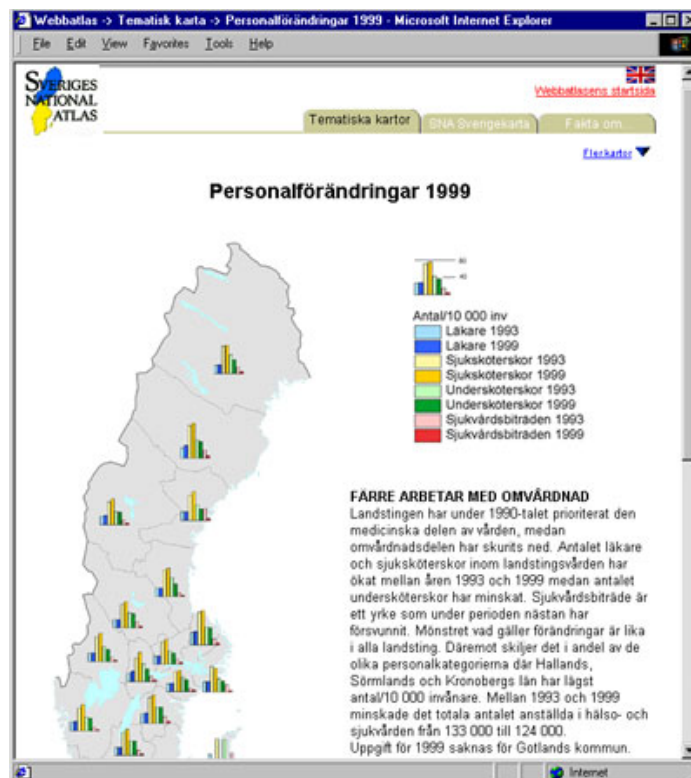


Fig. 4: Example on non-interactive map images with short descriptions (the present Webatlas)

The homepage has an increasing number of visitors. The numbers have been doubled in just one year and have now reached 30.000 visitors a month (approx. 4 million hits). Half of the visits are from Sweden, the rest from abroad.

2 Current Needs

As a natural consequence of new books, the total SNA package is growing larger and larger each year – recently it has become exceedingly difficult to publish updated CD-ROM versions once a year. We now face a cycle of 1.5-2 years between upgraded versions.

It is also hard to master all end user OS environments in combination with the latest ArcView developments. Schools tend to stay longer in older environments for financial reasons. They simply can't afford to keep up with the latest technology - and to increase licence fees just for the GIS software on top of this would be a dead end.

Quite often teachers have to carry out the upgradings themselves and they will tell you that it is a tedious, troublesome and time-consuming process – All they desire is an instant access to up-to-date facts with a minimum of fuss, particularly when paid for. Adding the PC-atlas on top of that burden is becoming less and less rewarding.

Students of today will go to the Internet for information. Installing a CD-ROM for the latest news is becoming old fashioned.

3 Present Developments

These circumstances have contributed to our short-term strategy to distribute the GIS functionality across the Internet instead. This will be achieved by implementing an ArcIMS platform, together with the ArcMap Server extension for maps containing charts.

Another reason is that this will enable us to integrate the web maps with the considerable volume of illustrated texts, once being transferred from paper to html. The development process is afoot and some parts of the atlas will be available at the end of 2003.

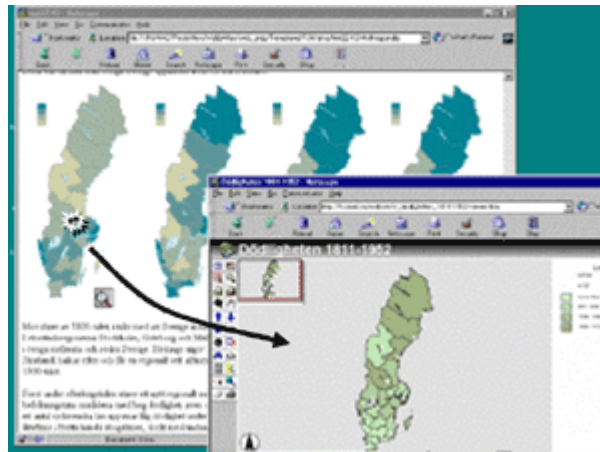


Fig. 5: Going from “book” to GIS in web format

This service will be called “Webatlas GIS” and the concept is pretty strait forward. Some of our partners have already tried similar solutions.

The prevailing Webatlas, based on GIF images, will remain as a free overview service.

Since we charge a fee for the PC-atlas we are at the moment considering subscriptions for the new Webatlas GIS. On the other hand, administering a lot of users and developing a login system does not come free of charge and if the subscription fees are set too high we will not be able to increase the number of customers, as we hope to do. The issue has been put forward to our Principal for decisions, since it otherwise has to be financed by other means.

4 Expansion and Future Potentials

4.1 Alternative Browsing

Letting the visitors go from chapter to map is easy to achieve by simple links. But if you are not familiar with the subjects, it leaves you to browse through all 19 books and various chapters in order to find a map that is relevant to you. Since the atlas is scientifically based it is not always easy to translate the table of contents into maps that might be of interest, particularly if you primarily focus on a geographical location. Ordinary people have a very rational way of approaching the geography. They usually point on a familiar place and expect to find out more.

What is there to read about this place?

You could call it a point-and-read method.

Would it be possible for the interactive webatlas to reveal its content in a similar manor? Presenting texts and thematic maps just by pointing on a simple road map could turn out to be quite a challenge. It would indeed make life a lot easier for less academically trained visitors.

The biggest obstacle would probably be to filter away the information overload, since you can expect too many irrelevant hits in a thousand layers, i.e. polygons covering most of the country. It would also require the topology of the geographical features to be stored in a spatial database (SDE in ESRI language). Could such filtering methods be developed? The web-GIS environment shows promising potential so far but it doesn't provide the logical rules for filtering.

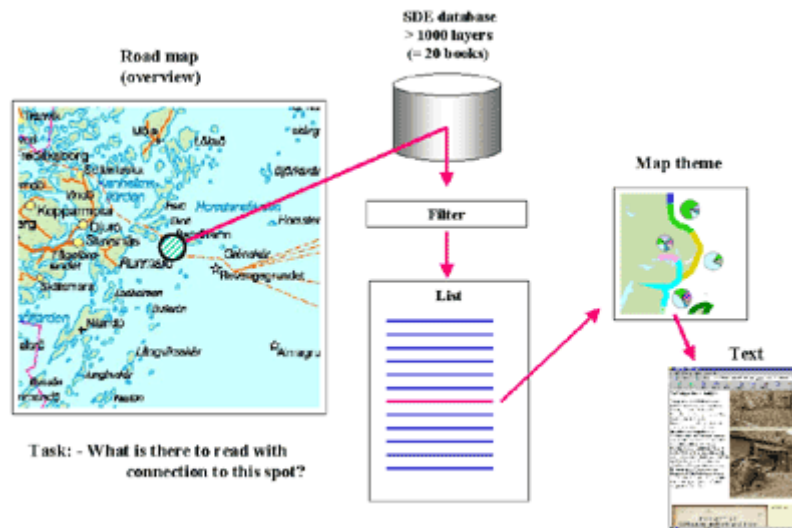


Fig. 6: The point-and-read concept (or “find-map-from-map”)

4.2 Keeping Data Up-to-date

We have developed a long tradition in collecting data through our editorial partners. Sometimes data is revised by hand and sometimes it can be selected from existing databases. For a vast material like the SNA the need for updates varies dramatically. For instance some geological facts never change but roads, telecommunications and other means of infrastructure changes constantly and needs to be updated at least once a year.

When possible we will try to link external databases to some SNA maps in order to keep the material up-to-date. This will be done by using ODBC or dynamic server pages.

4.3 Dissemination and Support

Once the new regional atlas of Western Sweden has been published we plan to launch the book and web package through local seminars. We have often noticed that the educational values of the product are more appreciated when demonstrated.

As with the PC-atlas the regional atlas will be accompanied by a set of exercises. We often underestimate the need for this kind of support and expect the teachers to have full knowledge of GIS.

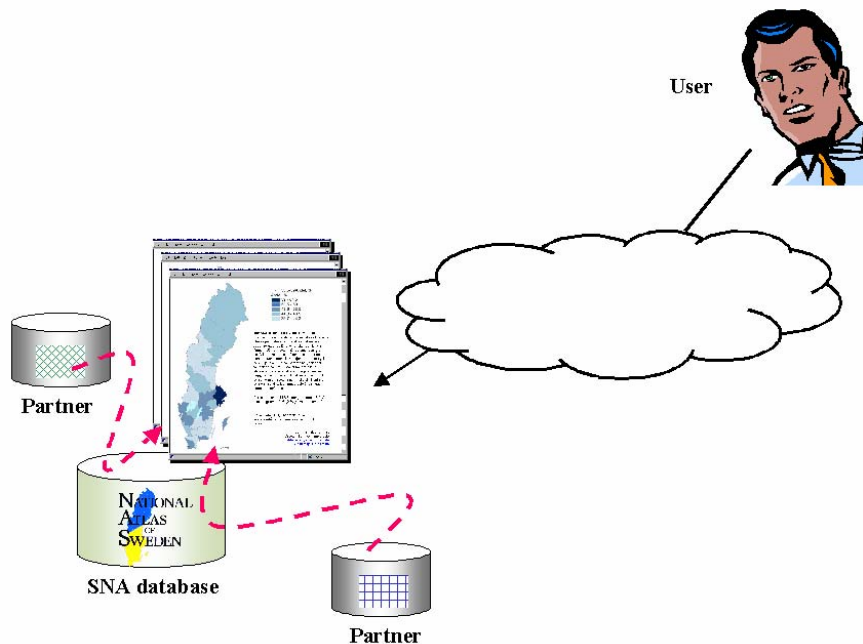


Fig. 7: External online databases at our editorial partners will be linked to SNA map layers.

This time we also intend to establish an educational symbiosis between the atlas, local schools, municipalities and major Swedish authorities. We will encourage students to screen local governments for complementary GIS-data and to persuade local administrations to publish some of their internal office material. We would like to think that SNA has a catalytic role to play in widening the local everyday use of GIS.

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Making Maps is useful but sometimes dangerous: The Experience of the *Atlas Electronique du Saguenay–Lac-Saint-Jean* in Canada

Majella-J. GAUTHIER and Carl BRISSON, Martin DION, Pierre-Martin CÔTÉ, Alain ROCH

1 Introduction

In 1997, a team of geographers and planners initiated a cartographic information research project for a region of the Province of Quebec, Canada. The *Saguenay–Lac-Saint-Jean* region, a remote territory in the boreal forest, has since been covered on the Internet by hundreds of thematic maps. Many projects (maps and reports) come from our own initiative, while others are the result of collaboration with regional partners. Some projects aim to discover geographical patterns, structures, systems, and dynamics, while others try to build models (GAUTHIER, CHAMBERLAND, et al. 2000).

Gathering data and information in the lab prompts the researchers to integrate them into their reflections. At the same time, they cannot resist the need to make public objective and processed information on current questions. In general, this type of initiative is appreciated but, sometimes, individuals and groups can be perturbed by the information, which may lead to strong reactions.

The paper presents the context in which the *Atlas électronique du Saguenay-Lac-Saint-Jean* project responds to needs, and more!

2 Overview of the Project

Atlas électronique du Saguenay–Lac-Saint-Jean is a research project and a production of geo-cartographic knowledge. It is a decision-making tool for social-economic leaders to help them determine the long-term trends and evolution of a regional territory for sustainable development and land planning. On the one hand, it is a set of geographical and scientific proceedings founded on reliable information and rigorous avant-garde research methods. On the other, it is a multimedia product available on the Internet, mainly made up of maps, images, texts, diagrams, video, sound, etc. In a sense, it is more than a conventional atlas.

The objectives of the project are: 1) to create an electronic atlas of the *Saguenay–Lac-Saint-Jean* region using a geocoded database on the territory, and produce maps under the direction of experts; 2) to investigate problems related to the region and to gather regional expertise for land management and regional planning; 3) to produce first-hand knowledge in the fields of economy, demography, environment, etc.; 4) to decentralise the national data and make information widely available on the Internet; 5) to provide the region with influent means for its own development and, at the same time, with a permanent tool for local and regional development; and 6) to support teaching-research integration at all levels of education.

The project focuses on major regional topics at various levels: from local to regional and peripheral. At the moment, the Web site offers more than 500 thematic maps and contains over 4,440 pages. In this project, the Information Highway is at the service of the territory. The Atlas is integrated into the *Atlas du Québec et de ses régions (AQR)*, a large project established for the Province at different geographic scales and with various territorial grids (CARRIÈRE, GRÉGOIRE & J.-L. KLEIN 1997).

The idea of undertaking a geographical atlas of the *Saguenay–Lac-Saint-Jean* region on the Internet took shape in 1995, along with that of the *Atlas du Québec et de ses régions*: a project structured on three levels: national, interregional, and regional. In 1997, a team from *Saguenay–Lac-Saint-Jean* presented a prototype to be applied to all Quebec regions, an example of what could be a regional atlas. The prototype was initiated by the UQAC (*Université du Québec à Chicoutimi*) team because of its expertise in the matter. Now, the *Atlas électronique du Saguenay–Lac-Saint-Jean* is well on its way. The launching phase was mainly sponsored by the University, the

FODAR program (*Université du Québec*), and *Fondation de l'UQAC*. For the production phase, the project received financial support and collaboration from partners and regional organisations.

The *Saguenay–Lac-Saint-Jean* region, as large as Iceland, is defined as a resource territory located north of Quebec City. The core of the area, a depression in the Canadian Shield with good conditions for settlement and farming, is a “Temperate oasis in the middle north”, where over 280,000 inhabitants are mainly employed by the forest and aluminium industries.

3 Maps for whom?

The initiatives taken to realise thematic maps of a territory mostly come from universities, where understanding of geographical space and dynamics is a concern (COMITÉ FRANÇAIS DE CARTOGRAPHIE 1993). Do researchers not have the mission of keeping their eyes wide open? To try and describe situations and define problems which they observe or predict? To propose analyses that respond to new, well-documented research hypotheses? Researchers thus satisfy their thirst for knowledge, their intellectual curiosity.

Among the **people and organisations** that can benefit from this useful new information, some are interested and involved in the production of such information, while others are simply users.

The **first** category is made up of mainly partners, regional organisations that are ready to invest in a project, not only with expertise and content, but also with financial support. In the case of the atlas, these organisations are: CRCO (*Conseil régional de concertation et de développement*), CLD (*Centres locaux de développement*), MRC (*Municipalités régionales de comté*), regional managers of provincial and federal departments, such as MDR (*ministère des Régions*), MTQ (*ministère des Transports*), MIC (*ministère de l'Industrie et du Commerce*), MRN (*ministère des Ressources naturelles*), HRDC (Human Resources Development Canada); or municipal administrators, *Ville de Saguenay* for example.

In all cases, the parties involved are top-level administrators who find useful to develop analysing tools, produce information, and make sure the results are made public.

The **second** category includes people and organisations that, while not directly involved in the development or realisation of the project, receive “free” information, which they can reflect on, or use for local or regional action. This extends to education, chambers of commerce, citizen committees, help groups, human rights protection groups, tourism, museums, etc, and, of course, any individual interested in the territory and its people.

4 Maps on what?

The choice of themes for study and illustration in a regional atlas is based on three requirements: research, needs of organisations, and current events.

1. Researchers initially provide a **general framework**, which includes the larger themes and categories of information to be included in a general regional atlas. In other words, they try to cover all dimensions of the region in question: physical, human, social, economical, environmental, etc. That is why the atlas is divided into five major categories: Territory, Environment, Population and Society, Activity and Resources, and Middle North. Then, content is subdivided into a tree structure leading to more specific subjects.

The task becomes increasingly difficult when the inventories have to be done, and one look at a regional atlas is proof enough. Choices had to be made: take up what had already been done, then identify research and production priorities. It will of course take a few years before all possibilities are covered. The map of attraction poles for urban centres is a good example of scientific questioning. (see Fig. 1).

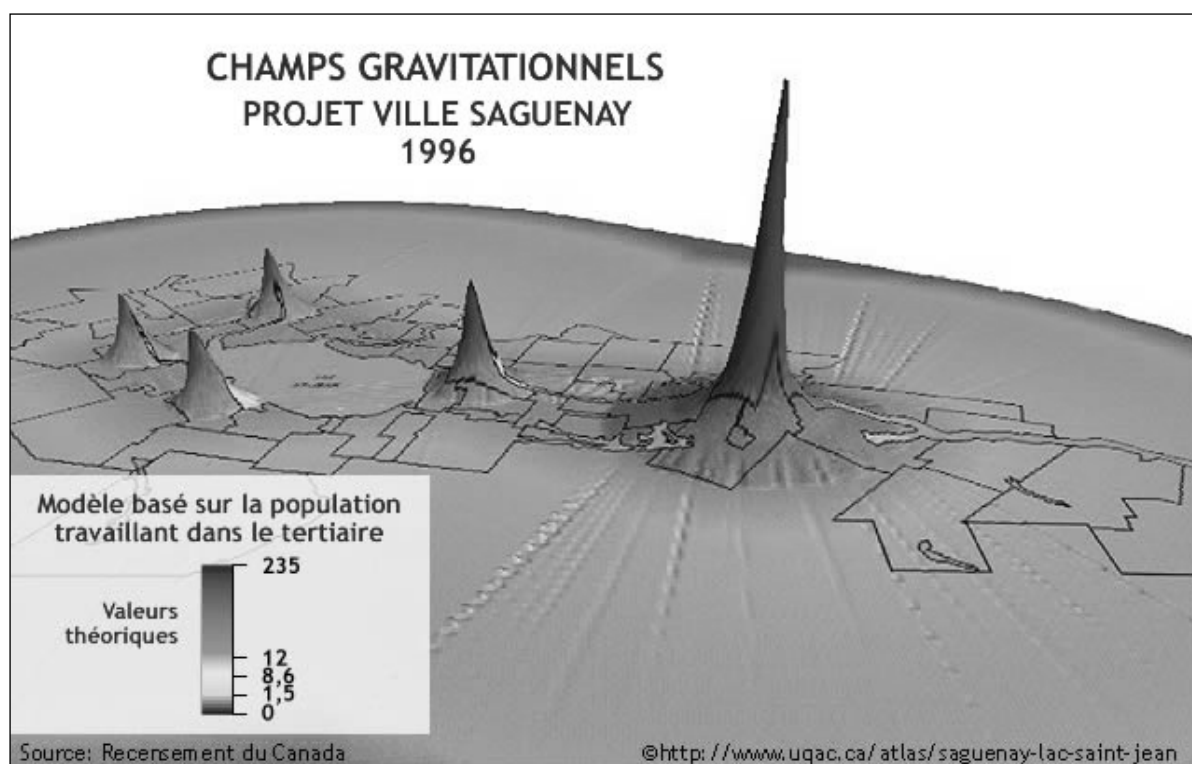


Fig. 1: Gravity models of urban centres before amalgamation (simulation)

2. Researchers must remain sensitive to the **needs of regional organisations** (especially since they provide most of the financial support). In fact, during meetings, interviews, and investigations, many suggestions for analysis and cartography were put forth. They refer mostly to questions of socio-economic development and concern social management and intervention. The following are a few of the studies that were conducted with partners:

- daily commuting of the workforce for all municipalities to determine the role of attraction poles,
- the workforce pool for large industry to demonstrate how they extend beyond municipal limits,
- buying habits to understand the spatial pattern of consumption,
- land use to study space dynamics,
- distribution of businesses to evaluate the spatial distribution of employment, (see Fig. 2).
- setting up a database of street names and addresses to better handle emergency calls.

3. **Current and certain other events** lead researchers to deal punctually with subjects that have an impact on the territory and people. For example, if the government plans to build a power dam or to divert a river, the maps need retouching based on the report before they are made available on the atlas Web site.

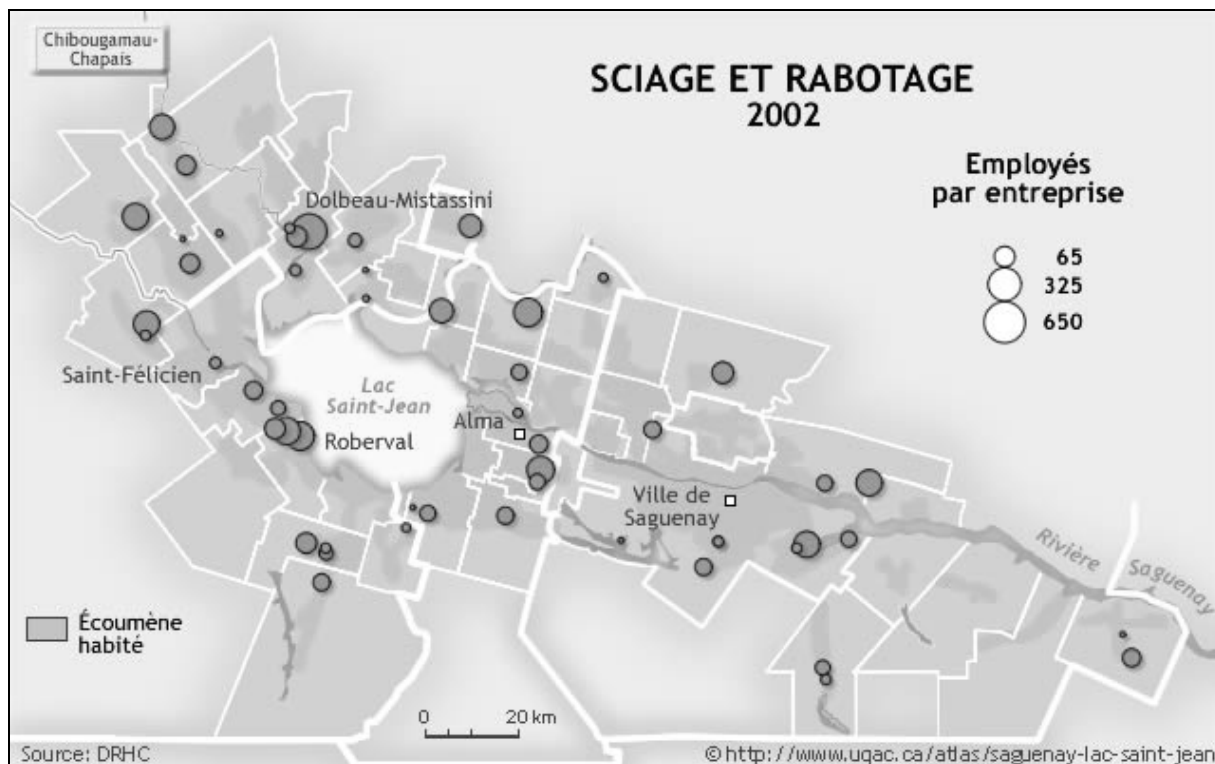


Fig. 2: Sawmills and employees

In the same sense, here are two more examples. Quebec's North is often the site of forest fires requiring immediate intervention before they become hazardous for populated areas, due to either the proximity of the fire, or smoke (over hundreds of kilometres), which creates uncomfortable conditions, especially for babies and the elderly. Researchers, on short notice, put satellite images on the Web daily, showing the progression of the fire in space and time, and the location of danger (see Fig. 3).

Other maps on the site are closely related to particular economic activity, such as blueberry picking in the woods. In fact, fires renew the growth of berries on the forest floor, blueberries among others. The information regarding the location, year, and size of past fires becomes important for pickers who spend weeks moving from one site to another. The map was produced shortly before the picking season and published in the regional newspaper (see Fig. 4).

5 Gathering and integrating Information

The fact of working on several issues related to space gives the team an opportunity to gather varied information and data in one location, and develop expertise in geographical analysis and cartography. The integration of such knowledge and know-how leads researchers to get involved in socio-economic debates that often have political repercussions. That is how researchers, of their own accord, published objective and rigorous information on a municipal amalgamation project; that of Ville de Saguenay (the urban centre of the region).

A first report on the place of urban areas in the organisation of regional space in Saguenay-Lac-Saint-Jean, presented to the government agent, showed the large inter-dependence between the three major cities involved in the amalgamation project. The report was acclaimed by the principal role players, among them administrators of the most populous city (Chicoutimi), and by regional newspapers (BOUCHARD 2001a). However, it did not please everyone. In fact, the population and administrators of a few municipalities saw the amalgamation project as loss of identity, loss of control over the development of their territory and, in the case of cities, dissolution of their zone of

influence. Moreover, the researchers knew well that the report would not please everyone. What was bound to happen, happened. The report was severely criticised through the media (BERNIER 2001), by reducing it to a mere technical study that did not reflect reality! (see Fig.5).

Another case, just as exciting, merits attention. It also concerns the municipal amalgamation mentioned above. **Political jostling** taking shape regarding a more or less precise option to include the municipality of *Larouche* in the new urban grouping. The research team decided to bring water to the mill and enlighten the deciders on the subject.

A report was therefore produced on the daily commuting to and from work, where employees of large industries live, and landscapes. To this information was added a reflection on the impact of the various political options in light of the environmental orientation of the town. Since the *Larouche* Town Council had decided to develop an industrial sector based on the environment, and that a decontamination plant was already in place, it was necessary to evaluate how future developments would affect the surrounding area. The research team described the conditions related to proximity, dominant winds, and water runoff. Finally, they warned deciders about a potential danger if control of environmental issues was left out of the hands of the majority of the population of the new city.

The report was well received by authorities... except those of the municipality in question. Through the newspaper, radio, and television the Mayor severely criticised the intrusion of outsiders in matters that did not concern them, people who had sold out to environmental issues (BOUCHARD 2001c). The newspapers reported, in a five-column article, very aggressive remarks aimed not only at the report, but also its authors.

6 Conclusion

Mapmaking is useful, but sometimes dangerous, as suggests the title of the present article. The case of the *Atlas électronique du Saguenay-Lac-Saint-Jean* is surely not unique.

Research conducted in a university and which leads to the production of maps for the region it serves is done in particular circumstances. Researchers are not insensitive to local and regional problems, they understand what is going on, relations are made between individuals and organisations, they are in touch with all the information available, public or otherwise. Is not the role of researchers to find and define the problems concerning the territory, and propose or back solutions that can improve the situation and lead to change?

Describing space in a factual manner creates less impact than analysing an active spatial problem. Putting documented maps on an current issue on the Internet and making them widely available makes it possible for the population in general to get a better idea of the issue and form an opinion. In most cases, both the public and deciders will appreciate the extra information. However, many will never be aware that such information exists, others will voluntarily ignore it, and others still will be upset.

The production of thematic maps and related Web sites must answer to certain needs. The information must be useful to someone. If producing maps that deliberately concern no one goes against the research ethics (PETERSON 2001, 5,3) that is certainly not the case here.

Note on the team

The project is carried out by the professors Jean Désy, Jules Dufour, Christiane Gagnon, Majella-J. Gauthier (coordination), Gilles-H. Lemieux and Martin Simard from the Department of the Human Sciences at UQAC and Michel Perron from *Cégep de Jonquière*. They are assisted by: Carl Brisson, Pierre-Martin Côté, Martin Dion and Alain Roch (research); Claude Chamberland, Jean-François Fortin and Monique Bérubé (multimedia, computer, animation); Stéphanie Bissonnette (linguistic review); Réal Beauregard (technical advisor).

Site of the atlas on the Internet: www.uqac.ca/atlas

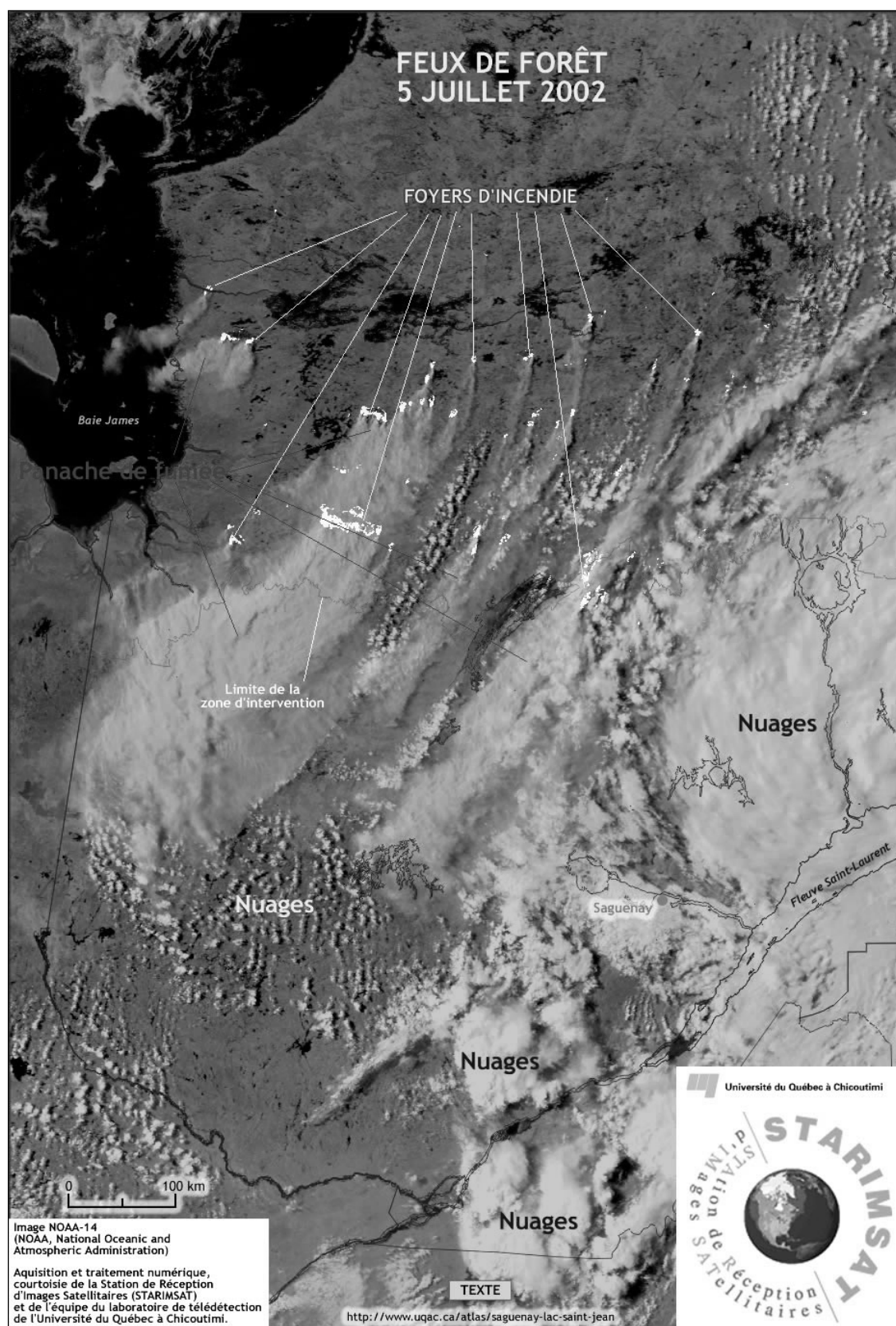


Fig. 3: Forest fires in Quebec, July 5, 2002

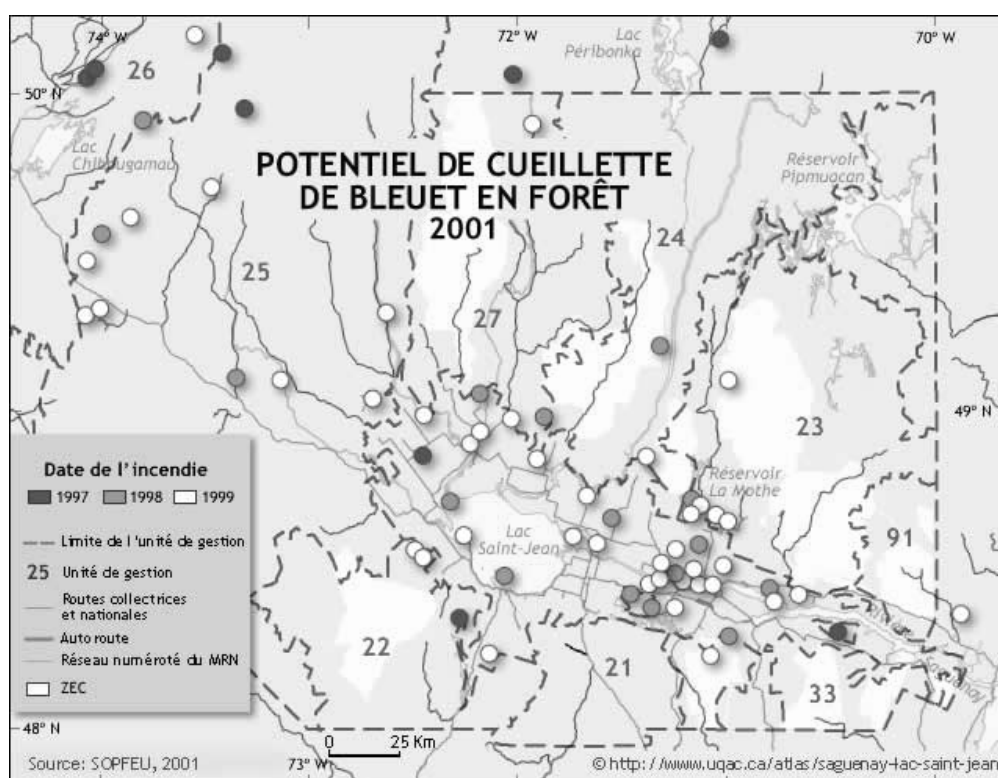


Fig. 4: Blueberry patches in forest



Fig. 5: Severe reactions of municipal authorities in the newspaper

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Conception for an Online-National Atlas of Germany

Olaf SCHNABEL

1 Introduction

The current version of the National Atlas of Germany exists only as a print- and a CD-version. With the rise of the internet towards a mass medium (1992: 1 million connected computers, 2000: 100 million connected computers) the Institute of Regional Geography, Leipzig started to work on an internet atlas prototype, in close collaboration with the Institute of Cartography at the Dresden University of Technology. The internet atlas should complement the printed and the CD-version. As a result of the collaboration a master thesis was carried out in 2001 which should work on the conception of the content, the layout and the technique for an online-National Atlas of Germany (SCHNABEL 2002).

2 Internet Atlases

To determine the content and the layout of an online-atlas, 12 selected thematic online-atlases were analysed regarding their content, user guidance and user friendliness, layout and interactivity. The 12 selected thematic online-atlases were:

- National Atlas of Canada,
- Atlas de France (National Atlas of France),
- National Atlas of USA,
- National Atlas of Sweden,
- National Atlas of Switzerland (prototype),
- Atlas of Ukraine,
- Western Australian Atlas,
- South Australia Atlas,
- Environmental Atlas Berlin,
- Atlas du Quebec,
- Nationalgeographic Atlas,
- Arctic Environmental Atlas.

The analysis of the above atlases led to the following classification scheme presented in Figure 1. Online-atlases can be divided on the basis of their generation in statically and dynamically generated online-atlases. Static online-atlases are pre-generated once, dynamic online-atlases are generated on demand. A further subclass could be introduced on the basis of the degree of interactivity: view-only and interactive online-atlases (based on KRAAK & BROWN 2001, p. 3). In view-only online-atlases the content and the cartographic layout can not be changed. Atlases with the ability to zoom and pan have to be classified in that group because the user can only change the map to a differed view. These atlas types often build on scanned raster maps.

In contrary to this group the content of interactive online-atlases can be changed. In dependence of the degree of interaction two interactive atlas types could derived. The first type limits the interaction of the user to predetermined possibilities which are determined by the atlas author. There is also no possibility to change the cartographic layout of the maps. For that type of online-atlases the presentation of maps is important. Reasonable colour and theme combinations are used which are predetermined by the atlas author. In the most cases the user can toggle thematic layers and change the map view (zoom, pan). The navigation is easy to use but limited to standard functionality. That's why this atlas type can serve a larger audience.

The second type has a higher degree of freedom. For this class the emphasis is on analysing the map data. That's why this type should be called analytical online-atlas. The user can select and combine layers objects. He can also

change the symbolization and colour-schemes of each map. But the most important aspect is the possibility to do numerical or graphical queries and analysis (e.g. buffering, intersection). The user has also the possibility to embed own scripts and macros just like in a GIS. The possibility to combine different topics and data paired with uncontrolled visualisation parameters can lead to thematically meaningless and cartographic bad visualisations.

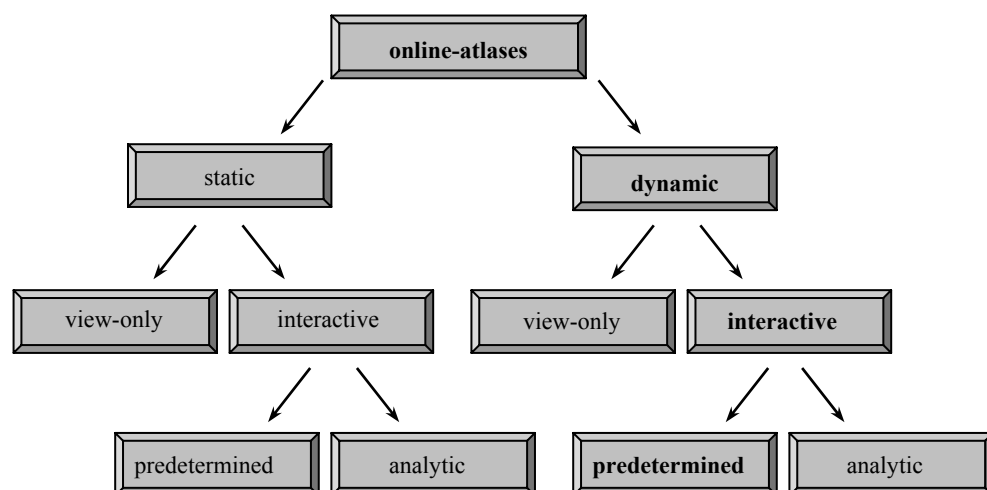


Fig. 1: Classification of online-atlases (depending on the classification of their maps)

If the 12 analysed online-atlases are classified in this scheme the following distribution (illustrated in figure 2) is seen: Most of the analysed thematic online-atlases are predetermined interactive. None of these online-atlases could be classified in the group of the analytic online-atlases (SCHNABEL 2002).

Online-atlases	Static			Dynamic		
	View-only	Interactive Predet.	Analytic	View-only	Interactive Predet.	Analytic
NA Canada					X	
NA France	X					
NA USA					X	
NA Sweden		X				
NA Switzerland (prototype)		X				
Atlas Ukraine					X	
W. Australian Atlas					X	
Environmental Atlas Berlin				X		
South Australia Atlas					X	
Atlas Quebec	X					
Nationalgeographic Atlas				X		
Arctic Environmental Atlas					X	

Fig. 2: Classification of the 12 analysed thematic online-atlases

3 Requirements for an Online-National Atlas of Germany

3.1 Content

From the analysis of the 12 thematic online-atlases some properties of the content could be derived. The content should be divided into a map-, text-, information- and service part. The map part should contain the maps, the text part the contribution texts and graphics, the information part general information on the atlas (history of the atlas, price list, links to other atlases, staff, ...) and the service part a help, a possibility to contact the atlas authors and a search function. A table of contents, an index and cross-references should facilitate navigation within the atlas and its topics. An important requirement is the bilingualism: the mother tongue German and the world's most accepted internet language English. An important issue is the interactivity which should be controlled and well prepared by the atlas authors. The text and information section should include links that point to additional related information.

In the case of the online-National Atlas of Germany the content is predetermined by the existing two versions (print- and CD-version). Contribution texts, collateral graphics, charts, diagrams, photos and maps already exist, these maps mainly in the Macromedia Freehand graphics format.

To standardise the content of an internet atlas a careful selection of the complementary material is necessary. The selection of the contributions for the internet version depends on the selection of their maps because maps form the main part of the atlas. Only maps with the scale of 1 : 2.750.000 had been chosen, which allow to see Germany at a glance. Also each contribution should only have one map so that contributions with two or more of such maps should be divided in two or more parts. Contributions without such a map had not been selected for the online-atlas.

Some of the analysed online-atlases have an intro. From the author's point of view an intro is not necessary because the content should be reached as soon as possible.

3.2 Layout

After a careful study of existing online-national atlases an initial layout could be introduced. Figure 3 shows the general structure and design of the atlas pages. Each part can be reached from the start page to already give the user a brief feeling and overview of the content he can expect to explore later on. However, we keep the number of initial links lower in order to avoid confusing first time users. As described in the chapter "Content" a segmentation of the atlas in a map part, a text part, an information part and a service part is necessary. The help function should be opened in a new window to simplify the comparison between the content and the help pages. Amongst other functionality the help system also explains the navigation system of the atlas.

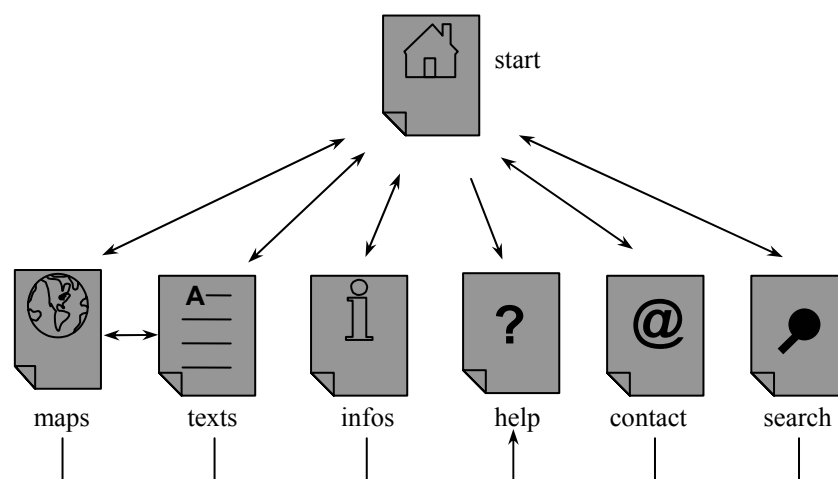


Fig. 3: Structure of the online-National Atlas of Germany

Because of the limited space on the screen it is useful to choose a small frame for navigation in the upper part of the browser window with a logo, buttons and pull-down-menus and a much larger frame in the lower part of the browser-window to display the content. A second navigation frame under the first would be helpful to separate the general navigation elements from the navigation elements for the displayed atlas part. But because of the low space on screens with a resolution of 800 x 600 points it is better not to use this second navigation frame.

The position of the navigation elements should always be the same in every atlas part. It is also useful to choose consistent colour schemes (e.g. background colour) for all atlas parts. A limitation of grouped menu entries is better than a larger but confusing number of entries.

3.3 Technique

3.3.1 Client side Techniques

After clarification of content and layout issues we want to discuss technical aspects. Generally in the internet the user interacts only through client software, in most cases the web-browser. The client sends a request to the server and gets a response. While a map-author can't influence the client software a map-user chooses to access web-content, he can decide on server side issues. This fact means that the map-author should have a good knowledge on up-to-date client side techniques and specifications for being able to present the online-atlas in an optimal form. The client side techniques for the internet mainly consist of the output medium "screen" and the browser. A typical screen has a much lower display area, a lower screen resolution (~ 72 dpi) and lower colour accuracy than a printed map. Colour accuracy means that one colour will be displayed consistently across different output devices. Colour profiles help in adapting device specific colour spaces to a more general purpose colour space that represents the lowest common denominator of all devices. Besides the colour representation the screen resolution changes from device to device (figure 4).

screen resolution	distribution
1024 x 768 or more	44 %
800 x 600	50 %
640 x 480	3 %
other	3 %

Fig. 4: Distribution of the screen resolution in July 2002 [Source: www.w3schools.com]

The second client side technique is the browser. The browser is the interface between the user and the internet. In July 2002 the Internet Explorer dominates the market (figure 5).

browser	distribution
Internet Explorer 6.x	39 %
Internet Explorer 5.x	51 %
Internet Explorer 4.x	2 %
Netscape Navigator 4.x	3 %
Netscape Navigator other	1 %
other	4 %

Fig. 5: Distribution of browsers in July 2002 [Source: www.w3schools.com]

Because the atlas author has no influence on the client side techniques he needs browser independence and a screen resolution independence.

3.3.2 Server side Techniques

In contrast to the client side software the author may choose server side techniques. The server techniques can be divided into 3 parts: the server software, the server extensions and the server interfaces. As shown in figure 6 the server gets a request from the client. The server interface sends this request to the correct server extension which can answer the question. The server interface translates the answer in pure HTML and sends it back to the client, so that no special plug-ins are necessary.

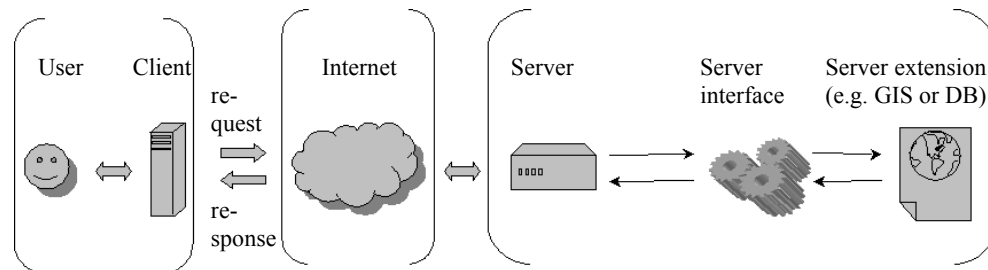


Fig. 6: Internet workflow

As server software the author chose the Apache server. The Apache server is open source and free (in contrast to Microsoft servers like the Internet Information Server or the Personal Web Server which have high license fees). It is intensively used, works very stable and is available for a lot of platforms.

Server extension for GIS and databases are available. The author chose the database MySQL because Geographic Information Systems in most cases are very expensive, depending on companies and involve expensive license fees. The database MySQL is open source and intensively used. It has a high performance and is available for a lot of platforms (in contrast to Microsoft Access which can only be used on Windows systems). And MySQL is free (in contrast to professional databases like Oracle or SQL Server).

As server interfaces a lot of scripting languages are available. The author chose PHP (PHP Hypertext Preprocessor). PHP is an open source scripting language which is very intensively used (in contrast to JSP). It is free, easy to learn, very stable and available for a lot of platforms (in contrast to ASP which only works on Microsoft servers – for other platforms expensive server extensions are available). PHP was especially developed for web servers and allows easy-to-use database requests and file accesses (HESS & KARL 2001). The PHP code is embedded in the HTML code of the internet page. If the server gets a request of a client the PHP code will be executed. The result will be transformed into pure HTML and sent back to the client. The advantage is that the user can use his standard browser without installing special plug-ins. Only the server has to interpret the scripting language.

3.3.3 Visualisation Techniques

Now we have to select reasonable graphics formats for the internet. For texts XHTML (Extensible Hypertext Markup Language) should be used. HTML is relative inflexible and loose concerning syntax checks. That's why it is better to use XHTML as its successor. XHTML is based on XML (Extensible Markup Language), has a modular construction and is backwards compatible.

For diagrams and photos raster graphics should be used. It is useful to choose the Graphics Interchange Format (GIF) for simple graphics. It allows a loss-free compression and interlaced or non-interlaced construction. It supports 256 colours and 1 transparent colour. For photos the Joint Photographic Expert Group (JPEG) format should be used. It can display over 16,7 million colours and optimises the colour palette. The JPEG format has a very strong but lossy compression. The PNG format is a third graphic format which could be used but because of the high distribution of the other two formats it isn't often used. The brand new JPEG 2000 format is not yet distributed but it should be watched for the future. It will allow lossy or loss-free compression (and a approximately 30 percent higher compression than the normal JPEG compression), an incremental progressive decompression, a zooming in regions of interest and it allows to define regions with different qualities (WEINRICH 2002).

For maps vector graphics are useful because they are resolution independent and have a small file size. There are a lot of vector graphic formats for the internet but in most cases they are developed by only one company and are low distributed. But all of them have a disadvantage: they need a plug-in (installed on the users browser). For maps only two vector formats are reasonable: the Flash and SVG (Scalable Vector Graphics) format.

Flash is a binary coded format with the possibility to zoom and pan, embed movies and sounds and interact and animate objects. But Flash depends on one company (Macromedia). So the specifications of the new versions are not in all cases compatible with the old ones and each version needs a new player. It has an own scripting language ActionScript. But modifications are only possible with the Flash software. Because of the integration of the plug-in in the installer of the Internet Explorer and the Netscape Navigator it is highly distributed.

On the other hand SVG is a text coded format with the possibility to zoom and pan, embed sounds and interact and animate objects. SVG is an official standard (based on XML) and open source. It is clearly structured and can be edited in any text editor. The content and the styling formats can be separated. The plug-in is normal distributed and the number of downloads of the SVG plug-in is increasing (CARTO.NET 2001).

With the development of a prototype the most reasonable map format is to discover.

4 Prototype

After the specification of the demands on content, layout and technique two prototypes (one for Flash and one for SVG) were created on basis of two selected contributions (National Atlas of Germany – volume “traffic and communication”). At first the maps have to be simplified. Unused and unnecessary layers (e.g. the road borders), text effects (e.g. text masks) and unnecessary vertexes were deleted. A conversion of the colour system to rgb and a simplification of the graphic symbols in the map were also necessary. Also each layer in the Freehand file should contain only one style. After the preparation of the maps the Freehand files were converted to the Flash and the SVG format and compressed with the gzip-algorithm. As a next step MySQL-database and PHP files were created (further information: (SCHNABEL 2002)). As a result two independent prototypes were created which only differ in their map parts. Now a comparison between these two vector formats was possible (figure 7 and 8). An advanced comparison of the two formats can be found at (HURNI, NEUMANN & WINTER 2001).

	Flash	SVG
effort for preparation	high (simplification in Freehand)	high (simplification in Freehand)
effort for conversion	low (trouble-free import in Flash)	low (opening in Adobe Illustrator, save as SVG)
effort for postprocessing	high (conversion to film-sequences, scaling)	high (optimisation of the source code by hand)
effort for interactivity	high (creation of buttons, menus, action scripts)	high (creation of groups, IDs, javascripts)

Fig. 7: Comparison between Flash and SVG (effort)

	SWF file (compressed Flash)	SVGZ file (compressed SVG)
contribution 1	140 KByte	121 KByte
contribution 2	201 KByte	202 KByte

Fig. 8: Comparison between Flash and SVG (file size)

In conclusion SVG is more reasonable for internet maps. It is possible to abandon the HTML code and generally display the maps as SVG file. With this format it is also possible to insert title, legend, scale and overview map as nested SVG. So the whole page could be scaled independent of the screen resolution.



Fig. 9: SVG-prototype (start page)

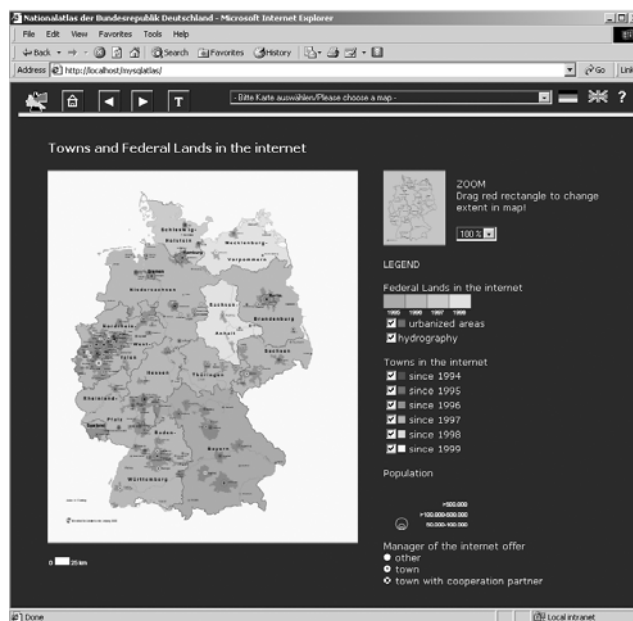


Fig. 10: SVG-prototype (map part)

5 Future

In the future the SVG-prototype should be advanced. There is a need for an automatic conversion of the Freehand files to geographic data which can be stored in the database. This will result in a simpler update. Also a dynamic generation of maps on demand in pure SVG (without HTML) should be considered. Now the prototype is only

optimised for the Internet Explorer. In the future browser independence should be reached. In the medium term the Institute of Regional Geography, Leipzig should reconsider publishing the National Atlas of Germany as stand-alone internet version/application (without print- and CD-version). Then a development of the prototype has to weigh against pure map-oriented online-GIS. There is also a need for a functionality check of the future open source (!) online-GIS for the usability in the map part – PostGIS, PostGres, GRASS just to name a few.

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Web Integrated Cartographic System for an Ecological Network of the Lower Danube Green Corridor

Iulian NICHERSU and Detlef GÜNTHER-DIRINGER

1 Introduction

The establishment, in the year 2000, of the Lower Danube Green Corridor along the 1000 km stretch of the Danube between the Iron Gate in the Carpathians and the Danube-Delta was one of the greatest successes of nature conservation activities in Eastern Europe. To fulfil the idea of the Lower Danube Green Corridor with life and with concrete, successful projects numerous activities have to be realized. The Danube Delta National Institute, Tulcea (Romania), who is responsible for the Romanian part of the Green Corridor, has a long-term cooperation with the German WWF-Auen-Institut (Institute for Floodplains Ecology), a project of the WorldWide Fund for Nature (WWF). A fundamental basis for all planning activities are the GIS capabilities of both institutions, where both authors can look back on more than 10 years of intensive development and interchange in the area of GIS. Due to this experience in the common projects, such as the described planning of the restoration of Calarasi-Raul-island, intensive GIS-applications will deliver the necessary information for planning purposes. And the next steps to integrate these data into a web-based cartographic system for the ecological network are in concrete preparation

2 The Idea of the Lower Danube Green Corridor

On its more than 2800 km journey from the Black Forest to the Black Sea, the Danube crosses ten European States. Its catchment area, with a surface of over 800.000 km², includes 17 states. Like no other European river it links different natural and cultural landscapes. In addition to important capitals such as Vienna, Budapest and Belgrade one also finds remarkable floodplain areas along the Danube e.g.:

- in Germany: the area of the Isar mouth between Straubing and Vilshofen,
- in Austria: the Danube floodplains situated East of Vienna up to Hainburg (Donau-Nationalpark),
- in Hungary: the Gemenc-Beda floodplain forest in Southern Hungary,
- Croatia: the Kopacki Rit, at the mouth of the Drava,
- Bulgaria: the Bulgarian Danube Islands,
- Romania/Ukraine: the Danube-Delta,

The areas listed above make up merely a small part of the former floodplain areas situated along the Danube and its tributaries. To obtain a general, global and transboundary view of the Danube floodplain area, the WWF-Auen-Institut (Institute for Floodplain Ecology) carried out a study on all existing and former wetland areas along the Danube River and its large tributaries (Morava, Drava, Sava, Tisza and Prut). (UNDP/GEF 1999). The study had included an ecological evaluation that will be relevant with regard to future nature conservation projects in the Danube river basin. It had been conducted on behalf of UNDP which was part of the Programme Coordination Unit (PCU) of the Environmental Programme of the Danube River Basin.

For the first time the results of the study showed an overview of the ecological situation of the floodplains of the studied rivers, evaluated on the basis of an elaborated consistent and common database. The study found out that the remarkable extent of floodplain loss is in excess of 80%. In addition to the evaluation of the ecological situation, the restoration potential of the floodplain areas was evaluated as well. The study showed that the Danube section situated on the other side of the Iron Gate up to the Danube-Delta, i. e. the lower Danube, comprises many areas with a high restoration potential.

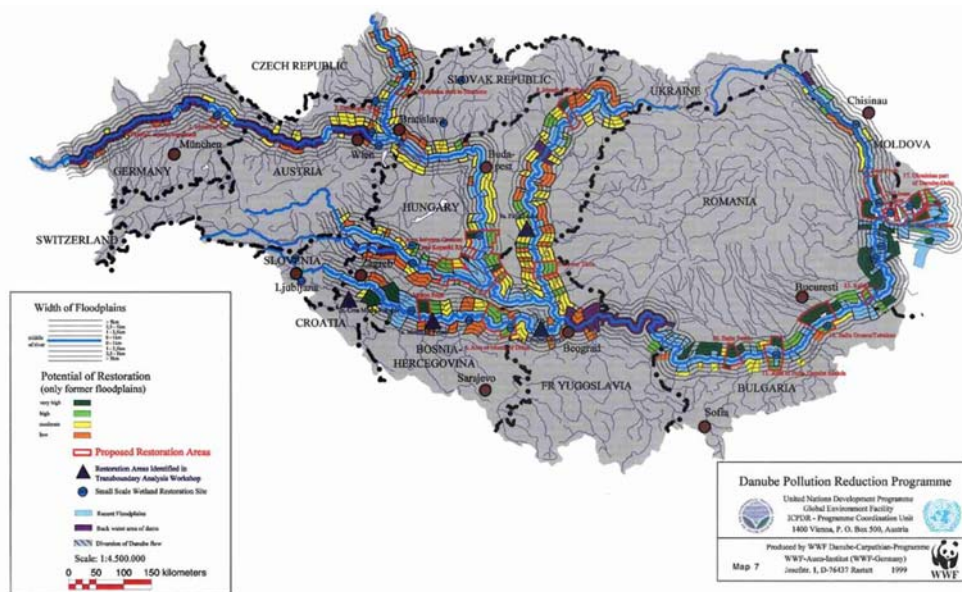


Fig. 1: Restoration potential of former floodplains in the Danube river basin with a visible focus on the lower Danube (dark green areas).

These results, together with existing, successful floodplain restoration projects in the Danube-Delta (see following chapter) founded the basis of a new concept, the so-called „Lower Danube Green Corridor“. In June 2000 WWF could achieve one of its greatest successes: the Romanian government had initiated, in cooperation with the governments of Bulgaria, Moldova and the Ukraine, the creation of a "Green Corridor" of natural wetlands along the Lower Danube. As the largest international, cross-border wetland restoration and protection initiative in Europe, this gallery of green will include wetlands, lakes, flooded areas, floodplain forests, and meadows. The activities in the Green Corridor will extend the Danube's natural capacities for pollution reduction, flood retention and nature conservation. Facilitating the protection, restoration and sustainable management of the Lower Danube floodplains, the Green Corridor will be of great benefit to the local people and the ecosystems of the Danube River and the Black Sea.

Why Protect and Restore Wetlands and Floodplains?

The floodplains of the Lower Danube are extremely valuable and important.. They have been chosen as a WWF Global 200 area for their outstanding biodiversity. Today, floodplains are widely acknowledged for the multiple benefits they offer: biodiversity conservation, water purification, pollution reduction, flood protection and support for socio-economic opportunities such as fishery and tourism.

Why A Green Corridor?

Despite the benefits of wetlands, the destruction of typical wetland habitats and increased pollution have now threatened many species, such as the Sturgeon, Dalmatian Pelican, Egret and White-tailed Eagle - all these species are now struggling for a space to survive. Development, dam building, irrigation and drainage, canalization, artificial flood protection measures and pollution from spills and war – they all represent threats to the ecological integrity of the Danube ecosystem. The floodplains left are often mere islands of green. Cut off from a network, they are slowly losing the capacity to perform their natural functions. The Green Corridor aims to reconnect these isolated islands by restoring their essential functions.

The initiative will connect existing protected areas, new areas to be protected and floodplain habitats to be restored: in total, a minimum of approximately 600,000 ha. The floodplain management will aim to optimise socio-economic benefits for local communities. The result will be important on both a regional and international level and will establish a Green Corridor along the lower Danube.

The Commitment

Romania, Bulgaria, Moldova and the Ukraine will make commitments to create a protected area system along the Lower Danube River, including the Danube Delta. This protected area system will initially include the following areas:

- 400,000 ha of already existing protected areas,
- 100,000 ha of newly protected areas,
- 200,000 ha of priority sites for restoration, some of which are included in the existing and newly protected areas.

In addition, the countries will create an action plan of implementation activities and identify additional sites for the Green Corridor. They will also create a monitoring system to facilitate the regular exchange of information and experiences in wetland conservation, restoration and pollution reduction.

The countries will further work together to develop economic instruments to reduce pollution and promote wetland conservation. They will actively seek for local, regional, national and international partners to cooperate and give support in the protection, restoration and sustainable management of the Green Corridor for the Danube.

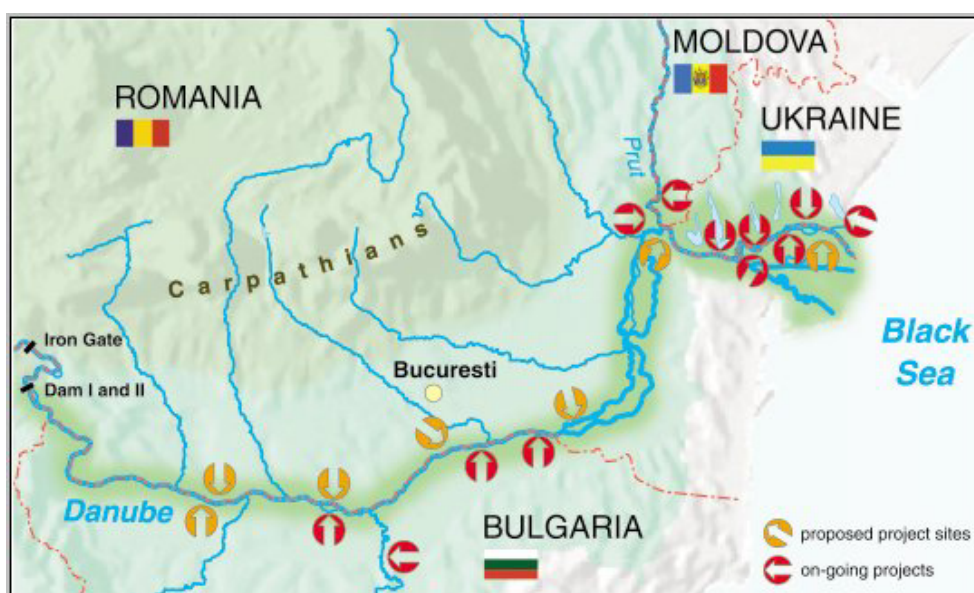


Fig. 2: Overview of projects along the Lower Danube Green Corridor

2.1 Examples of Wetland and Floodplain Restoration Projects on the Lower Danube

Within the frame of the reconstruction program of the abandoned polders in the Danube Delta Biosphere Reserve, the Danube Delta National Institute for Research & Development - Tulcea (Romania) collaborates with the WWF-Auen-Institute as for the abandoned agricultural polders Babina, Cernovca and Fortuna and with the RIZA-Institute (Netherlands) as for the fish ponds Holbina, Dunavăț and Popina.

Research started in 1992, the aim being to improve the ecological conditions of the natural ecosystem and the rehabilitation of abandoned agricultural polders and fishponds in the Danube Delta considered as inefficient by the economical agents. 16 abandoned polders have been identified, 7 among which are studied in view of ecological restoration and rehabilitation as wetlands.

agricultural polder	Babina	2100 ha
	Cernovca	1580 ha
	Fortuna I+II	2115 ha
Fishponds	Holbina	1270 ha
	Holbina II	3100 ha
	Dunavăț II	1260 ha
	Popina	3600 ha
Total abandoned areas		15.025 ha

2.2 Benefits obtained after the implementation of the projects for an ecological restoration of Babina (1994) and Cernovca (1996) islands



Fig. 3: Satellite image of the restored islands Babina and Cernovca

Ecological effects:

- the islands are brought back to their initial condition as wetlands, as habitat and reproduction area for fish and aquatic birds, by flooding;
- biodiversity reservoir and guarantee for genetic resources;
- improved water quality and trophic state of ecosystems;
- sediment holding and settling of toxic substances;
- bio-filter for Danube and Black Sea;
- return to the original landscape of the area.

Economical benefits:

- large quantities of fish, reed, meadows and game (hunting resources);
- touristic areas for rest.

Aquatic resources:

fish, crayfish, river oysters, frogs etc.

Ex. fish: 3000 ha aquatic surfaces x 40 kg fish/ha x 10 000 lei/kg = 1,3 mld lei (approx. 72 500 USD)

Vegetal resources: reed, meadows, forests, medicinal herbs, mushrooms

(Ex. reed 4000t x 330 000 lei/t = 1,28 mld lei (87 000 USD))

Hunting resources: game with fur and feathers

Landscape resources: eco-tourism, scientific tourism

30 tourists/day x 240 days/year x 200 000 lei/day = 1 44 mld lei (87 000 USD)

The studies that assess the impact, accompanying the investments to be made as for town-planning and economy, will prevent the perturbations for natural ecosystems. Preservation is cheaper than ecological restoration, therefore the management of valuable wetlands must be a participatory process that will include local communities. The major components of the strategy for sustainable development have to be the following: increase public awareness, inform people by stressing on the **cost/benefit** relation, focused on long term and short term benefit

3 The Involved Institutions

3.1 Danube Delta National Institute for Research and Development – Tulcea/Romania

History

The Danube Delta National Institute (DDNI) is the research body which has to develop fundamental and applied research in ecology and environmental protection for the management of the Danube Delta Biosphere Reserve (DDBR) which has been established in August 1990 by the Government of Romania, and also in other national and international wetlands for biodiversity conservation and sustainable development. The Institute originated as Hydrobiological Station Tulcea established in 1932 as part of the Romanian Directorate of Fisheries (PARID) and became a research Institute in 1970. In 1991 the Institute was reorganised in two departments: the Research Department and the Design Department.

From 1991-1999 a research program was worked out jointly with the DDBR Authority and generated with the Institute. Its responsibility is to provide the scientific basis for the formulation of the governmental policy and activities pertaining to the conservation and management of nature and natural resources of the fauna and flora of the DDBR. For this purpose it has to comply an inventory of the fauna and flora of the Danube Delta and the proposals for a Red Data Book. On a regular basis it has to provide environmental monitoring data on the main aquatic and terrestrial ecosystems of the whole reserve territory, to assess the different natural resources (fish, pasture, reed, forests) and to propose regulations for their sustainable use. The Research Department is also undertaking studies concerning the social issues of the inhabitants, tourism, ecological restoration of natural ecosystems and wetland restoration.

Activity

Experience: Fundamental and applied research for scientific of the management in the Danube Delta Biosphere Reserve (DDBR) and in other important national and international wetlands, for biodiversity conservation and sustainable development, studies for ecological restoration.

Research Groups: Biodiversity survey, Environmental monitoring, Natural Resources Monitoring (Fish, Reed, Pastures), Tourism, Human Impact, Socio-economic issues, Ornithology, Wetland restoration, Database and GIS, Atlas of DDBR, Migratory sturgeons, Sustainable agriculture and fisheries.

Research projects:

- GIS development
- Ecological restoration
- Biodiversity monitoring
- Hydraulic and water chemistry monitoring
- Monitoring of ecological factors
- Recovering threatened species
- Sustainable use of natural resources
- Atlas of the Danube Delta Biosphere Reserve
- Human Impact Assessment in the Danube Delta Biosphere Reserve

The Research Department has the responsibility to provide the scientific basis for the formulation and implementation of governmental policies and strategies as for nature conservation and management and natural resources in the DDBR and the national wetlands. The Research Department consists of 138 staff members including 46 graduates and 37 research assistants.

Users

- Ministry of Waters, Forests and Environment Protection
- Danube Delta Biosphere Authority
- Scientific community
- Nongovernmental organizations
- Local communities
- Commercial agencies

International projects

- EUREED II Dynamics and stability of Reed-Dominated Ecosystems in Relation to Major Environmental Factors that are Subject to Global and Regional Anthropogenically-Induced Changes
- “Wetland areas in southern Romania as potential Ramsar sites” Ramsar SMF for Wetland Conservation and Wise Use
- “Danube Delta Biodiversity” - Project funded by World Bank (GEF)
- “CORINE Land Cover” PHARE Programme
- DELWET – Center of Excellence
- DANUBS – Management of Nutrients in the Danube Basin and the impact in the Black Sea (FP5)
- IMEW – Integrated Management of European Wetlands (FP5)
- European Topic Center on Terrestrial Environment – EEA
- Agricultural Pollution Control – Ecological Restoration of Calarasi-Rau Islet Project funded by World Bank (GEF)

Awards for ecological reconstruction in the Danube delta

- General Association of Engineers in Romania - Environment Engineering Field - 1995
- EUROSITE 1995 - European Community
- WWF International 1996 - World Wide Fund for Nature

3.2 WWF-Auen-Institut

In order to carry on research, conservation, management and development of riverine landscapes in Europe, HRH Prince Philip, former president of WWF-International (World Wide Fund for Nature), founded the WWF-Auen-Institut (Institute for Floodplain Ecology) in May 1985 in Rastatt near Karlsruhe, FRG. The institute came into being as an interdisciplinary, international project to help provide a complete answer to the complex problems confronting the floodplains. For this reason it goes without saying that various fields of study, from limnology to landscape planning, and from hydraulic engineering to geobotany, are represented and must be closely coordinated. Today the institute is comprised of 14 permanent employees from six different countries. Additional specialists, guest scientists as well as others working on their doctorate or diploma, who are employed on a limited time basis, are part of this team.

Activities

The main fields of study of the WWF-Auen-Institut include:

- applied research
- mitigation and avoidance of impacts
- planning and development

in the floodplains on large rivers; accompanied by public relations work especially on floodplains, which helps further the goals of the institute (and in a broad sense the WWF) in the fields mentioned. Geographically the main areas of study are presently the catchment area on the Danube (Austria, Czech Republic, Romania, Bulgaria), the Upper Rhine (FRG/France), the Elbe (FRG) and the Odra (Czech Republic, Poland, Germany), as well as activities in regions overseas (Rio Magdalena in Colombia, Pantanal in Brazil) for the last years.

Research projects

Concrete, long-termed research projects are being conducted, for example, concerning the development and testing of environmentally compatible methods of silviculture in the floodplain forests, natural succession on former agricultural areas in inundation zones and the importance of the floodplains for the self-purification of the river.

4 Calarasi-Raul Island, Romania

High Potential for Nature Restoration

This island of Calarasi-Raul, with an area of 10,000 ha, owes its origin to the ever declining gradient of the Danube. The river splits into an increasing number of major lateral arms. Unfortunately, the large floodplain island was destroyed in the 1960s by the building of dams which cut the floodplains from the natural flood cycle of the Danube.

The 10,000 ha of dammed floodplains on Calarasi-Raul is mainly used for agriculture by a commercial company. There are no settlements on the island, only buildings of the agricultural production company.

The very high nature restoration potential of this area is partly attributable to the absence of settlements and partly due to the presence of a number of smaller Danube islands close by, upstream, which are naturally flooded. Their proximity will promote a relatively quick genetic exchange, forming the basis for the natural restoration of the native flora and fauna. It is possible that in the future an extensively used mosaic of wetland forests, grazing land, meadows, and natural fishing grounds will be realised, with the typically high bioproduction associated with floodplain areas.

A successful implementation of nature restoration measures in this area could be regarded as a model project for other possible restoration areas, comparable in hydrological and morphological terms, and is thus of major significance.

Within the frame of a World Bank project with an emphasis on sustainable use of agriculture in an area of about 100.000 ha in the judetul of Calarasi, the eastern part of the island Calarasi-Raul (ca. 3500 ha, s. fig. 4 and 5), is planned for nature restoration. The project started in autumn 2001 and different proposals with possible measures have to be prepared up to the end of 2002.

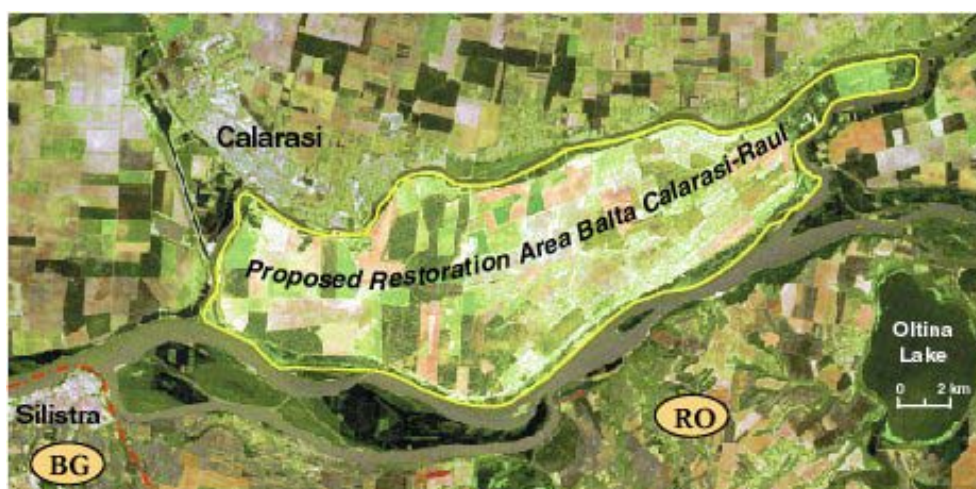


Fig. 4: Satellite image of planned restoration area Calarasi-Raul Island

Given basic data

In a first step an intensive data gathering has to be carried through to get the necessary spatial information. Due to the former activities of the Danube-Delta-Institute and the WWF-Auen-Institut, some information was available before the project started. During the first phase of the project the following basic data could be collected:

- Romanian and Bulgarian topographical map 1:50.000
- Landsat Satellite images (1997) with a spatial resolution of 30 meters
- Historical map (Generalkarte von Mitteleuropa) from 1897 –1914 (1:200.000)
- CORINE LandCover-data (100m spatial resolution)

The mentioned data sources were all integrated in the available GIS-system by different GIS-processes (scanning, georeferencing, extracting, mosaicing) to set up a homogenous spatial data base. But for planning purposes these data gave only an overview of the project area and more detailed data were necessary. Due to data investigation on different Romanian administration levels, the following analogue information could be collected:

- Recent and historical land use map
- Recent cadastral map
- Shipping map of the Danube river
- Hydrological data of different gauge level stations on the Danube
- Hypsometrical map with morphological information before dyking (1960), 1:25.000

These analogue informations were digitalized and integrated within the GIS-System as well.

Measured field data

Although the existing topographical map 1:50.000 contained contour lines, they were not detailed enough to get the necessary information of the recent terrain. Due to this reason a surveying team of the Danube-Delta-Institute measured more than 5000 points in the field to get accurate and current terrain information.

Other scientific colleagues from the Danube-Delta-Institute and the WWF-Auen-Institute made a field trip to get an impression of the current ecological situation. They confirmed the situation, that inside the dyked area a very dry area with agricultural using exists, whereas in the surroundings small areas between the dyke and the Danube and on a peninsula in the north-eastern part of Calarasi-Raul-island, where natural flooding is given, a typical floodplain-mosaic of different plant and animal societies exists. Especially the north-eastern peninsula, with a size of about 1000 ha could serve as a model for the restoration plans, because in spite of the given hydrological dynamics with its regular floodings, the local people use the area for cattle grazing, fishing grounds and forestry.

GIS-processed data and applications

One of the most important factors for floodplain restoration is the connection of the adjacent river to restore the hydrological dynamics in the area. To model this situation in a current dyked area it is important to get both detailed terrain data and hydrological data of the river (a minimum ten-year level data). Due to these demands the mentioned measuring of more than 5000 field points was necessary. The point data were imported in the GIS-System, georeferenced and classified in different types, e.g. dyke, water surface, electricity pylon, etc. Afterwards the data were supplemented with important edge lines of the area (dykes, channels, border of Danube). In the next step a digital terrain model in grid-format with a spatial resolution of 5 m was calculated.

The same result, a 5m-terrain model, had to be calculated from the historical hypsometric map from 1960, which showed the conditions in the field before dyking. The large map in scale 1:25.000 was scanned in different parts, then georeferenced and mosaiced. The conversion from raster to necessary vector data of the contour lines was effected by automatical vectorization. After correction, completion and labelling with the appropriate altitude information of the vectorization result, it could be transformed to a digital terrain model in grid-format with the same spatial resolution of 5m, as for the digital terrain model of the current state of the area.

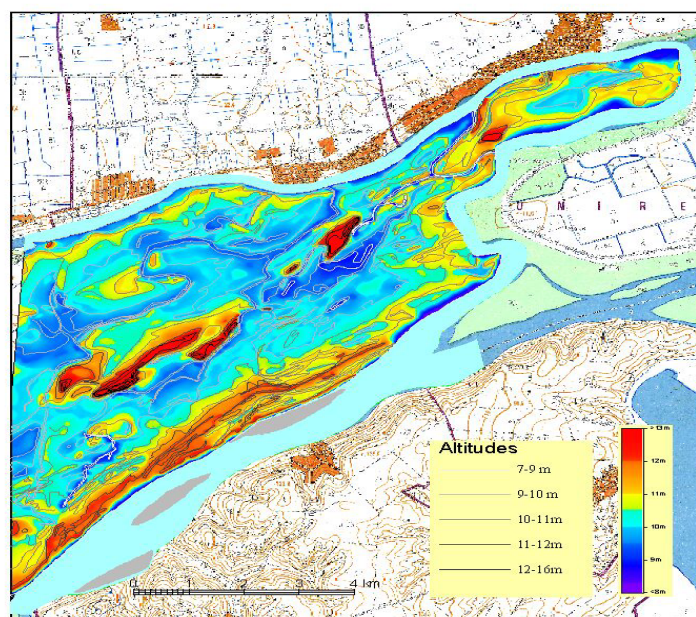


Fig. 5: Digital elevation model of historical situation (before damming) of the eastern part of the island Calarasi-Raul.

Now the differences in the field before and after the dyking of the study area could be compared. In the next steps, which are just in preparation and not finished yet, the link to the hydrological data has to be made. For this purpose the specific values of the hydrological long-term duration curve will be transferred to the altitude data of the field. The long-term duration curve shows the number of days on which the river exceeds a specific water level. The number of days of flooding corresponds to different floodplain types such as softwood floodplains, lower hardwood floodplains and so on. Due to the relation of the water level data to the calculated digital terrain model, the area can be classified in different floodplain types. On this basis ecological experts can make predictions of the future development of the area after its restoration.

Future project steps

During and after the project processing the visualization of the data and the GIS-based results are at first important for the scientific team to solve the complex problem of the project tasks. A very important part of the general world bank project is the dissemination of the project results to different public groups:

- local population: leaflets with general information on the project
- local stakeholders: it is planned to organize a hearing at the end of the year. For this task the necessary project data have to be prepared and visualized in poster form and on overheads.
- stakeholders on a regional and state-wide level: detailed reports are the appropriate form of information.
- international project partners: intensive exchange of actual project data
- international financing organizations: reports

Due to the fact that the project of Calarasi-Raul acts as a pilot project for floodplain restoration on the lower Danube (after the successful projects in the Danube-Delta) it is important for the engaged partners that the given spatial information of this project as well as information on other possible project areas within the frame of the Green Corridor is available. For this data dissemination of a WEB-GIS-Server is very useful. As described in the above mentioned points, the data were integrated in a homogenous spatial database. With the available tools of the used GIS TNTmips from MicroImages it is only a small step from this spatial database to a digital atlas where the different map layouts were combined to a digital atlas with the tools of HyperLink-capabilities. With the software TNTserver the data of the digital atlas can be viewed via internet by every browser on your local computer. The digital version of the Oder-Auen-Atlas (Odra-Floodplain-Atlas) published by WWF in 2001 may serve as an example of this

process. The digital atlas is available on CD-ROM and can be viewed with public domain-Software TNTAtlas or via Internet hosted at the microimages-homepage: <http://www.microimages.com/tntserver/oderinfo.htm>

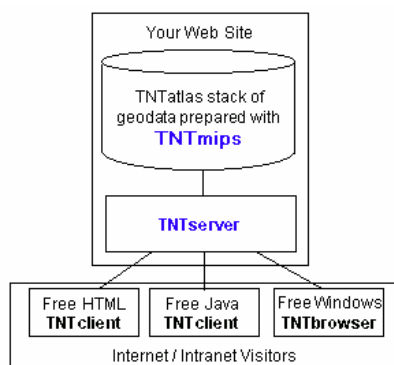


Fig. 6: Structure of TNT Server

This way the spatial data of the whole lower Danube from the Iron Gate in the Carpathians up to the Danube Delta are to be prepared and can serve as a basis for the realisation of the ambitious ideas and commitments of the Lower Danube Green Corridor.

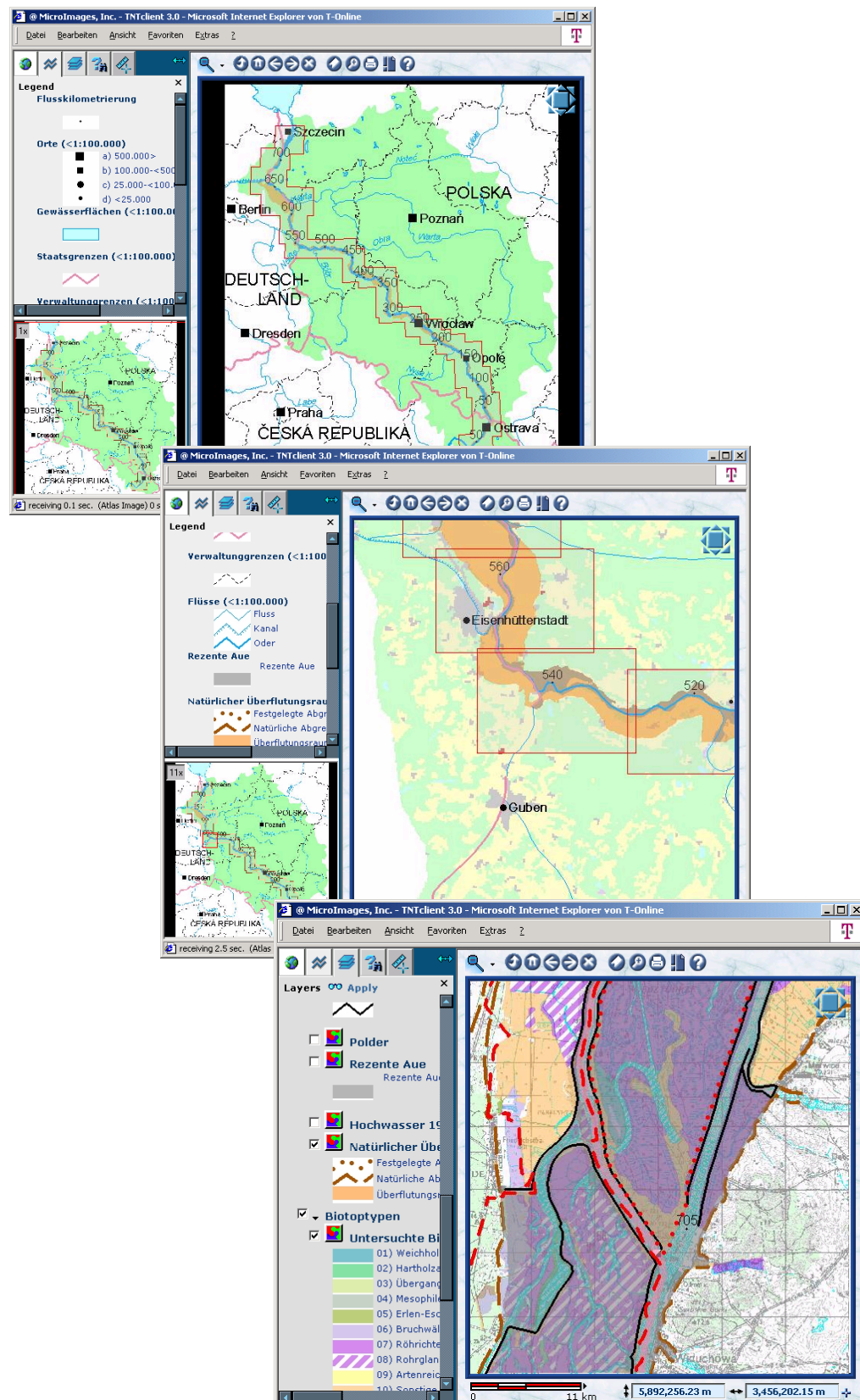


Fig. 7: Three screenshots with different levels of detail of the web-based Odra-Floodplain-Atlas:
<http://www.microimages.com/tntserver/oderinfo.htm>

5 Further necessary GIS-steps within the frame of the Lower Danube Green Corridor

The final aim of the Program “*Green Corridor of the Lower Danube*” is to develop a *Regional Ecological Network in the Danube Floodplain*, integrated into National Ecological Networks, by applying the concept “spatial structure coherence” for all of the Danube floodplains.

Short term specific objectives:

	Objectives/actions:	Purpose:
1.	Inventory of the wild genetic fund in the Danube Floodplain Establish a quantitative and qualitative unitary inventory of flora and fauna species on the territory of the Danube Floodplain	To achieve a unitary quantitative and qualitative inventory of the flora and fauna species on the territory of the Danube Floodplain,
2.	Monitoring in the core areas To elaborate and apply a monitoring plan for the core areas	To permanently acknowledge the state and evolution of the ecosystems of the core areas, in order to adopt the management measures to preserve their ecological integrity
3.	To protect the habitats of the birds with high ecological value - Quantitative evaluation of the globally endangered specific populations - Researches on aquatic colonial internationally important species - Identification of the migratory ways and the passageway locations	Scientific arguments in the projects which propose the establishment of core areas
4.	To protect and re-establish the populations of migratory sturgeons in the Danube Establish the essential habitats (wintering resting places in the Danube, spawning areas) for each sturgeon migratory species in the Danube	To identify the core areas and the ecological corridors important for the protection of these fish species;
5.	Establish a feasibility study for the dammed islands in the Danube Floodplain Elaborate the documentation of economical evaluation of the dammed islands in the Danube Floodplain	Mapping the degraded or abandoned islands so as to include them within the ecological restoration
6.	To develop an integrated data basis, in GIS To design a unique information system for the Danube Floodplain	To create the logistic support for the management of an ecological network
7.	To define the legal and institutional frame for administering the Green Corridor of Danube To propose the functional, legal and institutional frame for the “Lower Danube Green Corridor”	To develop the functional and juridical frame of the Regional Ecological Network “Lower Danube Green Corridor”

Specific objectives in the medium term:

	Objectives/actions:	Purpose:
1.	To establish the protection and conservation measures of remarkable species in the Danube Floodplain To elaborate and apply in-situ and ex-situ protection and conservation measures for endangered species in the Danube Floodplain	To prevent endangered wild animal and plant species from extinction
2.	Monitoring the biodiversity in the Regional Ecological Network "Lower Danube Green Corridor" To elaborate and apply a monitoring plan for the "Lower Danube Green Corridor"	To permanently fill in the inventory of biodiversity from the "Lower Danube Green Corridor"
3.	To create a monitoring system of the environmental factors To design and implement an integrated monitoring system of the "Lower Danube Green Corridor"	Model the processes and supervise the quality of the environment in the "Lower Danube Green Corridor"
4.	Land leasing, mainly of those areas used for agriculture and fishery, compelling the persons who leased to respond to the protection measures. - To elaborate the tasks the leasing of the transitory areas - To project and implement a monitoring program regarding sustainable use of resources in the Danube Floodplain	Sustainable development in the "Lower Danube Green Corridor"
5.	Optimizing the ecological functioning on the basis of economical management in the restored areas To elaborate the documentation of assessment of ecological functions in the restored islands in the Danube Floodplain	Ecological reconstruction of the proposed islands and management of the natural resources for their use by the local population
6.	Actualization of the integrated data basis, into GIS To actualize the data basis of the "Lower Danube Green Corridor" and its analyses during the decision-making processes	To create the logistic support for the management of a regional ecological network
7.	To promote the "Lower Danube Green Corridor" as national and international touristic product - Scientific justification for a plan for ecological tourism development as a tool to stimulate the localities in the "Lower Danube Green Corridor"	To develop alternative activities as a source of income for the local population
8.	To introduce an information system and to carry ecological education from "Lower Danube Green Corridor" - To publish and spread materials, informative leaflets and brochures on tourism and ecological awareness - To promote by mass media	To develop the educational systems in the domain of protection and environmental conservation
9.	To develop the cooperation with organizations abroad to establish cross-boundary reserves. Participate in regional environmental programs	Promote international cooperation for environmental protection

Long term specific objectives:

1. To develop the juridical and institutional frame of implementation of the “Lower Danube Green Corridor”
2. Management of natural resources in the “Lower Danube Green Corridor”
3. To protect and revive the key-ecosystems and the important species which compose the landscape and biological diversity in the “Lower Danube Green Corridor”
4. Sustainable development in the “Lower Danube Green Corridor”
5. To actualize the map “Lower Danube Green Corridor”
6. To integrate the socio-economical systems in “Lower Danube Green Corridor”
7. To integrate the “Lower Danube Green Corridor” into the National and European Ecological Network
8. To create cross-boundary reserves
9. International cooperation in environmental programs
10. Improve the educational system regarding environmental protection

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Meta Data, Techniques and Applications

Grid Data Analysis in the CommonGIS System: an Example from Forestry

Gennady ANDRIENKO and Natalia ANDRIENKO

1 Introduction: Raster (Grid) Data

CommonGIS is a system for visual data exploration and analysis in the Internet (ANDRIENKO and ANDRIENKO 1999). It enables visualization of user's data on interactive maps and statistical graphics. The system is implemented in Java 1.1 and can run either as a standalone application or as a web applet within standard Internet browsers. An important feature of the system is its interactivity. In particular, all graphical displays of the system are linked via dynamic highlighting ("brushing").

The latest release of the system includes new developments. Formerly, the functionality of the system was limited to processing of vector geographical information (points, lines, and polygons). Now the system supports also grid data and includes powerful tools for their presentation and analysis. Raster (grid) geographic data are specified as regular grids with numeric values in the nodes. Characteristics of a raster are: number of columns, number of rows, cell sizes in X- and Y-dimensions, and geographical reference (often specified as co-ordinates of the upper-left corner of the grid).

Thus, it is possible to import grids from standard GIS and visualize them. Additionally, the system implements various functions for processing grids, for transformation from vector to grid data, and for calculating attributes of vector objects from grids. For example, it is possible to calculate an illumination model from a DTM or to find mean altitudes for polygon objects. We demonstrate a variety of grid data analysis functions on the example of forest information and digital elevation model of Europe.

The system with the example described in the paper is available online, URL is <http://www.ais.fhg.de/and/EFISApplet2002/>

2 Visualisation of Raster Data

In order to show raster data on a map, Descartes/CommonGIS constructs an image where each value from the raster is represented by some colour. The correspondence between values and colours is specified by a so-called "colour scale". Thus, in the figure 1 the values of elevation (map layer "relief") are encoded by shades of blue and yellow colours. Blue colour is used for values below zero and yellow for values above zero while zero values are shown by white colour. The encoding is explained in the legend on the right of the map.

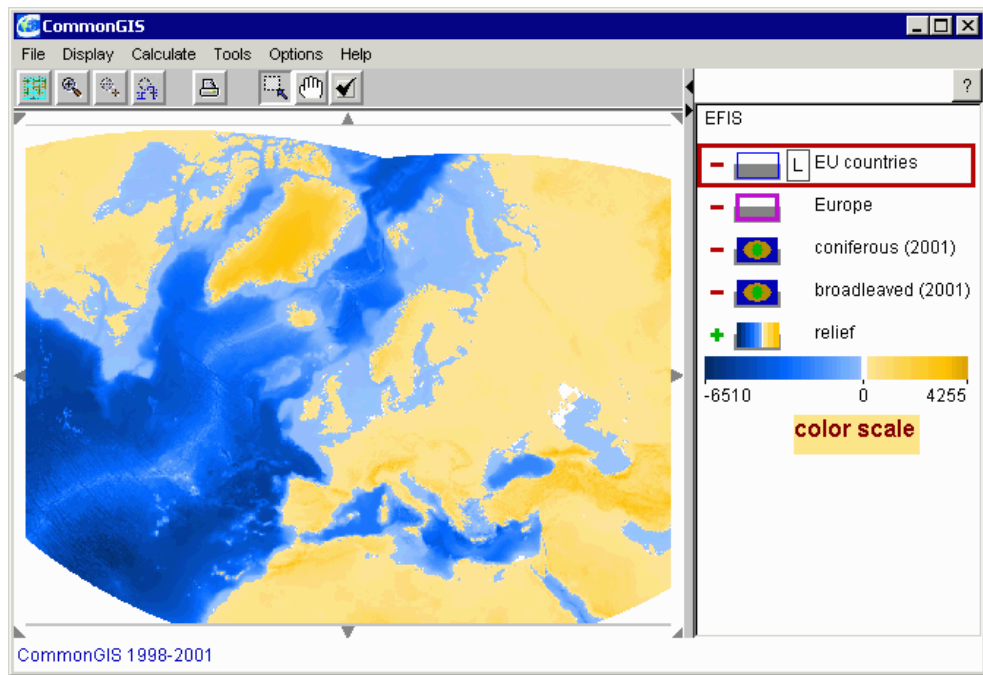


Fig. 1: User interface for map viewing and manipulation

Note that an application (configuration of map layers and tables to be loaded in the system) may include layers that are not loaded immediately. They are not shown in the map but only in the legend and marked in with "minus" signs. When a raster layer has not yet been loaded, it is not assigned any colour scale. Therefore it appears in the legend like the layers "coniferous (2001)" and "broadleaved (2001)" in the picture above. When the user wishes to load such a layer, he/she needs to click on the "minus" sign of the corresponding legend item. The system will load the layer, assign a default colour scale to it, and draw in on the map. The "minus" sign in the legend will be turned to "plus", and the legend item itself will change to reflect the current encoding of values.

The user can choose different colour scales and manipulate parameters of visualisation, for example, transparency. In order to change the current colour scale for a layer, the user needs to double-click on the colour scale representation in the legend. In response, the system will display a dialogue for colour scale selection and varying colour scale parameters (Figure 2):

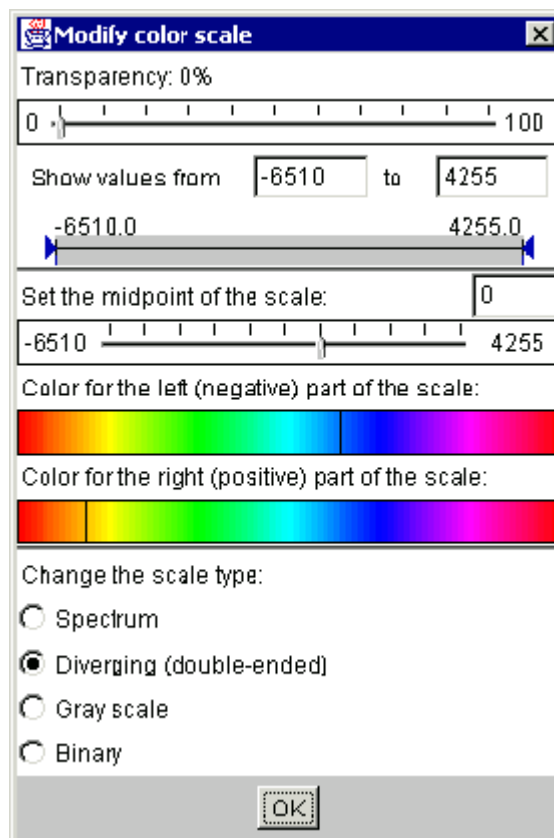


Fig. 2: Dialog for changing of layer's colour scale

The appearance of the dialogue differs depending on what colour scale is currently selected. The invariant parts of the dialogue are the upper controls for setting the transparency and the limits on values to be shown and the lower collection of radio buttons for selection of the scale type. The middle part of the dialogue changes when another colour scale is selected. The set of available colour scales may differ depending on the system configuration.

The upper control of the dialogue (the slider) regulates the transparency of the image constructed from the grid. Note that transparent images look rather ugly under Java versions 1.1.*. In order to use Java versions 1.2.* with Web browsers, you will need to have a Java plug-in installed on your computer.

The controls below the transparency slider are used to restrict the range of values to be shown on the map. The values that do not fit within the limits are not represented on the map. The resulting image may look like in the figure below in which shades of green represent only the values of the raster "coniferous (2001)" that are higher than 10. In order to restrict the represented range of values, one may either drag the triangular delimiters or enter exact values in the text fields (Figure 3).

Different colour scales may have their particular parameters and, hence, particular controls for manipulating them. Thus, the diverging colour scale (used for representing the raster "relief" and "coniferous (2001)" in the examples above) allows the user to change the colours of its left (negative) and right (positive) ends and to move the position of the midpoint. For example, in the figure above green colour was chosen for positive values in the raster "coniferous (2001)".

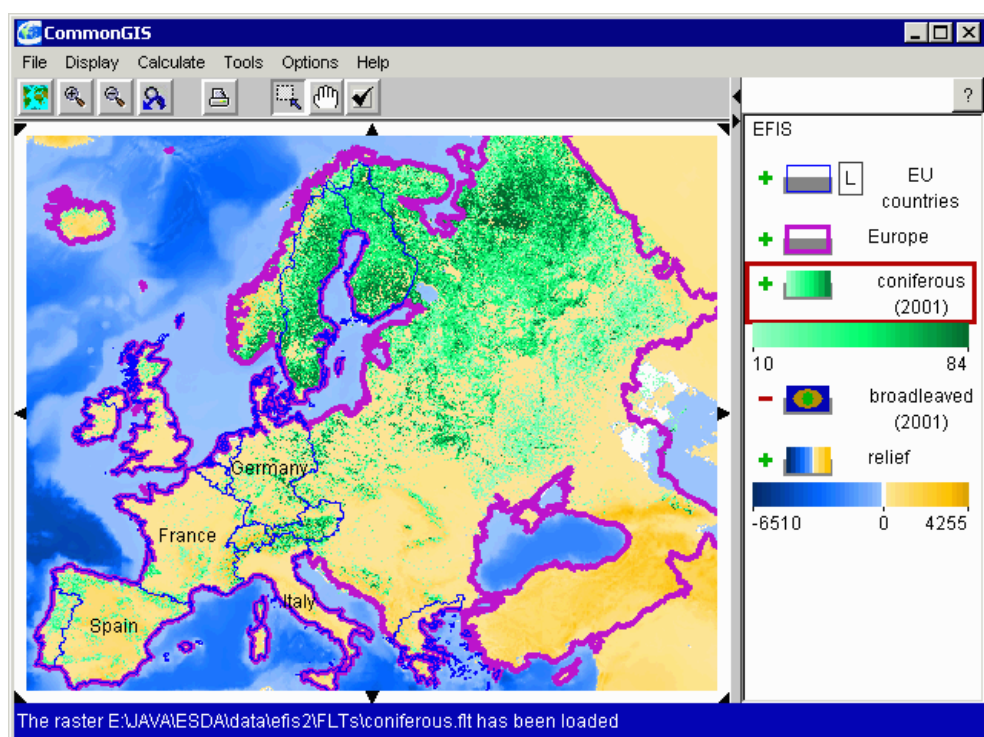


Fig. 3: Only selected range of values is shown on the grid layer

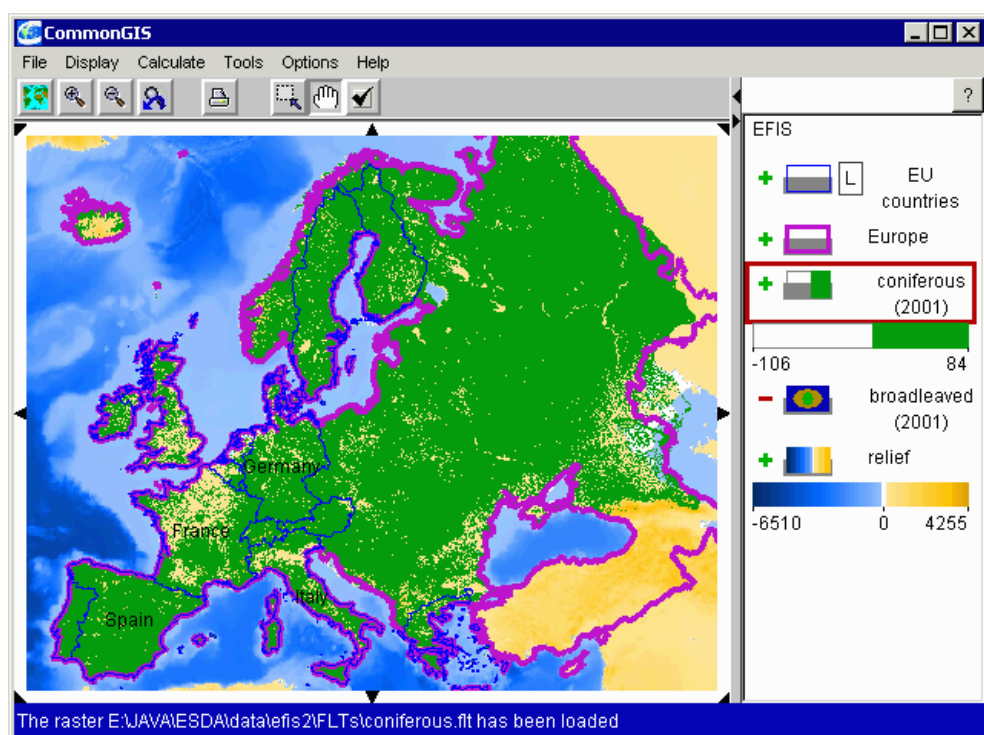


Fig. 4: Binary colour scale visualization of the grid layer

The **binary colour scale** was specially designed for binary raster, i.e. raster containing only values 0 and 1. Such raster result from querying raster data. With the binary colour scale values 1 are represented by some colour (that

can be selected by the user) while zero values are not shown. In principle, this type of scale can be also used for non-binary raster. In this case all positive values are shown in one and the same colour while zero and negative values are not shown. In the figure 4 the binary colour scale is used to visualise the raster layer "coniferous (2001)".

3 Transformation of Raster

Raster data may have some features that make them inappropriate for analysis. For example, the raster "coniferous (2001)" contains some negative values (-106 and -1) that, probably, mean absence of data. Look how the layer appears with the diverging colour scale without putting limits on the values to show (we selected magenta colour for the negative part of the colour scale and green for the positive part):

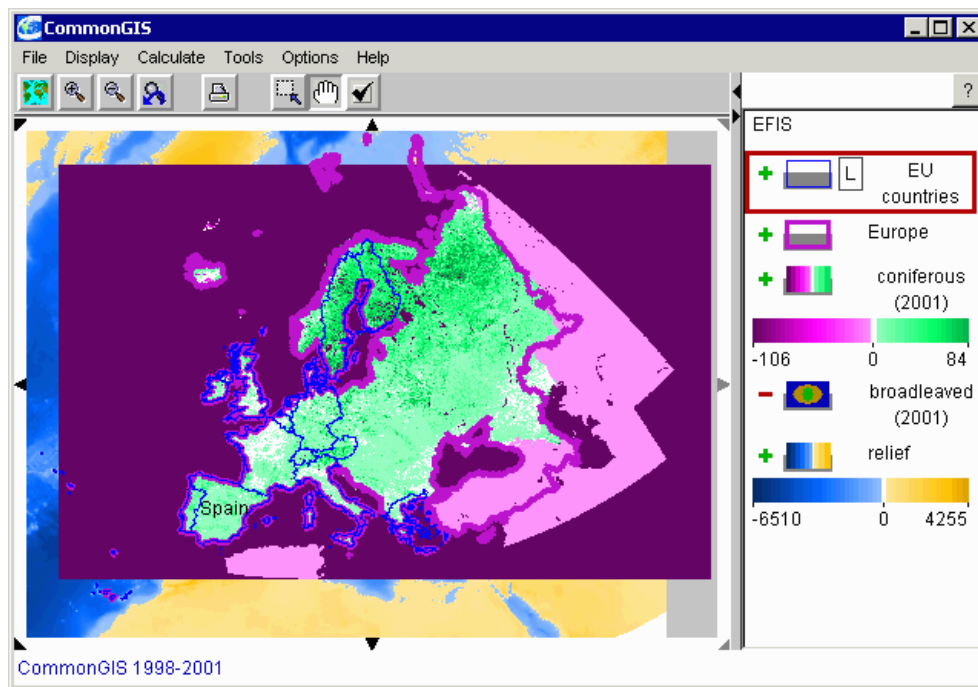


Fig. 5: Map before data cleaning

Suppose, for example, that we wish to calculate the mean value of coniferous for each EU country. Due to the presence of the values -106 inside the contours of the countries (see the enlarged contour of Finland on Fig.5) the results of calculation will be wrong. For this kind of task it is appropriate to replace the negative values by zeros. This operation can be done in the system using its geocomputational tools.

Here is the sequence of operations needed to replace the negative values in a raster with zeros:

- 1) Select geographic computations tools dialog, then select layer transformation operation, and enter a formula:

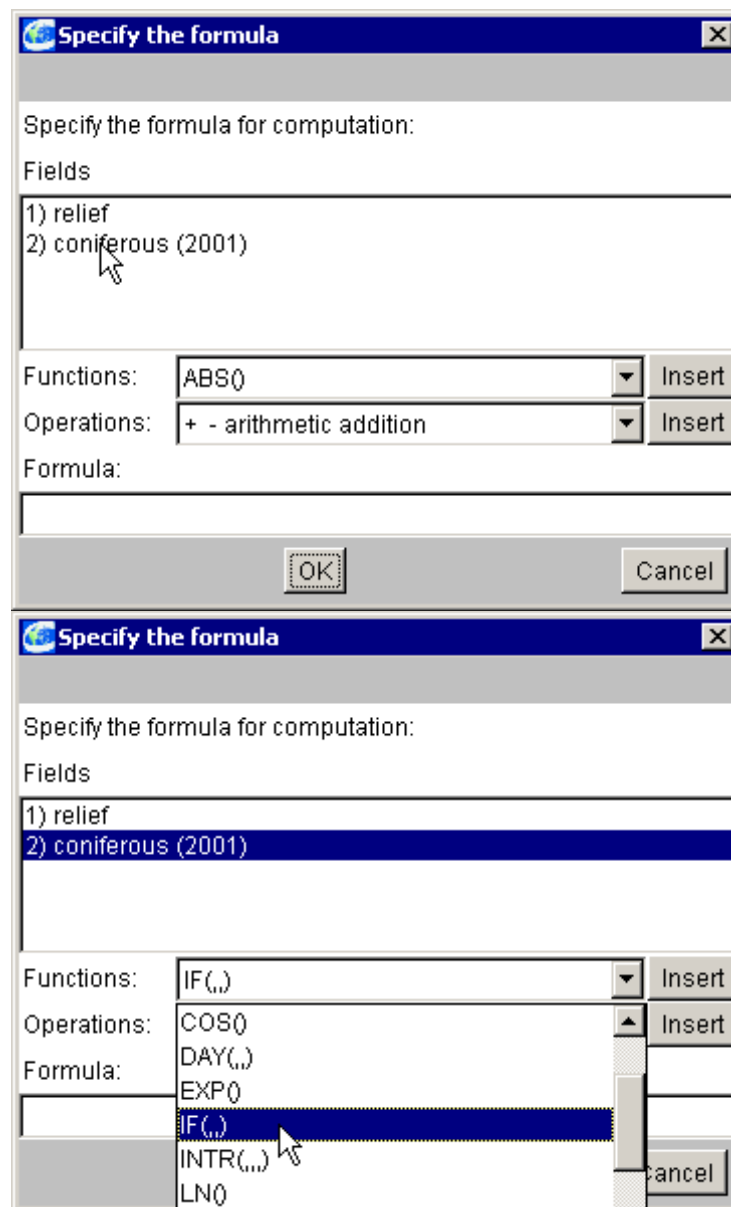


Fig. 6: Dialog for entering a formula

2) Enter the formula $\text{IF}(\$2 < 0, 0, \$2)$ in the field "Formula" at the bottom of the dialogue. Here \$2 stands for "coniferous (2001)" (it is the 2nd item in the list "Fields" in the upper part of the dialogue). You can select the function $\text{IF}(,,)$ from the list of functions and press the button "Insert" on the right of the choice element. The expression $\text{IF}(,,)$ will appear in the formula field. The expression \$2 will be automatically inserted in the formula field when you double-click on the second item in the list "Fields". Signs of arithmetic operations (in particular, "<") can be entered by selecting them in the choice element called "Operations" and then pressing the button "Insert" on the right of it. One may also enter any symbols using the keyboard.

3) When the formula is ready, the tool will do the computations. The progress of the computations is shown in the status line (in the main window of the system, below the map). The result of the computations is a new layer to be added to the map. The system will assign to it a default (grey) scale that can be changed by the user. For example, one may choose the diverging colour scale with green right end. In addition, one may remove zero values from the view by setting the lower limit of the represented value range to 0.01.

The initial layer "coniferous (2001)" may be now switched off (by clicking on the "plus" sign in the legend) or even removed from the system. In the latter case the memory it occupied can be eventually used for other purposes. To remove a layer, select the item "Remove map layer" in the menu "File".

Other transformation operation that may be useful depending on the analysis tasks is smoothing. It is also possible to change such parameters of a raster as the number of columns and rows (resolution), or cell size. This is done by selecting the tool "change parameters of a raster".

4 Analysis of Raster Data

Raster data can be analysed visually by representing them on the map using appropriate colour scales, overlaying them with vector layers, and manipulating the visualisation parameters such as transparency, the lower and upper limits of the represented value range, the midpoint of the diverging colour scale, and so on (see Visualisation of raster data). The following operations are useful in visual analysis of raster data in combination with vector data:

1. Switch on/off drawing of map layers: click on "minus" and "plus" signs in the legend.
2. Change the order of layer drawing: drag the layer icons up and down in the legend.
3. Switch off filling areas (i.e. painting inside the contours) in vector layers: double-click on a layer icon activates a dialogue in which layer drawing parameters may be set.

In addition to the visual means of analysis, the system offers various computation-based tools for raster data. The list of tools available in the system is displayed after selection of the item "Geographic computations" in the menu "Calculate". This list may vary depending on the system configuration. Here we consider three tools: combine raster, query raster data, and derive attributes of vector objects from raster data.

4.1 Combining Raster: Find a Sum of Coniferous and Broadleaved Forests

Before analysing raster data it may be necessary to transform them (see Transformations of raster). Suppose that the layers "coniferous (2001)" and "broadleaved (2001)" have been transformed by replacing negative values by zeros. The names of the layers after the transformation are "coniferous (transformed)" and "broadleaved (transformed)", respectively.

Assuming that the values in the raster "coniferous" and "broadleaved" correspond to the parts of territory covered by coniferous and broadleaved forests, respectively, we would like to calculate the part of territory covered by both kinds of forests in total. For this purpose we select the tool "transform or combine raster" (Menu "Calculate" > "Geographic computations" > tool selection dialogue). The tool displays its own dialogue for specifying the formula for the computation. We double-click on the item "coniferous (transformed)" in the list "Fields" in the upper part of the dialogue window, then select the operation "+ - arithmetic addition" in the choice element "Operations" and press the button "Insert" on the right of it, and, finally, double-click on the item "broadleaved (transformed)" in the list "Fields". As a result, the text edit field "Formula" at the bottom of the window contains something similar to $S_2 + S_3$ (the numbers depend on the positions of the items "coniferous (transformed)" and "broadleaved (transformed)" in the list). After the formula is ready, we press OK. Of course, the tool allows to construct a large variety of formulas with the use of the functions and operations listed in the choice elements "Functions" and "Operations".

When the tool finishes the calculations, it proposes to give a name to the resulting new raster layer. We give it the name "forests total". The system, by default, represents the layer using the grey colour scale. We change it to the diverging scale, select green colour for the right end of the scale, and remove zero values from the view by setting the lower limit of the represented value range to 0.01 (see above). The result is shown in the figure below (we moved the vector layers to the top of the legend to make them drawn over the raster layers):

Note that in combining raster layers with different resolutions the cell size of the resulting raster will be set to the maximum cell size of the source raster. If there is not enough memory for the resulting raster, the system will decrease its resolution until it fits to the available free memory.

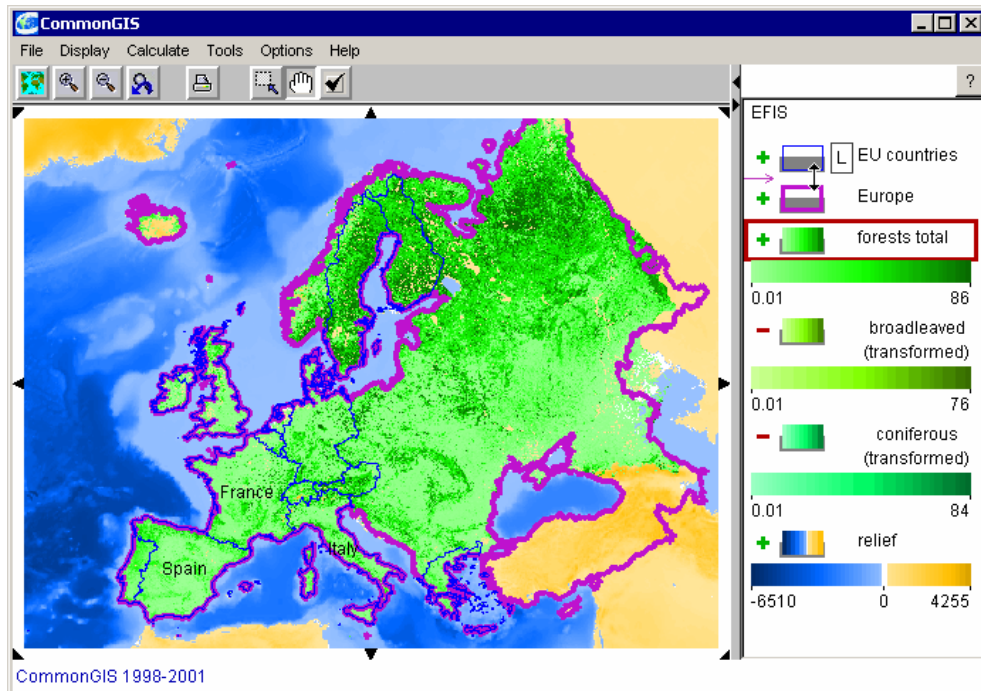


Fig. 7: Map represents calculated layer

4.2 Querying Raster Data: Show Forests on Altitudes from 1000 to 1500

In order to query the system about raster data, the query tool must be invoked (Menu "Calculate" > "Geographic computations" > tool selection dialogue > select "query raster data" > press "OK"). Like the tool for transforming and combining raster, the query tool displays a dialogue window in which the user can construct a query condition involving the raster layers loaded in the system. The condition may include comparison operators =, <, <=, >, >=, <> (not equal), logical operations AND, OR, and NOT, and arithmetic operations +, -, *, and /. Sub-expressions may be enclosed in parentheses. Operation signs are inserted in the formula field when the user presses the corresponding buttons. One may also enter any symbols using the keyboard. Double-clicking on a layer name in the list of raster layers in the upper part of the window will result in appearing of the expression \$<n> in the formula field, where <n> is the position (index) of the layer in the list. For example, \$1 may correspond to "relief", \$2 to "coniferous (transformed)", \$3 to "broadleaved (transformed)", and \$4 to "forests total".

In order to find all forests growing on the altitudes between 1000 and 1500 m, we specify the following logical formula:

$\$4 > 0 \& \$1 \geq 1000 \& \$1 \leq 1500$ (i.e. forests total > 0 AND relief $\geq$ 1000 AND relief $\leq$ 1500)

After the formula is ready, we press the button "OK". Since two raster layers with different territory extents participate in the formula, the system will ask us how to define the extent of the resulting layer: as intersection or as union of the source layers. Intersections means the largest rectangle included in all the raster. Union means the smallest rectangle including all the raster. In this case only intersection makes sense.

After this the system performs the calculation. Note that the cell size of the resulting raster will be set to the maximum cell size of the source raster. If there is not enough memory for the resulting raster, the system will decrease its resolution until it fits to the available free memory.

When the computation is finished, the system proposes to give a name to the new layer. We enter the name "forests on altitudes from 1000 to 1500". After that the layer is shown on the map with the use of the binary colour scale since this is a binary raster with values 1 for the cells satisfying the query and 0 for the cells that do not satisfy the query. The zero values are not shown on the map while the values 1 are shown, by default, in red colour.

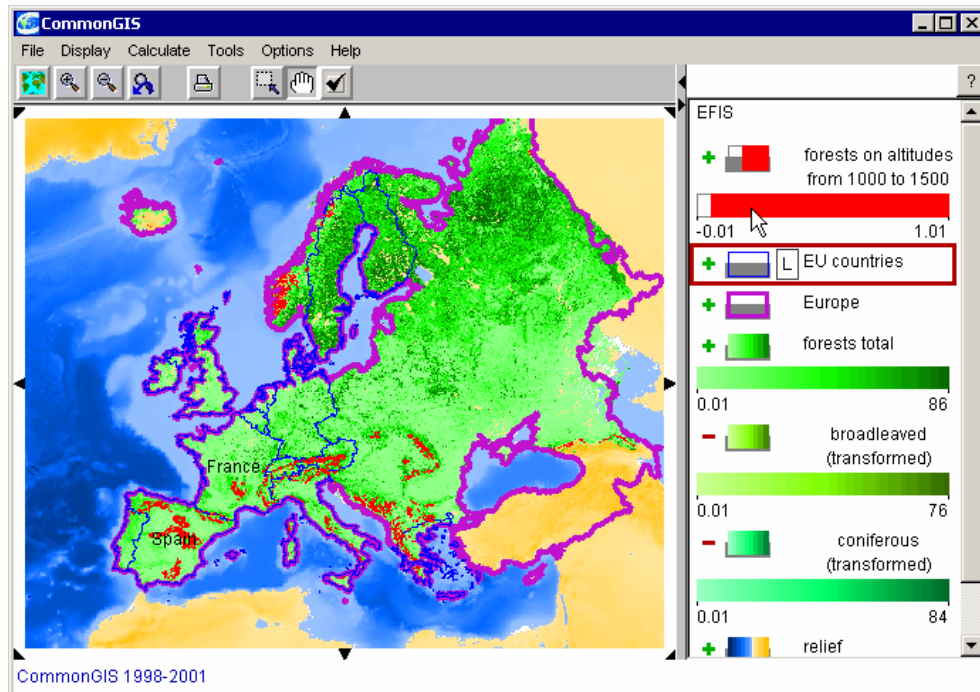


Fig. 8: Query results are shown on the map

4.3 Deriving Attributes of Vector Objects from Raster Data: Aggregate Forest Data by EU Countries

Using the vector layer "EU countries", we can now compute the area of forests growing on the altitudes from 1000 to 1500 m in each country of EU. For this purpose we invoke the tool "derive an attribute of vector objects from raster data" (Menu "Calculate" > "Geographic computations" > tool selection dialogue > select "derive an attribute of vector objects from raster data" > press "OK"). First of all the tool asks us to select a vector layer from the list of all currently loaded vector layers. We select the layer "EU countries". After that we must select the raster layer that will be used for computations. We select the layer "forests on altitudes from 1000 to 1500" resulting from the query operation described above. Then the tool displays the dialogue (Figure 9):

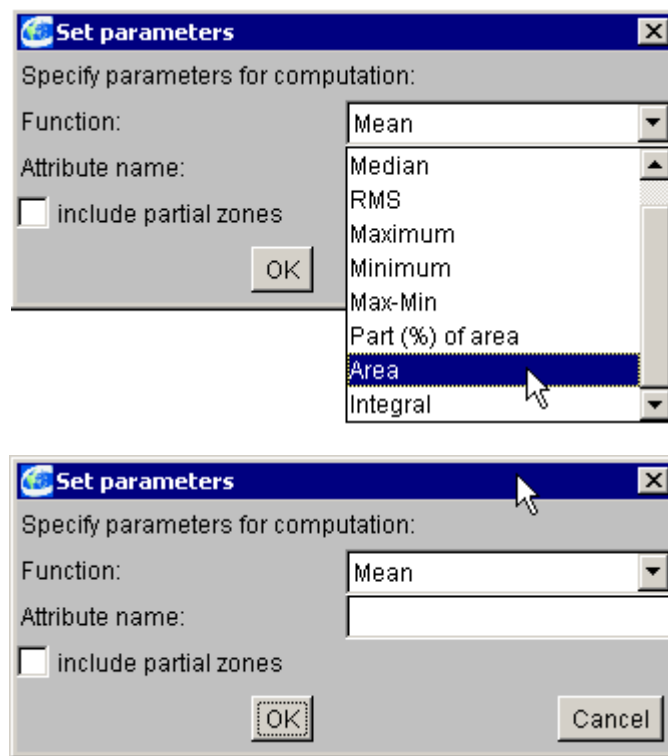


Fig. 9: Dialog for calculating attributes of vector objects

In this dialogue we select the function "Area". The checkbox "include partial zones" should be checked in this case, otherwise the system will not compute the area of the forests for such countries as Spain: this country includes islands lying beyond the extent of the raster. We enter the desired name of the new attribute, "Area of forests between 1000 and 1500 m altitude", in the edit field "Attribute name". If we do not specify any name, the system will generate a default name. When we press the button "OK", the system performs the calculations and represents the results on the map: the countries are painted according to the values of the just derived attribute.

In a similar way we can derive the mean values of coverage by coniferous and by broadleaved for the countries. In both cases we select the function "Mean" in the above-described dialogue. To compare the values of the derived attributes "Mean coverage by coniferous" and "Mean coverage by broadleaved", it is convenient to represent these attributes on the map together using parallel bars (menu "Display" > "Display Wizard..." > select the table "EU countries" > select the two derived attributes > select the "parallel bars" visualisation method). The resulting map is shown on figure 10.

Attributes on the basis of raster data may be also derived for user-defined vector objects. The system allows the user to construct a new map layer by drawing geographical objects on the map using the mouse. The layer constructing/editing tool is activated through the menu "Tools" containing the item "edit or construct a map layer".

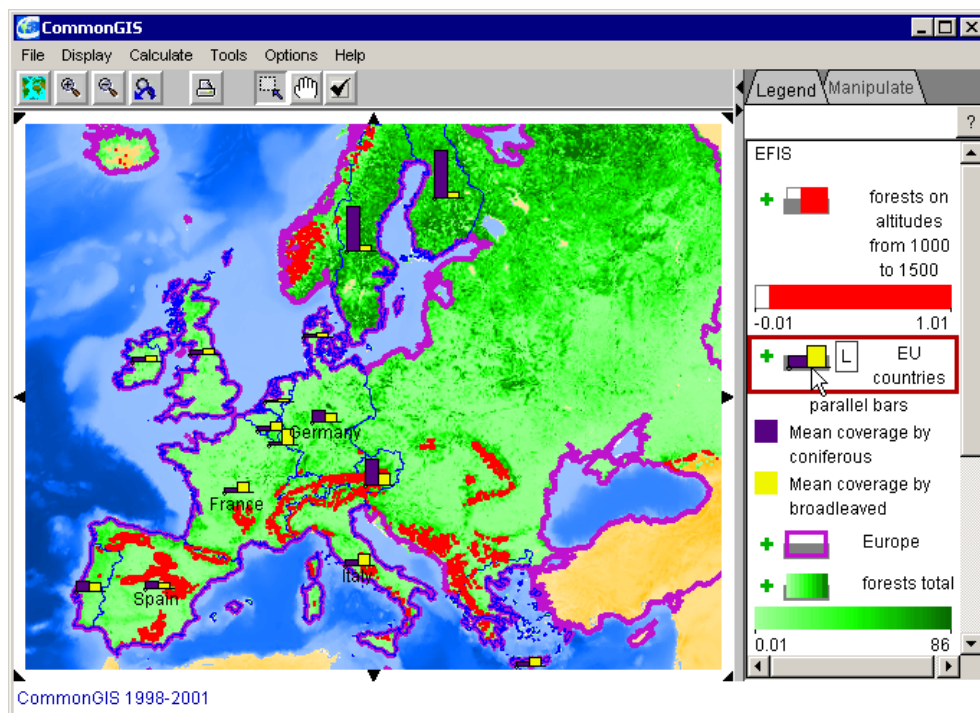


Fig. 10: Bar charts represent areas covered by coniferous and broadleaved forests

5 Conclusions & Acknowledgements

The paper demonstrated how interactive maps can complement computational methods of grid data processing for providing a synergetic effect in data analysis.

The system described in the paper has an open architecture and allows easy configuration. An API for extending the system (supporting new data formats, including new calculation or visualization tools, etc.) is provided. The system is available for downloading for research and educational purposes at the URL <http://www.CommonGIS.de>

The work was done within the EFIS project which was awarded by the EURO-Landscape project of the Institute for Environment and Sustainability, Joint Research Centre, to a consortium of organizations under contract number: 17186-2000-12 F1ED ISP FI, URL <http://www.ec-gis.org/efis/>. We are grateful to Dr.V.Gitis and Mr. I.Denissovitch for their participation in the design and implementation of the grid data processing module.

6 References

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User-specific Spatial Soil Quality Meta-Information mapped on the Internet

Jandirk BULENS and Wies VULLINGS, Onno ROOSENSCHOON, IJke van RANDEN

1 Summary

Alterra is responsible for the largest collection of soil data in the Netherlands. These data are collected during the last 40 year. They contain soil profile descriptions, analyses of data, etc. At the moment these databases are only available to a limited group of professionals. To change this we initiated an attempt to make these data more accessible. We specifically made a start to visualise coverage and completeness of the stored data by the use of maps on the internet. The users can dynamically interact using the interface on the internet to compile a certain query on the database. A server application collects the subset from the database and visualises this in the form of a map which is send back to the user to be viewed in the browser.

Data can be queried using selected areas such as provinces or municipalities. These areas are predefined and stored in the database due to performance reasons and ease of use. In these areas all points available in the database are shown on a map indicating the availability of certain attributes (for instance pH-values). Different attributes can be selected depending on the user requests.

To build the application we made use of an Oracle database with SDE (ESRI), a server application (ISAPI DLL) build with Delphi using MapObjects (ESRI) mapping components.

In the future we would like to make the web application independent of predefined areas, add more meta-information aspects (on data sets and/or object data level), add more depth choice options. The use of a Map server could possibly improve flexibility in mapping options. The first release proves that it is possible to query a database interactively and dynamically on specific quality parameters in an effective way.

2 Soil Data

2.1 Alterra

Alterra, Green World Research, is the main Dutch centre of expertise on rural areas. A wide range of expertise on rural areas and their sustainable use, including aspects such as water, wildlife, forests, the environment, soils, landscape, climate and recreation, as well as various other aspects relevant to the development and management of the environment we live in are combined in research.

Alterra is part of Wageningen University and Research Centre (Wageningen UR) and includes two research sites, one in Wageningen and one on the isle of Texel. The research departments are subdivided into teams focusing on specific research themes.

2.2 Soil Data

In many of the research themes soil data play a major role. Most of the soil data in the Netherlands are gathered by Alterra and its predecessors. Gathering of data for the soil map 1:50.000 and regional maps on a larger scale started in 1960. Data such as descriptions of soil profiles, physical and chemical analysis results at point locations were collected. In the second half of the seventies a start was made to digitise soil maps. In 1992 the digital soil map 1:50.000 was completed. Since 1993 additional soil point data are gathered according to a statistical approach to upgrade the existing soil map (LSK National Sample Soil Map units) by statistical characterisation of map units on the parameter level. All the files are consistently stored in BIS (Soil Information System) in which point information is stored in the relational database using ORACLE, and the pattern information is stored in a GIS using ArcInfo. This is schematically shown in fig 1.

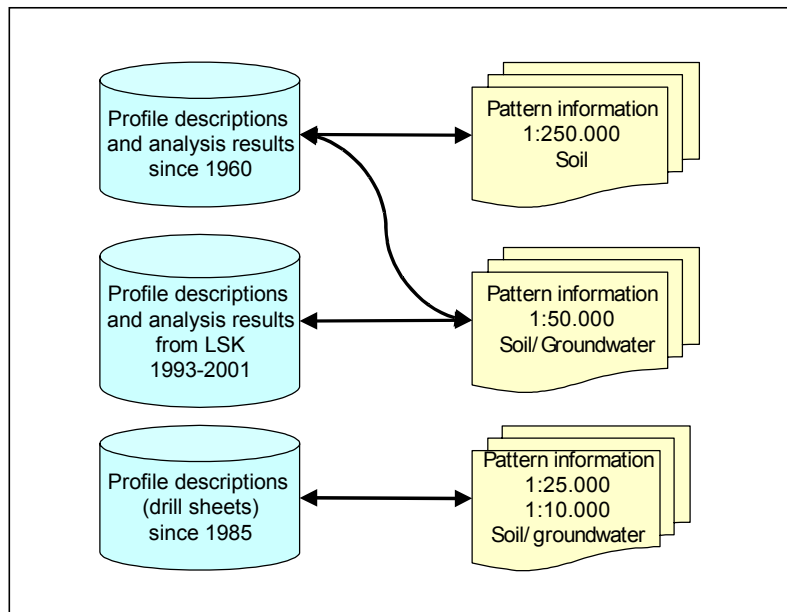


Fig. 1: Data structure of BIS

2.2.1 BIS Structure

Building BIS took mainly place in 1983-1989. In BIS information on the profile descriptions (point based) contains general data and layer data for the different layers within a profile. The existing profile descriptions are evaluated using the following criteria:

- 1 Presence of a complete description including x-y co-ordinates;
- 2 At least 4 layers should have physical/chemical analysis results;
- 3 Presence of a detailed situation map

Profiles satisfying all three criteria are included as “reference” profiles. If no situation sketch was present they are included as “plus” profiles. For regional studies (detailed mapping) there are specific data collected resulting in “calibration” profiles used to calibrate field estimates e.g. of soil texture. A last category of profile descriptions are “deep drills” which have no physical/chemical analysis data.

Beside profile descriptions so-called representation profiles are also available in BIS. These are descriptions of an “average” profile corresponding to one of the Map units used on the soil map of the Netherlands 1: 50.000

In figure 2 a conceptual model of BIS is presented. The data are grouped in a project (i.e. map sheet). The legend with Mapping Units is described by the tables on the left side. It gives access to tables with suitability data. The base data and the analysis data are stored in the tables at the right side of the diagram.

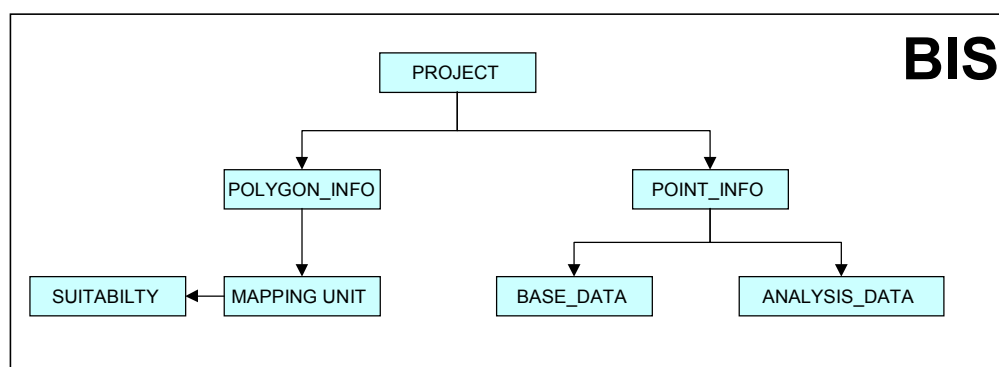


Fig. 2: Conceptual datamodel of BIS

2.2.2 LSK Structure

Building the LSK database took place since 1990. Its structure is similar to BIS. The soil profile is described on a drill sheet and contains also general and layer data. Correspondingly to BIS, descriptions in LSK may or may not correspond to samples in the “physical” soil sample archive.

2.3 Access to Soil Data

The soil data are stored in an Oracle database in tables according to the data models in the previous paragraphs. It is obvious that this structure is complex and not easy to access for users. Users need to be familiar with the data structure as well as having knowledge of SQL. For this reason projects are proposed to give access to data using internet techniques. Since we deal with geographic data there is also a need to use a geographical entrance by using web-mapping. The first study (LEETERS et al. 1999) comprises a definition study for a user friendly interface to access the databases. The study proposes a two-step approach. First meta-information of the soil data should be made accessible followed by giving access to the data itself in the second step. The advantage of the two-step approach is that experience can be build up in web-mapping techniques prior to disclosing the soil data self. This paper focuses on the first step, giving access to the meta-information. Special attention is given to quantify quality parameters on coverage and completeness of the soil datasets.

3 Meta-Information Soil Data

3.1 Meta-Information Standards for Spatial Data Sets

Currently two major standards concerning meta-information are in use. One is the CEN standard (CEN ENV. 12657; 1998) used in most European countries, and the other is defined by the FGDC, the Content Standard for Digital Geospatial Metadata (CSDGM, 1994), used in the USA. At this moment efforts are undertaken to merge these two standards into one harmonised ISO-standard for spatial data sets (AALDERS 2002).

In the Netherlands the NCGI, National Clearinghouse for Geo-Information uses the CEN standard. At <http://www.ncgi.nl/catncgi/index.htm> the meta data specifications for soil data can be found.

3.2 Quality Meta-Information

In this research information on the quality of the available data is included in the meta-information. Especial coverage and completeness of the data for specific areas can be of interest for the users. For these two parameters we defined an interface to get this information. Quantitative information is calculated on-line and on the fly for an area given by the user.

4 The Web Application

All information on the soil data of Alterra in the Netherlands will in the near future be found at <http://www.bodemdata.nl>. The aim of this specific project was to give access to the described quality parameters in paragraph 0. At this moment a prototype application is being realised to get an impression of possibilities to deliver this kind of data. The prototype is restricted in the since the user cannot point out the area of interest geographically. In the database pre-defined areas are available which can be selected.

4.1 System Components

The design of the web application is based on the tree tier architecture. In fig 3 the components are shown schematically. On the server side we have the data layer and the business logic layer. Data are stored in an Oracle spatial database on top of which a SDE-server gives access to the spatial data. SDE is chosen because within the organisation ESRI software is used so that the data infrastructure is based on the way ESRI software is structured. In the database geographic data to deliver soil information is present as well as referential geo-data sets used for background and orientation. For the prototype administrative boundaries are included as reference data sets. In the business logic layer we have a web-server to connect to the web. The application software comprises a connector, an application server and a spatial server. We did not use a dedicated map-server because of the specific nature of the required functionality. Our experience so far with map servers is that they perform sub optimal when not directly used under specific conditions because of the overhead they produce. In this way flexibility in extending functionality in the future is lost. On the other hand this is a prototype to explore possible functionality and for this purpose the above described architecture is satisfying. We used Delphi in combination with MapObjects of ESRI to build the server components. On the client side we only need a standard web browser. Since we use images to transfer data over the net no specific plug-ins are needed to view the data.

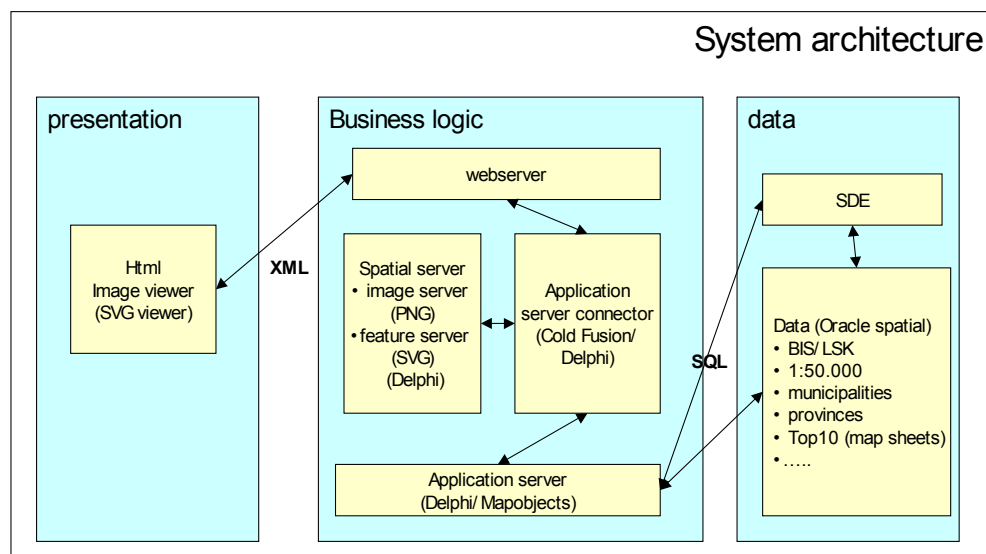


Fig. 3: Web application system architecture

4.2 System Model

Through experience in previous projects we noticed that it is wise to limit the length and content of URL's. In this version we still use them, but we plan in the near future to prevent problems on the server by making sure that each internet session is captured in a kind of session object. All the necessary information will be passed to this session object which is capable to handle the request and generate the necessary output. In the class diagram the session object takes a central position. It contains the information supplied by the user, for instance what polygons should

be selected and which meta data must be provided etc. Each session object has a unique id known by the internet server. So the user sends the request to the internet server object (TInternetServer). The internet server object is capable to interpret the user information and evaluates if it is necessary to pass on the request to the session object. The session object on its turn passes it on to the application which will execute the request. In order to avoid abandoned sessions, session objects have a limited lifetime. To describe the system model we use the UML (Unified Modelling Language) for showing the class diagrams. In figure 4 the class diagram for the simplified architecture is shown. The most common relations shown in the UML class diagrams are those representing associations, aggregations, composites and generalisation. For the legend and a short description of these relations see appendix A.

4.2.1 Geo Objects

The user selects for a specified area all the objects present in that area. We call these Geo-objects. For the selected objects the user must indicate for which characteristics the quality parameters must be presented. More than one item can be selected per Geo-object. The geo-object retrieves for each item its values. Items are described by a value, a name and a type. The values of an item are dependent on the depth. In this version we distinguish a lower and upper part in a soil profile.

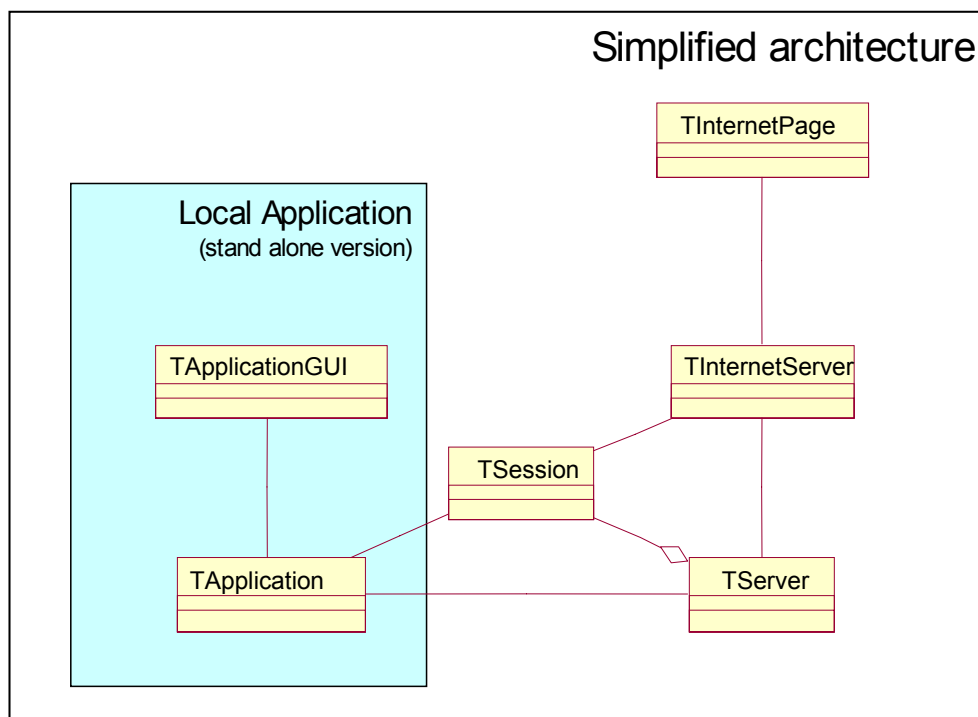


Fig. 4: Class diagram of the simplified architecture

The data in the geo-data base are considered to be geo-data sets. A geo-data source is a collection of geo-data sets. Each geo-data set is connected to a SDE-layer. One SDE-layer can be connected to several geo-data sets. A geo-data set has an intersect function. The result of this function is a new geo-data set containing all features which are inside the given argument (clipping function). The class diagram is shown in fig 5.

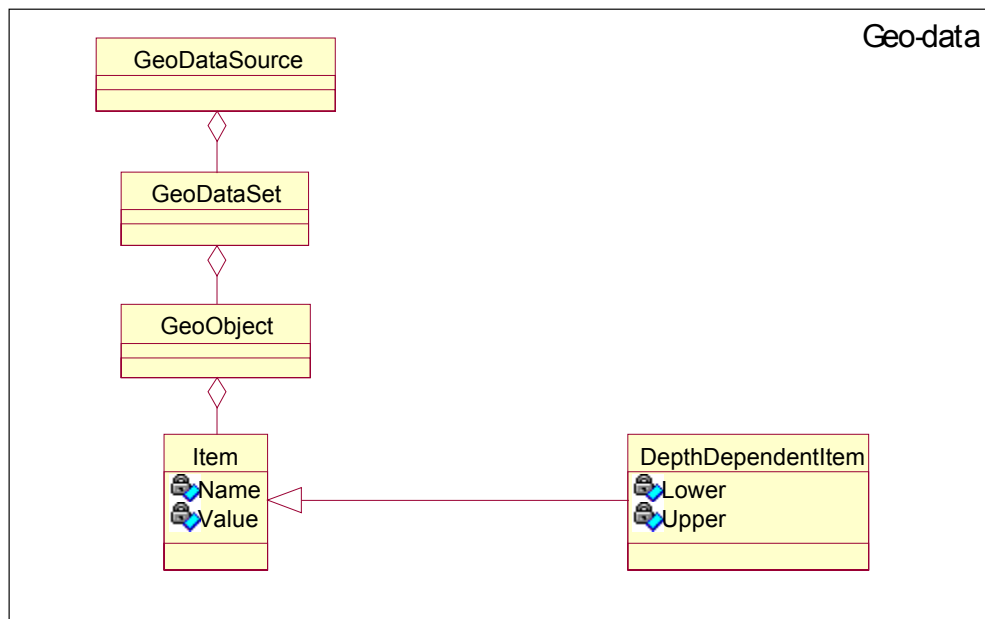


Fig. 5: Class diagram of Geo-data

4.3 Web Interface

The first release of the web-application assumes a user who is at a certain level familiar with the nature of soil data. Once the user decides to retrieve quality data about coverage and completeness there are 6 steps defined to obtain the results. The screen dumps shown originate from a preliminary version, the first version to be released will differ slightly, but will have the same functionality.

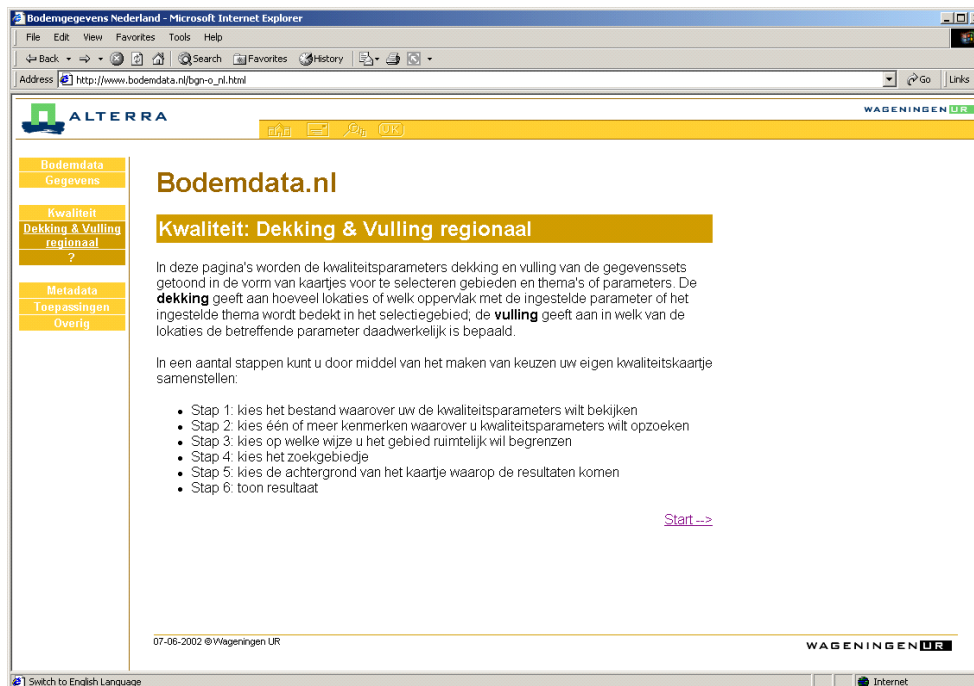


Fig. 6: Screen lay-out user-steps

In Step 1 the data for which quality parameters are to be reviewed can be selected. The following data sets are initially available:

- BIS profiles:
 - BIS Reference profiles
 - BIS Research profiles
 - BIS Plus Profiles
 - BIS Calibration profiles
- LSK Profiles

In Step 2 the characteristics for which availability must be shown (the items or attributes of the record in the data sets) can be selected from these data sets. Initially the following characteristics can be selected:

- CEC between 0 and 50 cm.
- Al-Oxalate
- Fe-Oxalate
- HUMUS 0-50 cm
- PH-KCL 0-50 cm. ...etc

In future this step will be extended to show more than only availability of the data. The value itself as well as post processing the values should be included.

In Step 3 the area of the Netherlands for which the information should be gathered can be selected. Initially we stored relations for the provinces and the map-sheets of Topographic map 1: 10.000 of the TDN, the national topographic Service

In Step 4 the search area(s) for example province(s) or map sheet(s) can be selected.

In Step 5 the background data set for presentation can be selected. The following data sets are initially available:

- Provinces (boundaries 1998)
- Map Sheets top 10 vector

In Step 6 the query is executed and the results are shown.

In figure 8 an example of the results are shown. The results are shown in two ways. For each map sheet a table shows the number of profiles matching the request (Yes/J) and the number of profiles not matching the request (No/N). For each item the table will have a separate column. The maps show the location of the search area (Yellow) and the availability (green/red) and location of the profiles.

Bodemdata.nl

Kiezen bronbestanden

Geografische selectie
 Provinciegrenzen 1990

Dataset
 BIS Plus Profielen

Achtergrond
 Topkaarten 1 : 50000

Maak een keuze welke vlakken uit het bestand voor de geografische selectie gebruikt moeten worden bij de zoekactie:

☐ Noord-Holland
☐ Noord-Holland
☐ Overijssel
☐ Flevoland
☐ Flevoland
☐ Gelderland
☐ Zuid-Holland
☐ Utrecht
☐ Noord-Brabant
☐ Limburg

Selectie-> Data overlay type

☐ Alle gegevens rakend aan geografische selectie
☐ Alleen gegevens volledig binnen geografische selectie
☐ Geen onderscheid

Data <-> Presentatie overlay type

☐ Alle gegevens rakend aan geografische selectie
☐ Alleen gegevens volledig binnen geografische selectie
☐ Geen onderscheid

Beschikbare items voor BIS Plus Profielen

☐ CEC tussen 0 en 50 cm - mv.
☐ Al-Oxalaat
☐ Fe-Oxalaat
☐ HUMUS 0-50 cm - mv.
☒ PH-KCL 0-50 cm - mv.

Volgende >>

Fig. 7: Screen lay-out all user input

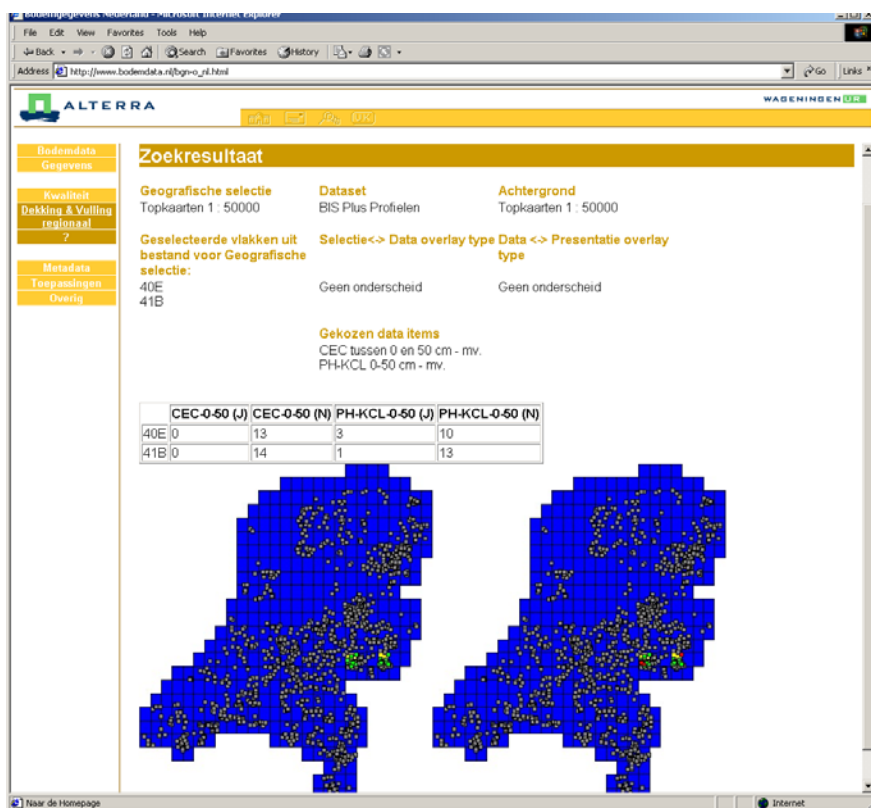


Fig. 8: Query results

5 Conclusions & Future Research

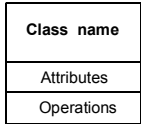
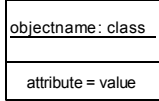
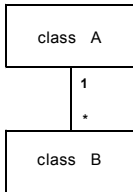
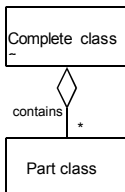
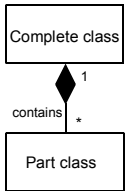
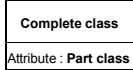
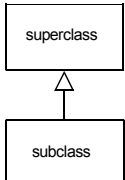
Recently we made the web-application operational. There is still a lot to be improved. Especially the interaction with the user; the GUI must be improved in a way that a less experienced soil data user can figure out how to use the interface. The principle to retrieve the data live from the database seems to be satisfactory on the condition that performance still has to be improved. The fact that the GIS-operations i.e. the overlays are stored at forehand contributes already greatly to performance issues, but has the disadvantage of making the system less flexible. An alternative might be to process the query off-line and mail the data after processing. Hopefully also when maps-servers will evolve in better performing services in the near future this would improve the flexibility in a more constructive way.

Next step is to give access to the real data in a flexible way. Give the user the opportunity to examine the data. Also give ways to retrieve the data on-line from the internet. Before that can be realised matters such as security, authorisation and licence issues should be addressed to in a satisfactory way. Recently we started to improve performance of the existing web-application and made a start with the data retrieval part.

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Appendix A UML class diagrams notation descriptions

part	description	Notation
Class	A description of a group of objects having communal attributes and operations. A class can be directly implemented in an object-oriented language.	
Object	An unique instance (individuel member) of a class	
Association	An association is a relation between two or more classes. An association can have attributes and operations. To present the amount of objects that are connected to each other multiplicity is used. The range of a multiplicity can be one (1), zero-to one (0..1), zero to many (0..*), one to many (1..*) or many (*), two (2), two to four (2..4) etc.	
Aggregation	An aggregation is an association between a composite class and a component class (is part of). Objects of a subclass can be added or deleted. If the multiplicity of the site that is complete, is not one, this aggregation is regarded as a shared aggregation. An aggregation is shown as a line with an empty diamond at the complete side.	
Compositie (-aggregatie)	Composite: A composite is an association in which a class is part of another class (composite). A property of a composite is that objects of a sub-class form the composite class. If the composite class is deleted, so are the sub-classes. Objects of the sub-class can not be added or deleted, as is possible in an aggregation. An composite-aggregation is shown as a line with a filled diamond at the complete side or as attributes in a complete class	 
Generalisatie	Generalisation A generalisation is a relation between a super-class (general class) and a sub-class (a specialised class). The sub-class contains extra information or operations. A generalisation is a relation in which attributes and operations are inherited from a super-class to a sub-class.	

Interactive Topographic Web-Maps Using SVG

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Abstract

There is a clear demand for web-maps that not only allow to locate places and calculate routes - as it is possible with today's common web mapping services - but also to interact with the map. The paper deals with possible interactive methods that allow exploring topographic maps. To achieve these goals a map-author could either choose expensive GIS-Mapping-Server/Java-Applet/Plugin combinations or use standard web-technology, such as SVG or Macromedia Flash, that are not primarily designed for a use in the domain of mapping or GIS. Along with the paper we present a prototype of an interactive topographic map implemented in SVG/ECMA-Script. This implementation tries to close the gap between high-demands in terms of interactivity on one hand and keeping cartographic quality, using open standards and keeping the code maintainable, on the other hand. While this first prototype already works and proves that the chosen SVG solution is a passable way, we still have to fix bugs, enhance and apply it to larger datasets, kept in spatial databases.

A second part of the paper presents an interactive map-browser for the Swiss national 1:25.000 topographic maps. The map-browser was developed by Yvonne Isakowski during her stay at ETH as a trainee. In addition to a small-scale overview-map the viewer features the display of metadata, such as the up-to-dateness of the map-sheet, coordinates of the map corners or administrative units the map covers. Interactive map-browser, such as the one presented, could help the user select a printed map during a visit at an online map-store.

1 Introduction – Goals of the Project

Web maps in general, and in particular address-matching/routing systems, are extremely popular among web users. However, while most mapping-systems still lack good cartographic quality - concerning symbology, generalization and labelling -, it gets even worse when examining the level of interactivity that most current web mapping systems offer. Because most current systems are mainly server-based, each interaction still requires contacting database-server, which generates answers/feedback for the requests. This process is quite time-consuming and results in undesirable delays when querying or examining objects. Furthermore, the large-amount of client-server traffic burdens map-servers and bandwidth resulting in the needs for very expensive server/database-cluster and network infrastructure for still being able to meet customers demands. New approaches, using a combination of open web standards, such as SVG, XML, DOM, ECMA-Script and CSS/XSL, not only allow high (carto-)graphical quality but also a considerably higher amount of interactivity while at the same time saving computing power, license fees and network bandwidth.

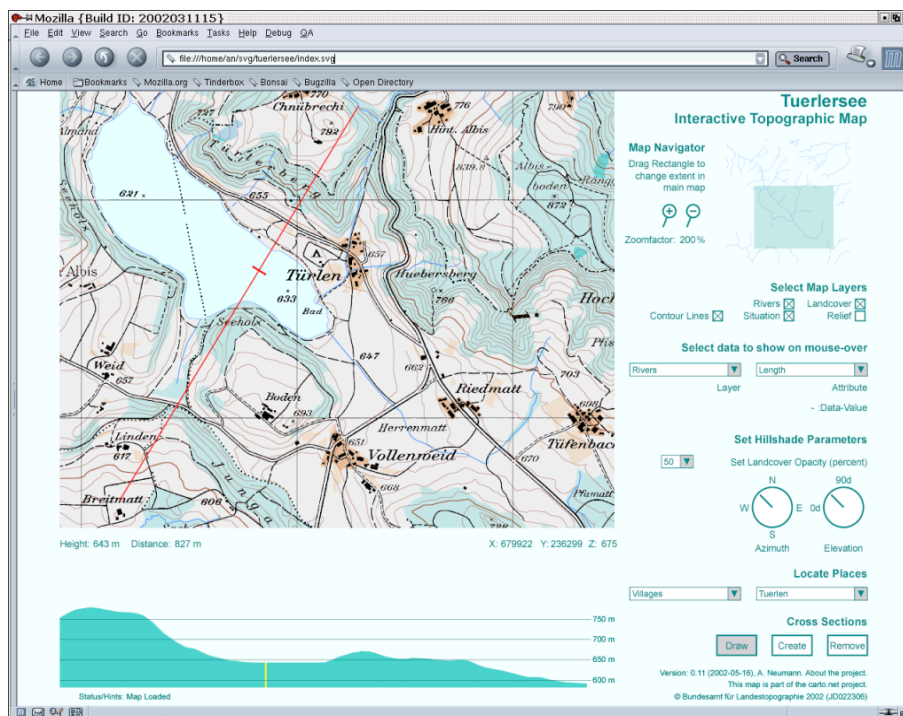


Fig. 1: Screenshot of the prototype "Tuerlersee" (Interactive topographic map)
 - see also <http://www.carto.net/papers/svg/tuerlersee/> - © Bundesamt für Landestopographie (JD022306)

The goal of the project was to develop a highly interactive topographic webmap that uses only open standards and may be served and run without paying expensive license fees (in terms of the involved software, both client and server). The resulting work, presented at the conference, is work in progress: some features are already implemented while others are in the queue and should be developed later on the project. The current prototype features map navigation (zooming and panning), display of coordinates and z-values on mouse-move, analytical hillshading with the ability to change the light-vector, switching map-layers, show attribute values, locate places and create cross-sections on demand. A screenshot of the prototype is included above - the interactive SVG-map may be found at the projects webpage. It was not included in the conference proceeding because it is still under development.

2 Features useful for an Interactive Topographic Webmap

The following table lists a number of features useful for an interactive topographic webmap. It lists whether a feature is already implemented, needs further enhancements, or is only planned so far. Because the prototype is work in progress many features are only partially or not at all implemented. You should contact the projects webpage for an updated version (<http://www.carto.net/papers/svg/tuerlersee/>).

Feature	Implemented	Needs improvement	Planned
Navigation, Spatial Reference			
Linked Reference Map for Navigation/Panning	X	-	-
Pan at the map-borders/corners	-	-	X
Zooming	X	X ₁	-
Show Coordinates on mouse-move	X	X ₂	-
Grid Lines	X	-	-
Adaptive Scalebar, automatically generated	-	-	X
Measuring, Locating, Routing			
Get Element Length	X	-	-
Get Element Area	-	-	X
Locate Elements	X	X ₄	-
Calculation of shortest paths	-	-	X ₅
Progressive Drawing of the result of a queried route	-	-	X
Attribute-Data Integration			
Show linked data on mouse-over	X	-	-
Select Elements by Attribute-Data	-	-	X
Linked DTM, DTM Analysis			
Show Elevation Value on Mouse-Over	X	X ₂	-
Interactive Hillshading, allows to set light vector	X	-	-
Linked elevation Profile	X	-	-
Calculate Aspect	-	-	X
Calculate Slope	-	-	X
Personalization			
Personal spatial bookmarks	-	-	X ₃
Change symbolization/colors	-	-	X ₃
Include personal symbols	-	-	X ₃
Upload GPS waypoints	-	-	X ₃

₁Currently only fixed zoom-levels, free zoom planned

₂Currently has problems on Internet-Explorer/Windows in maximized window

₃Requires user profiles and a linked database

₄Currently only predefined objects - no flexible search mechanism

₅Might be implemented, more complex algorithms...

3 Target Platforms: OS, Browser and SVG-Viewer

The prototype had been partially developed on Linux and Windows systems with both Mozilla and Internet-Explorer as a Webbrowser. Unfortunately the Adobe-SVG-Viewer for Linux/Mozilla is still in beta-stage and does not generate useful ECMA-script error-messages. The main reasons for this drawback are unfrozen or insufficient plugin API's of the Mozilla browser. This circumstance forces us to use mainly the Windows-version and deploy on Linux, Mac, Solaris and Windows. The prototype works on all Browsers supported by the Adobe SVG-Viewer. All scripting, form-elements and DOM-Manipulations are using SVG and the viewer's internal Scripting-Engine only. The restriction to these core techniques will soon allow to deploy on other, SVG only viewer, such as the Batik-SVG-Viewer or X-Smiles. Both teams work also on enhanced scripting, interactivity and integration of other XML techniques, such as XForms and XSL.

4 Data-Sources and Workflow Aspects

The core data-sources used for the project come from the Swiss federal office of topography: VECTOR25 serves as the main vector-data source (rivers, land cover, administrative boundaries, etc), the situation (houses, road network, place-labels, cliff-drawing, etc.) uses the raster-based PK25 (pixel-maps) and the DHM25 contributes contour lines, spot-heights and a grid-based digital terrain model. The situation (black layer of the map) is still in raster format, because it either contains data not available in vector-format so far (such as the house polygons) or objects with more complex line-styles, such as the road network. All the labels (e.g. place-names) are still in raster format either. High quality label placement is still an unsolved topic. Future versions of the prototype, however, will replace more and more raster based objects with vector data.

The input data is delivered either in arcview shapefile or arcinfo coverage format. After conversion to the text-based ungenerate format and to dbase-files (for the attributes) a perl-script converts the data to the SVG-format. The output is converted using the Swiss-coordinate system, with the y-axis inverted by prefixing a minus sign. This approach allows to easily integrate different geo-referenced data-sources, because they all share the same coordinate systems without having to use additional transformations. The beginning of the path geometry uses absolute coordinates while the following vertices use relative ones. The conversion script also allows grouping of objects with the same attributes, such as an object class. Each object gets an internal unique identifier which links to the attribute-data, automatically converted to js-files, storing the data in arrays. Each unique group can be linked to a css-style, defining fill and stroke-attributes. All parameters needed for the conversion process are defined in a metafile containing the same prefix than the input geometry and attribute-data file.

After the conversion process the rest of the development process was mainly done using a simple text-editor such as nedit, vi and ultraedit. Hopefully, future svg development tools will help to develop mixed SVG and ECMA-script with coding support, validation and debugging features. The eSVG and Ormide Tool from Intesis is already very promising (JEZIC 2002) regarding support of ECMA-Script. A combination with powerful WYSIWYG tools (such as Adobe Illustrator, CorelDRAW or JascWEBDRAW) would result in a very powerful toolset, in case they are well integrated with each other. The figure below shows the architecture of the system regarding the linked files (css, js). We tried to separate data from functionality and reuse some code, such as the code to generate drop-down selection lists.

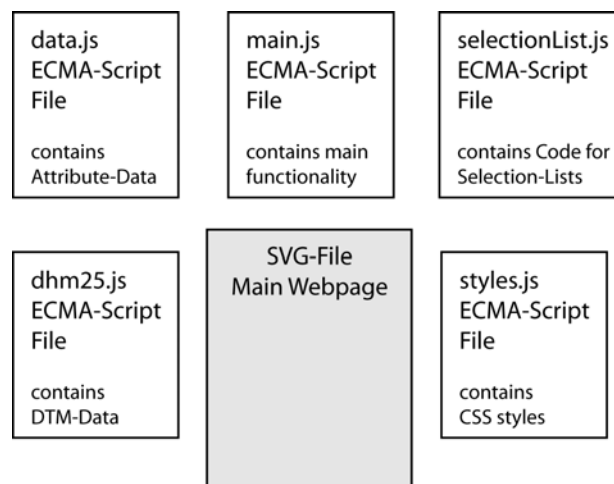


Fig. 2: Architecture of the interactive maps, linked files

5 GUI – Graphical User Interface

The whole webpage is filled by a "scalable" SVG with 100% width and height in the outer SVG element. This means that the whole user-interface is "scalable" to a certain extent. Of course the text-size would be too small if the user resizes to a very small window. The outer SVG's coordinate system uses screen coordinates with a 4:3 ratio. It contains two other SVG-elements that are defined with the Swiss-coordinate system (simplified in a cartesian system and the y-axis inverted): The main map and a small linked reference map for navigation purposes, where the user can zoom and pan. An additional section below the main map serves as an "info panel" to show additional data.

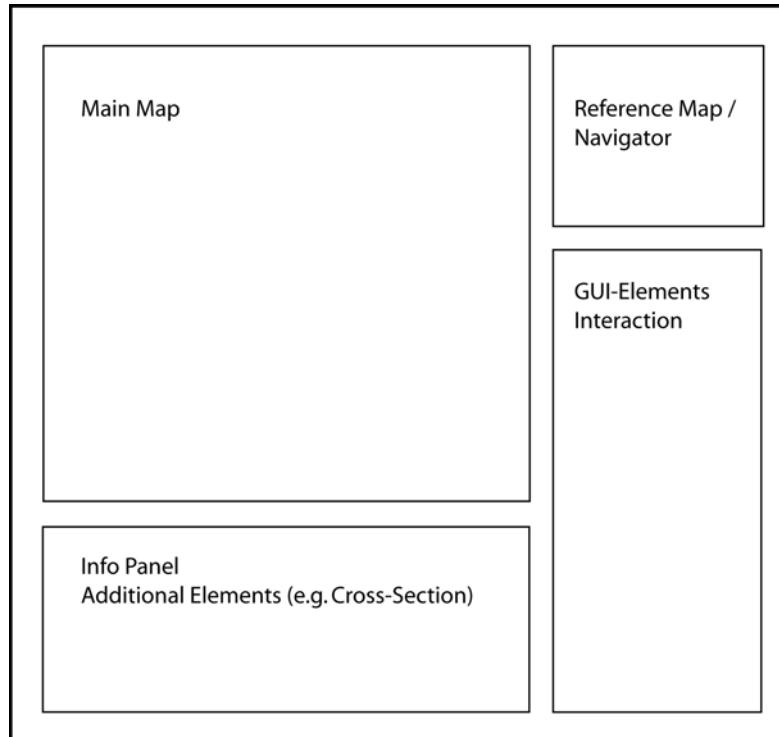


Fig. 3: Map Layout

```
<?xml version="1.0" standalone="no"?>
<!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 20010904//EN" "http://www.w3.org/TR/2001/REC-SVG-
20010904/DTD/svg10.dtd" [
  <!ENTITY colorText "fill:darkcyan;">
  <!ENTITY knob "fill:white;stroke:darkcyan;stroke-width:2;">
  <!-- some entity definitions -->
]>
<svg xml:space="preserve" width="100%" height="100%" onload="initMap();"
  onresize="resetFactors(evt);" zoomAndPan="disable" viewBox="0 0 1024 768"
  xmlns:a3="http://ns.adobe.com/AdobeSVGViewerExtensions/3.0/"
  a3:scriptImplementation="Adobe">
<script xlink:href="main.js" language="text/ecmascript" />
<script xlink:href="selectionList.js" language="text/ecmascript" />

  <!-- GUI elements code -->

  <!-- overview map, navigation -->
  <svg id="overviewMap" x="820" y="60" width="200" height="156"
    viewBox="679000 -238000 4000 4000">
    <desc>Overview-Map Tuerlersee</desc>
    <g style="fill:none;stroke:dodgerblue;stroke-width:3;">
      <use xlink:href="#RiversGroup" />
    </g>
```

```

<rect id="rectForPlace" style="&rectstyle;" x="679900" y="-236500"
  width="2568.8" height="2000" onmouseover="statusChange('click and
  drag rect to change extent') onmousedown="beginPan(evt)"
  onmousemove="doPan(evt)" onmouseup="endPan()" onmouseout="endPan()" />
</svg>

<!-- main map -->
<svg id="mainMap" x="0" y="0" width="700" height="545" viewBox="679900
-236500 2000 1557.1" onmousemove="showCoords(evt);">
  <g id="relief" visibility="hidden">
    <image xlink:href="dtma.png" x="679000" y="-238000" width="4000"
    height="4000" style="filter:url(#filterHillshade)" />
  </g>
  <g id="Landcover" style="fill-opacity:0.5;">
    <g id="Landcover_Z_BaumS" style="fill:lightseagreen;stroke:none;">
      <path id="Landcover0" onmouseover="showAttribData(evt,'Landcover',0)"
      onmouseout="showAttribData(evt,'Landcover',0)" d="M682792.9 -237324.1117.199
      .515.9 7.299z " />
      <path id="Landcover1" onmouseover="showAttribData(evt,'Landcover',1)"
      onmouseout="showAttribData(evt,'Landcover',1)" d="M682867 -2369661-42.5
      .65 26z " />
    </g>
  </g>
  <!-- additional geometry -->
</svg>
<!-- additional GUI elements -->
</svg>

```

Code-Snippet: Nested SVG Elements for GUI, main-map and reference-map

The GUI-Elements (checkboxes, selection-lists and knobs) are all implemented in native SVG with the help of events and ECMAScript. Although, at first glance this seems tedious, it ensures browser and platform-independency and guarantees a consistent "look and feel" in all operating systems. And, as a map-author, you get full control of every single aspect a GUI-component looks like. Of course it would be welcome if SVG-viewer offers support of the XForms language, to help developers save time. X-Smiles (XSMILES 2002), a Java-based XML-viewer for XHTML, SVG, SMIL, X3D and others already supports XForms and looks very promising. And other viewer, like Adobe SVG Viewer and Batik are likely to follow. SVG's strength will be fully exploitable if it is integrated with all other important XML-standards, quite similar to the way the X-Smiles team is working on. Another option to efficiently use GUI-Elements in SVG is "SVGUI" a project led by Kevin Lindsey (LINDSEY 2002). Kevin works on implementing a separate namespace for GUI-elements. The foreign-namespace is parsed, triggered by the onload-event, and replaced by the corresponding SVG elements and ECMAScript functionality.

6 Selected Features of the Prototype

The prototype allows to show attribute-data with mouse-over events, while exploring the map. To switch between different layers for the mouse-over events it is very useful to change the pointer-events-attribute of the non-active layers to "none". The user can locate an element by using a selection list. The map is automatically centered either around the objects bounding-box (you can get that with the element.getBBox()-method) or by an rectangular area defined around the feature.

The analytical hill shading is done using a <feDiffuseLighting/>-filter with a <feDistantLight/> as a child-element. The user can set azimuth and elevation of the lightsource by using the knobs in the GUI-section of the map. The dtm data was sliced in a GIS-system to 256 values and exported to a png-image. The height information is stored in the alpha-channel of the image.

```
<!-- hillshading filter -->
<filter id="filterHillshade" filterUnits="objectBoundingBox" x="0%" y="0%"
  width="100%" height="100%" filterRes="510">
  <feDiffuseLighting in="SourceAlpha" diffuseConstant="1"
    surfaceScale="200">
    <feDistantLight id="lightsource" azimuth="225" elevation="45" />
  </feDiffuseLighting>
</filter>
```

Code-Snippet: filter-definition for an analytical hill shading

```
<g id="relief" visibility="hidden">
  <image xlink:href="dtma.png" x="679000" y="-238000" width="4000"
    height="4000" style="filter:url(#filterHillshade)" />
</g>
```

Code-Snippet: filter assignment to the image containing the dtm-information

```
function setAzimuth(event) {
  if (event.type=="mousedown") {
    azimKnobStatus = 1;
    azimKnob = event.getTarget();
  }
  if (event.type=="mousemove") {
    if (azimKnobStatus == 1) {
      myXdifff = myKnobCenterX - (event.getClientX() - mapOffsetX) *
        scaleFactor;
      myYdifff = myKnobCenterY - (event.getClientY() - mapOffsetY) *
        scaleFactor;
      direction = (180 - (toPolarDir(myXdifff,myYdifff) / 3.14 * 180))*-1;
      azimKnob.setAttribute("transform","rotate("+direction+",myKnobCenterX,
        myKnobCenterY)");
      azimValue = direction;
      if ((direction < 0) && (direction > -90)) {
        azimValue = direction + 90;
      }
      if ((direction > -360) && (direction < -180)) {
        azimValue = 360 + direction + 90;
      }
      if ((direction < -90) && (direction > -180)) {
        azimValue = 270 + 180 + direction;
      }
    }
  }
  if (event.type=="mouseup") {
    azimKnobStatus = 0;
    myLightSource = svgdoc.getElementById("lightsource");
    myLightSource.setAttribute("azimuth",azimValue);
  }
}
```

Code-Snippet: ECMA-script function to turn the knob and change the azimuth-attribute of the filter-definition

The cross-section generation is a bit more complex and will be explained in detail in another article at the carto.net webpage (<http://www.carto.net>). First of all the user has to draw the cross-section line on the map (the line can have more segments). An algorithm densifies the line, reads the z-value along the line, using the coordinates from the densify algorithm and a bilinear interpolation function to get the correct z-values between the four surrounding grid-values, according to the location of the point within those four grid-corners. Another function draws small rectangular slices to generate the profile, adds gridlines and event-handler to show data distance and elevation data on mouse-over. If the user clicks on a slice a script shows the current position in the map along the digitized profile line.

7 Code Optimization

Good SVG code is not only compact and readable but also allows for efficient maintenance – e.g. to quickly change attributes and properties centrally. Following is a "catalogue of measures" that helps to ensure small file sizes and easy maintenance.

- **Use of relative coordinates** - when dealing with longer coordinate pairs where only a few digits around the comma change, it helps to use coordinates relative to the preceding coordinate pair (path-commands `m`, `l`, `c`, `s`, `q`, `t`, `a`, `h`, `v` instead of `M`, `L`, `C`, `S`, `Q`, `T`, `A`, `H`, `V`)
- **Use only nr of decimals really necessary** - many GIS-systems export a large number of decimal places. For most applications this "accuracy" is exaggerated and in many cases far beyond the precision the dataset can match when it had been acquired.
- **Use of Splines** - Spline or bezier curves not only reduce the size of a path, but also lets the path look more smooth (better graphical quality), splines are in particular useful for the river and traffic network (roads, railroads, etc.)
- **Use of Symbols** - SVG-symbols may be used to place icons and symbols for both maps and GUI-Elements. Symbols may contain any SVG-code and are rendered using the `use-element`
- **Re-Use of Geometry** - Re-Use of geometry is useful wherever you need to use the same geometry twice or several times - this can be useful to have reference maps in a different scale or to symbolize more complex lines by cloning and overlaying elements (e.g. with linestyles for roads where the same geometry is used up to three times) - see code and figures below
- **Generation of Objects on the fly** - sometimes it is useful to generate elements "on the fly", f.e. where symbols have to be created dynamically, or a diagram can be generated from original data, while still allowing different creation parameters. This adds flexibility to the interactive map/tool and saves filesizes, because the geometry is not transmitted, but created on demand.
- **Use of centrally defined style-sheets** - Centrally defined stylesheets can help to compact code and to make a project maintainable, it is more or less a "must" if a project gets larger
- **Use of Entities** - any text-block (e.g. part of a path-geometry, stylesheet-definition, duration of an animation, etc.) may be stored in an entity. An entity is simply centrally defined (e.g. in the header of the file) and may be reused later within any code - as part of an element content or attribute. The parser replaces all entity-instances with the actual content
- **Compress your files with gzip** - any files involved in an svg-project may be zipped, including `.js` and `.css` files



Fig. 4: Complex Line-Styles composed of three lines sharing the same geometry, but with different line-styles.
source: (WINTER, NEUMANN, 2001)

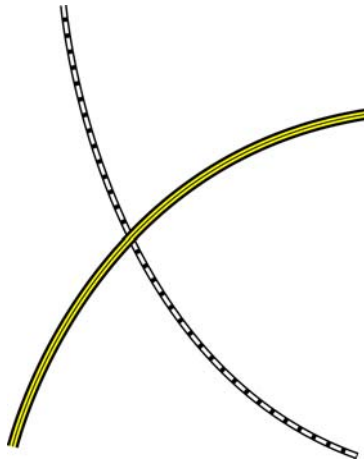


Fig. 5: Complex Line-Styles composed, Example SVG

```
<?xml version="1.0" encoding="utf-8"?>
<!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 1.0//EN" "http://www.w3.org/TR/2001/REC-SVG-
20010904/DTD/svg10.dtd" [
  <!ENTITY roadBelow "fill:none;stroke:black;stroke-width:10;">
  <!ENTITY roadAbove "fill:none;stroke:yellow;stroke-width:5;">
  <!ENTITY roadAboveSmall "fill:none;stroke:black;stroke-width:1;">
  <!ENTITY railroadBelow "fill:none;stroke:black;stroke-width:6;">
  <!ENTITY railroadAbove "fill:none;stroke:white;stroke-width:3;stroke-
dasharray:10,4;">
]>
<svg width="310" height="390">
  <g id="railroads" style="&railroadBelow;">
    <path id="railroad1"
      d="M44.32,0.047c0,0,26.77,305.973,253.425,387.671"/>
    <use xlink:href="#railroad1" style="&railroadAbove;" />
  </g>
  <g id="roads" style="&roadBelow;">
    <path id="road1" d="M0.485,379.5c0,0,60.274-249.315,308.219-286.302"/>
    <use xlink:href="#road1" style="&roadAbove;" />
    <use xlink:href="#road1" style="&roadAboveSmall;" />
  </g>
</svg>
```

Code-Example: Reuse of existing geometry to compose complex linestyles; Code for the above svg-graphics.

8 The Swisstopo Map-Browser project

While interactive maps are advancing and getting quite popular, there is still a high demand for printed paper maps. Paper maps are superior in several aspects: they are mobile, can be large format, don't need batteries, feature a high resolution display and are usually more dense in content than their counterparts on screens. Printed maps are still very much used for planning purposes and orientation within the terrain, especially for mountaineers. It is also a matter of fact that online map-stores (with additional metadata, search-engines and a preview of the map) are more and more frequently used during the decision process when buying a paper map. A good map-browser can assist the user in choosing the best map needed. The Swiss Federal Office of Topography is famous for its high-quality paper-maps, esp. for their way of terrain and cliff representation, and offers map series in different scales, with the scale 25.000 as a base scale.

The project presents an innovative way of browsing map-informations, by using the 25.000 map series of the Swiss Federal Office of Topography. The map browser shows the following important metadata, useful for choosing and buying a map-sheet:

- Map sheet number and name
- Coordinates of the map-extent
- Up-to-dateness of the map, release date
- Estimated next publication date
- Administrative units, covered or intersected by the map-area, and vice versa
- A small-scale preview of the map-content (scanned raster-image) on mouse-click

The browser also features toggling map-layers, a linked reference map for zooming and panning and the display of map-feature-attributes, such as object names (currently "Kantone" and hydrology). Currently the browser only contains information on the 25.000 scale map series, other scales, however, could quite easily be integrated, if needed.

The input data was exported using the same conversion-script mentioned above, at the Tuerlersee-Project. The map-sheet layer and the administrative boundaries (in our case the cantons) had been overlayed in a GIS-system in order to get the information which administrative units are covered by a map-sheet and vice versa. ECMAScripts handle the way the metadata is displayed in the interactive legend.

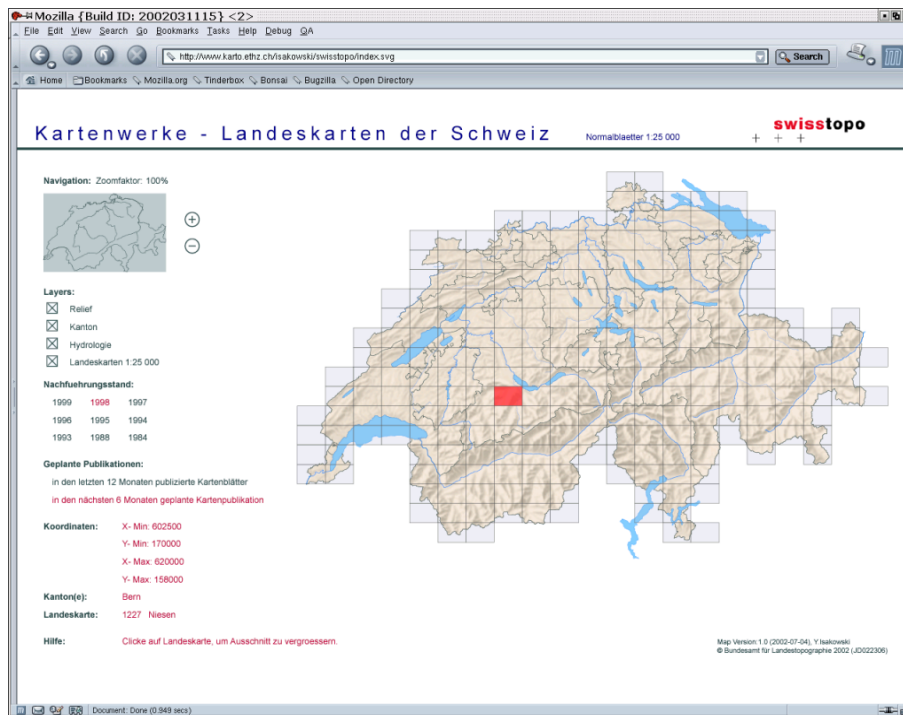


Fig. 6: Screenshot of the prototype "Swisstopo mapbrowser" - Link to the project site:
<http://www.karto.net/papers/svg/mapbrowser/> © Bundesamt für Landestopographie (JD022306)

Other useful features could be added to the existing prototype: It would definitely be interesting to allow the user query maps by placenames or combine searches with other metadata. Currently only the administrative level of "Kantone" is overlayed with the map-sheet boundaries. It would be useful to add districts and communities.

Additional topographic features (such as mountain peaks, cities and traffic-network), maybe also combined with levels of details, would make the base map more attractive. Finally the browser could be integrated with a map-store and would allow the user to graphically select map-products.

9 Conclusions

The above two prototypes have shown the huge potential, SVG offers for interactive maps. By using open standards and open-source or free software, also smaller companies and universities can afford to serve interactive maps, because there are almost no software licensing fees involved. However, the projects are still in an early stage and are only "scratching the surface" in terms of what really could be done. Some of the planned features are already listed above. So far, we can only serve limited map-extents. One of the next steps would be to generate the map-content out of larger spatial databases, such as the PostGIS (POSTGIS, 2002) extension to the Postgres Database. Finally there are still open question in terms of protecting map-content, ensuring copyright and data licensing fees.

Authoring complex SVG projects without powerful authoring tools, that also support coding and debugging, can be a pain. While XML-editors can help coding and tracking errors in SVG-files, the support of ECMAScript debugging is still in an early stage and only covered so far by the eSVG tools. The urgent need for SVG development tools opens new opportunities for software vendors in the graphics and development tools industry. While the SVG-Viewers are rapidly maturing, there is still no viewer available that implements the whole SVG 1.0 standard. We hope that the market-penetration and acceptance of the SVG standard will evolve rapidly for being able to serve even better and more interactive maps to the map-user. If authoring and viewer tools as well as SVG-content mature, SVG can have a bright future in interactive graphics and in particular for interactive maps.

10 References

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EDINA Digimap: A virtual Map Library for the UK Tertiary Education Community

David MEDYCKYJ-SCOTT and Tim URWIN, Chris HIGGINS, Barbara MORRIS,
Emma SUTTON, Peter BURNHILL

Abstract, corresponding to an Online Demonstration

One EDINA Digimap is an Internet service, which provides a subscription-based virtual map library of digital map data for staff and students in UK Higher Education Institutions (HEIs). Registered individuals can browse a map database comprising Ordnance Survey (OS) digital map data to produce high quality cartographic output and to download data files to import into application software.

End-user requirements and consideration of the environment in which any service would be used were foremost during the design stage. A variety of web-based clients, including a sophisticated Java applet, are provided for both novice and more expert users.

Until the launch of the Ordnance Survey MasterMap service last November, the Digimap database, with 300,000,000 objects, was the largest on-line cartographic database in the UK. The architecture enables other digital map products to be added to Digimap.

Digimap users want higher quality maps than those produced by many Internet services. This has serious performance implications as complex cartography requires intensive computer processing.

Considerable effort has been spent ensuring that the maps appear as close as possible to OS paper equivalents while not degrading performance of the service. This has been achieved, in part, by the use of Laser-Scan software as the underlying GIS.

Digimap was launched as a national service in January 2000, following a 3-year trial with six universities. Now, with over 10,000 users from 64 UK HEIs, Digimap is firmly embedded as a research and teaching tool within UK higher education, broadening the use of maps and leading to research being undertaken that would not previously have been possible.

The online demonstration will show the variety of clients, the functionality and how, through the use of the OGC web map server interface specification, maps can be served up as backdrop images in other JISC services and for on-line learning materials.

Hearing Spatial Information - Audiovisual Maps on the Internet

Holger SCHARLACH and Jean-Claude MÜLLER

1 Introduction

Sound is used to communicate information since ancient times. E.g. the shouts of night watchmen told people to stay in their houses and lock the doors. In the same way church bells defined the area of a village: everyone hearing the striking bells was informed about the actual time or a disastrous event as a conflagration. Some of these sounds still exist but many have disappeared during the last century. Following SCHAFER (1973) “in the West the ear has given way to the eye as the most important gatherer of environmental information.”

Until the end of the 19th century all sounds had one thing in common: they could only occur at a certain time in a certain place. This changed with the invention of electroacoustical equipment for the transmission and storage of sound in the 19th/20th century (SCHAFER, 1988). These technical devices give us the ability to dislocate sound in time as well as in space. Today digital sound processing even allows us to alter recorded sounds and make new sounds with standard PC equipment. In addition to that the internet gives us the possibility to disseminate digital sounds worldwide.

The term *multimedia* is used to describe the actual efforts to integrate different media in a PC environment. Therefore the first chapter deals with the broad concept of multimedia and more specific approaches to the combined use of sound and graphical user interfaces. Afterwards some practical and theoretical approaches to sound maps are explained. Disseminating sound maps over the internet imposes certain restrictions on the map design. To give an insight into this topic, sound compression, straming media and possibilities to combine sound and maps are discussed in the following chapter. Afterwards an example of a sound map is presented and finally some conclusions are drawn.

2 Sound and Multimedia

2.1 Properties of Sound

Although one generally accepted definition of Multimedia does not exist, certain terms appear frequently in this context: computer-based, media-integration and interaction (CARTWRIGHT and PETERSON 1999; RIEDL 2000). In addition some authors differentiate between time-dependent and time-independent media (STEINMETZ 1999) and conclude that the integration of time-dependent media is a fundamental requirement for multimedia systems. The different media used in combination with maps include video, animation, pictures, text and sound. Compared with static media like a graphic, sound has different properties that impose certain restrictions on its use in the context of multimedia (Fig. 1).

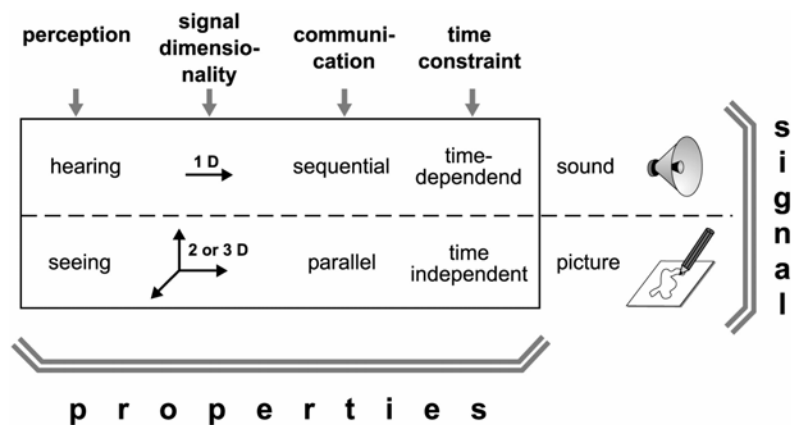


Fig. 1: Property differences between hearing and seeing (MÜLLER and SCHARLACH 2001)

Most important, sound is time-dependent and therefore cannot be perceived in an instant. With our ears we gather one piece of information per unit of time and will not get the entire information before the sound has reached its end. It is not possible to simply speed up this process by forwarding because in this case crucial information may be missed. In contrast to that we can gather information from a two dimensional graphic display in a moment by directing our eyes to the important locations. The choice of the locations depends on our experience and the graphic structure itself.

2.2 Sound and Interface Design

The idea of combining sound and graphics is not quite new. It dates back to the mid-1980s when research in the field of computer interface design concentrated on using realistic and abstract sounds to inform the user about certain events. The two main ideas can be expressed by two terms: *Earcons* and *Auditory Icons*.

Earcons are defined as “nonverbal audio messages used in the user-computer interface to provide information to the user about some computer object, operation, or interaction” (BLATTNER et al. 1989, p. 13). They can also be described as abstract synthetic tones that can be used in structured combinations to create sound messages (BREWSTER et al. 1994). On the other hand *auditory icons* are informative sounds that we rely on in everyday live to gain information about the world (GAVER 1986). They can be described as realistic sounds that can be related to visual symbols, as e.g. a (visible) STOP-sign and an (audible) siren for an approaching ambulance.

2.3 Categorization of Sounds

A categorization of sounds used within a multimedia system can be based on the following three groups: spoken text, music, abstract and realistic sounds. A *spoken explanation* of a graphic/map or an ongoing animation can help the user to understand the patterns or processes shown. *Music* can attract the user’s attention but is highly emotive and therefore should be used with care.

Abstract and *realistic sounds* can be further subdivided into categories depending on the perceived realism of the sound (Fig. 2). E.g. a sound recorded at a certain place and a certain time gives an impression of the soundscape of that place, hence it can be described as being realistic. Compared to that, abstract sounds cannot be related to realistic objects. They are value-free and therefore can be used without the danger of misinterpretations. Sounds of single objects stand between these extremes. E.g. the sound of a singing bird can stand for the whole bird race.

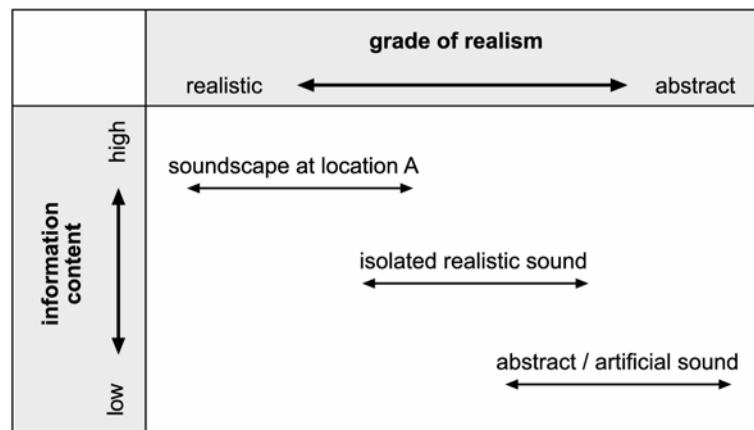


Fig. 2: Classification of realistic/abstract sounds based on their perceived realism

2.4 Functions of Media

Instead of differentiating between the types of sounds it is quite common in multimedia psychology (HASEBROOK 1995) to ask questions about why a certain medium is used for specific purposes? E.g. background music is often used to make a multimedia presentation more attractive but does this really lead to better communication of the information presented? Does it help the user in understanding the content or is it simply a gadget?

From a didactic point of view media can have different functions (DRANSCH 1999): The *function of demonstration* helps the user in getting the right picture of a phenomenon. The *function of setting in context* helps the user to place the information into a bigger context. If media have a *function of construction* they support the user in building complex mental models. Only motivated users will explore the whole system and spend much time on it. Therefore the *motivation function* of media should not be neglected.

3 Sound Maps: Theoretical and Practical Approaches

The first ideas to combine sound and maps date back to the early 1990s when computer technology for the first time allowed the widespread development of multimedia systems (MULLER 1991). But although several authors suggested the use of sound and maps, cartographic applications remained sparse during the following decade. In 1999 BUZIEK still points to the fact that “investigations for the use of sound in multimedia maps are still at the beginning”.

In other sciences sound was applied earlier, e.g. to differentiate between bomb explosions and earthquakes (SPEETH 1961). Adding sound to graphical displays proved especially useful in scientific visualization. MINGHAM and FORREST (1995) give a good overview of the research area and present SSound as an example of a sonification system for surface data. BLATTNER et al. (1994, p. 458/459) combined auditory display techniques with maps to test theoretical ideas on the sonic enhancement of two-dimensional displays. In their opinion maps are optimal because presenting too much information visually can result in a (visual) information overload. In such cases using a sonic representation can help to keep the graphical display as simple as possible.

FISHER (1994) made one of the first attempts to combine a map with sound. He used a classification map of a remotely sensed image and added audible information about the reliability of the classification. As the user moves the mouse pointer over the map certain parameters of the tone (e.g. pitch, frequency) change according to the reliability.

SHIFFER (1993) uses sound in a collaborative planning system to convey information about actual and predicted traffic flows. KRYGIER (1994) developed several examples to combine sound and maps, e.g. abstract sounds in

combination with a choropleth map. A digital sound database was developed by SERVIGNE et al. (1999) to support noise maps by using a click and play back interface.

SCHARLACH (2002) used sound to enhance the understanding of urban noise. As the user moves the mouse pointer over an aerial photograph three sounds are played simultaneously. Depending on the position of the mouse pointer the loudness of all three sounds is changed so that the user gets an impression of the soundscape at each spatial location. E.g., near a railway track the railroad sound is dominating and therefore masking the other sounds.

Considering the small number of sound map examples so far, one has to keep in mind that the map has been optimized for the reproduction on paper since centuries. Hence, it is difficult to integrate information from a new medium without changing the structure/appearance of traditional map itself. The “paper thinking” (PETERSON 1995) still prevails and impairs the development of multimedia maps. The integration of different media alone does not result in a better or more understandable map until the structure of the underlying data in connection to the media used for representation is fully understood.

KRYGIER (1994) contributed remarkably to the theoretical foundations of sound cartography by using Bertins ideas of graphic variables to develop so-called sound variables. In the way that we change the appearance of symbols (e.g. colour, size, filling) we can accordingly change the characteristics of sound (e.g. frequency, pitch, duration). When applied to abstract sounds a high loudness can represent high data values whereas a low loudness can represent small data values.

Although the combination of sound and maps seems to be useful for certain tasks one has to keep in mind that empirical research is still sparse. LODHA et al. (1999) combined a crime map of Los Angeles with music from Sting and The Police. Value differences are indicated by abstract sound variables as loudness or pitch. These maps were presented to 15 subjects who had to perform several map reading tasks with an audio only map, a visual only map and an audiovisual map. The results show that subjects performed better with the audiovisual map. Besides the test subjects felt motivated by the music but this is not a real surprise because they were mostly students. Perhaps older people would have preferred classical music. However, this investigation is a first step and shows that further research in this area is necessary to prove the effectiveness of sound maps.

4 Sound Maps on the Internet

In the last decade the internet became an important medium for distributing information. This development affects the discipline of cartography in a way that could not been foreseen twenty years ago. According to PETERSON (2001) millions of maps are distributed daily over the internet and the numbers are still growing. Whereas the distribution of traditional maps could be restricted to a certain user group, at least in a certain geographic area, maps on the internet can be accessed by everyone connected to the web worldwide. Although internet cartography can be seen as a chance for the whole discipline of cartography one also has to be aware of the limitations and restrictions.

Having net access does not imply automatically to have a high download rate as well. In general, transfer rates became much higher in recent years but many users are still connected by a 33.6 or 56 kb modem. Hence the size of data files is still crucial. Furthermore the screen resolution and size of the monitor as a display medium imposes restrictions on the map design (BRUNNER 2001). Giving an overview of a large area is only possible with a substantial loss in detail. A visual overload can be prevented by presenting detailed information just on request (e.g. clickable areas). Besides these more technical problems ethical questions play a more and more important role: Who has the possibility to access information on the net and who is excluded from the net society (PETERSON 2001)?

4.1 Data Compression

Graphics, sound and animations, the basic elements of multimedia, tend to be storage space intensive. To overcome the problem of low transfer rates many compression algorithms and appropriate data formats were developed. Especially popular and widely disseminated are the gif, jpeg and png formats for raster graphics.

The compression type has to be selected carefully for each application due to the fact that each compression algorithm works in a different way and therefore has certain advantages and disadvantages. E.g. the gif-format provides the best compression results for graphics with big uniformly colored areas, whereas the jpg-format should

be used for pictures with subtle color nuances. But it is difficult to set up general rules for the use of compression techniques: ultimately a decision has to be made for each isolated case (GREBE, SCHARLACH and MÜLLER 2001).

This is also the case for sound files. The size of a sound file depends on four factors: *sampling rate*, *channels*, *bytes (quantization)* and *length* and can be obtained by the following formula:

size (in bytes) = sampling rate x channels x bytes x length in sec.

Consequently a sound in CD quality (15 sec.) can easily become bigger than 10 MB. It is obvious that uncompressed sounds are not suitable for distribution over the internet.

For this reason the Fraunhofer Institute started in 1987 to work on a sound compression algorithm in the framework of the EUREKA (EU) project "Digital Audio Broadcasting" (www.iis.fhg.de/amm/). With the latest internationally standardized version ISO-MPEG Audio Layer-3, CD sounds can be compressed by a factor of 12. For sounds with a lower quality even higher compression rates can be achieved (Tab. 1). The compression uses several filters and is based on a perceptual model. Although information is changed and deleted it is nearly impossible to distinguish the compressed sound from the original one. MP3 became a worldwide standard for sound compression.

Sound quality	bandwidth	mode	bitrate	reduction ratio
Telephone sound	2.5 kHz	Mono	8 kbps *	96:1
Better than AM radio	7.5 kHz	Mono	32 kbps	24:1
Similar to FM radio	11 kHz	Stereo	56..64 kbps	26...24:1
Near CD	15 kHz	Stereo	96 kbps	16:1
CD	> 15 kHz	stereo	112..128 kbps	14..12:1
*) Fraunhofer uses a non-ISO extension of MPEG Layer-3 for enhanced performance ("MPEG 2.5")				

Tab. 1: MPEG Layer-3 reduction ratios for different sound qualities. (www.iis.fhg.de/amm/techinf/layer3/)

The Shockwave-Audio format, used for sound compression in Macromedia Director, achieves comparable results. Except small differences both file formats can be regarded as being identical (LESKE et al. 2000). Sounds in Macromedia Flash can be either compressed in the MP3 format or by using the ADPCM- (Adaptive Differential Pulse Code Modulation) compression which is especially optimized for short low quality sounds, as e.g. button clicks. The same as for the compression of graphics can also be said for the compression of sounds: choosing the optimal compression requires substantial experience and time to experiment with different settings.

4.2 Streaming Media

Imagine a long sound file, e.g. a musical piece. If the whole sound has to be loaded over the internet and the connection is slow it may take some time until the download is completed and the sound can start to play. Hence, users may be annoyed sitting in front of the computer and nothing happens. After waiting some time they will probably go to another page before the download is completed. Of course this is not desired.

Working with streaming media reduces the blank-screen-time significantly, because media are transmitted in a continuous fashion, using data packets. The sound can already start to play when the first package has been successfully downloaded. However, if the connection is slow the sound may stop somewhere in the middle because the following data package still has not finished downloading.

Even more complicated is the synchronization between sound and animations. In the example of Macromedia Flash, sounds are either the slave of the animation or they control the animation. Unfortunately it is not possible to

foresee how the animation will look like if distributed over the internet, because there are countless different computer systems with countless properties.

4.3 Linking Sound and Map

As stated above, the limited screen size is an obstacle for presenting detailed or a wide variety of information within one map. How can maps and sound be integrated to solve this problem?

The senses of hearing and seeing are strongly interconnected. Every time we hear a sound we try to relate it to a visual object in our environment. Therefore it is difficult to represent spatial information just by using sound. Visual information is necessary to link a sound to a certain location in two-dimensional space. Depending on the specific properties of sound as a medium (see above) it can be connected to a visual map in different ways:

Connecting sound to the whole map

A spoken interpretation can help in understanding the patterns shown in a map. Spoken explanations are also used in connection with animations and have the advantage that the map user can concentrate on the process shown without being visually disturbed by visual texts. Music can contribute in the same way by synchronizing dramatic passages with substantial changes in an animation.

Connecting sound to discrete objects

These so called “click and play back” applications are quite common today. Even less Multimedia-oriented GIS offer this functionality to allow the integration of sounds. When the user clicks e.g. on a church symbol a sound of striking bells is played back.

Connecting sound to continuous objects

By using sound in this way a whole “sound layer” is integrated. Hence, the user gets an audible response at each location on the map. The sound can be either played continuously (rollover) or on user request (mouse up, mouse down).

Moreover the sound layer can be either connected thematically to a visual layer or used to present additional information that is not visible in the map. The following examples illustrate this point:

A map showing the mean annual rainfall in Europe is shown visually. As the user moves the mouse pointer over the map a realistic sound of rainfall is played and the loudness changed according to the position of the mouse pointer over the map. In this example the same information is simultaneously presented visually and audibly.

As the visual map of mean annual rainfall is replaced by a visual map showing the topography, the user gets information about two interconnected features: topography (visual) and rainfall (audible). Thus the user can make hypotheses (e.g. connection of height and rainfall) and test them by moving the mouse pointer to certain locations on the map. The term “map exploration” fits perfectly in this context. The concepts are presented in Fig. 3.

	layers	perception	thematic information
continuous / discrete geographic phenomena		visual	thematic information about one geographic phenomenon
		audible	
		visual	thematic layer 1
		audible	thematic layer 2

Fig. 3: Layer concept for the combination of sound and maps

5 Production of Sound Maps

5.1 Sound and Vector Maps

Sound can be added to presentations on the internet in several ways. Basically HTML and JavaScript provide sufficient possibilities to disseminate sounds over the internet and produce “click and play back”-applications. Still under development are specifications by the W3C Consortium (www.w3c.org) that allow a more sophisticated use of sound in audiovisual presentations. Currently two developments are noticeable:

- Synchronized Multimedia Integration Language (SMIL): An HTML-like language allowing to write multimedia presentations in a simple text format. The second revision SMIL 2.0 became a W3C recommendation in August 2001. Authoring tools are already available
- Scalable Vector Graphics (SVG): An XML-based language to publish vector data on the web. SVG 1.0 became a W3C recommendation in September 2001

Besides these open source approaches Macromedia was quite successful in marketing the vector-based authoring tool Flash. Based on the products FutureSplash Animator and FutureSplash player the first version of Flash was published in the beginning of 1997. The latest version Flash MX is available since the beginning of this year. Macromedia Flash is mostly used to produce short animated web page intros and other gimmicks that sometimes rather frustrate users looking for substantial information. But of course one has to keep in mind that a tool in itself does not define the application.

Using Macromedia Flash to publish vector (sound) maps on the internet has several advantages:

- the file size is quite compact
- the scripting language ActionScript (based on ECMA-262 like JavaScript, aside from small differences) provides powerful possibilities to produce complex unique applications
- sound can be directly embedded and compressed in the mp3 format

The necessity of a Plug-In to view swf files may be regarded as a disadvantage but this PlugIn is available on at least 90% of all computers connected to the internet. Furthermore and even more important the swf file format is not

an open standard. Hence, developers are dependent on the information made available by Macromedia. Compared to the svg format another disadvantage of Macromedia Flash is the missing possibility to separate device and viewport coordinate-systems (NEUMANN 2002).

However, we used Flash for the following example because of previous experience in the programming language ActionScript. Besides the sound map tries to illustrate ideas of a more theoretical nature and Flash is just one (of several) possibilities to produce these maps.

5.2 Sound in Flash

There are two steps to extend a Flash presentation by sound. First of all a sound can be imported and integrated in the timeline of a movie¹. Thus the sound is played back a) at a certain time during a presentation (synchronization is possible) or b) in connection with a certain event, e.g. a button click.

However, more sophisticated sound controls can be included by using ActionScript. Objects of the sound class can be controlled programmatically throughout the movie. For each individual sound object the *pan* and the *loudness* can be adjusted. Furthermore the *transform* method gives control over how the channels of a sound are output to the left and right speakers (MOOCK 2001).

By assigning sound objects to the timelines of different movie clips² the properties of each sound can be controlled separately. Hence, e.g. three sounds can be played simultaneously and the loudness of each one controlled by a slider.

5.3 Example: Continuous Sound Map

A classified isarithmic map showing noise stemming from industrial estates was used for this example (source: Landesumweltamt NRW 1999; www.lua.nrw.de). The contours were digitized in the DTP software Macromedia Freehand and afterwards imported into Flash. A separate movie clip was generated for all areas falling into one class. Afterwards a sound resembling industrial noise was imported. When the movie starts to play a sound object is generated and the industrial sound is attached to this object. Afterwards the sound is started and the loudness is set to zero.

As the user moves the mouse pointer over the map the mouse pointer position is continuously requested and stored in a variable. The *MovieClip.hitTest* method is used to recognize if the mouse pointer is within the area of a certain movie clip. When this is the case the name of the movie clip is determined and the corresponding loudness value is retrieved from a beforehand defined list. Finally the loudness of the sound is changed with the *Sound.setVolume* method and the loop is repeated.

In this way the loudness of the sound changes continuously according to the position of the mouse pointer over the map. It is important to mention that it is not necessary to place the movie clips on the uppermost level. Hence, a visual map showing noise conflict areas can be combined with the audible industrial noise map. It is also possible to zoom into the map and keep the sound script working. The example can be found on the internet: www.ruhr-uni-bochum.de/kartographie/sound/sound.html.

As the volume of sounds can be controlled separately it is also possible to integrate noise maps of different sources, e.g. railway noise, traffic noise etc. and combine all the sounds to give the user an impression of the soundscape of a certain area.

6 Conclusions

Maps can be combined with audible information in several ways and for several purposes. It is nowadays possible to disseminate sound maps over the internet, although several obstacles as data compression and streaming media have to be taken into account. Further research is necessary especially regarding the still incomplete theoretical and

empirical foundations. However, combining sound and maps on the internet should be envisaged for the following reasons:

- From a technical point of view using the audible information channel can help in reducing the complexity of the map graphics. In this case the sense organs eye and ear complement one another in receiving the information presented.
- Audiovisual maps can help map users with impaired vision. Because of the limited display size text labels are often not easily discernible. In this case a spoken text can improve the communication of information.
- Colours are prone to misinterpretations as they are used in different cultural contexts (KEATES 1996, S. 231). However, maps published on the internet can be accessed worldwide. It is questionable if a “western” colour scheme is always the best solution. MACEACHREN (1995, S. 160) points to the problems “in trying to select colors for maps used in cross-cultural contexts or default colors in mapping systems for a multinational market.” Perhaps using sound can help to overcome this problem. Presumably, the concepts of loud and quiet exist across cultures. However, empirical research on sound maps is still in an infant stage. More detailed research in this area is definitely necessary to prove the effectiveness of sound maps.
- Sound is time dependent and therefore audible information cannot be grasped in an instant. This may be regarded as a disadvantage but can also be seen the other way round because map users are “forced” to explore the map. Simply looking at a continuous sound map is not sufficient. The mouse pointer must be moved over the map to get in all the information. Thus the map must be “explored” so that previously hidden information becomes subsequently visible.
- And, last but not least, the basic technical prerequisites for sound maps, sound device and speakers, belong nowadays to the standard equipment of every PC.

Footnotes

¹ in Macromedia’s terminology the whole Flash presentation is named a *movie*. The appearance of the elements on the *stage*, the working area, is controlled by the *timeline*. The timeline is subdivided into *frames* (columns) and *layers* (rows).

² in Flash objects can be converted into *symbols*. Symbols have their own properties and can be *graphics*, *buttons* or *movie clips*. Symbols are stored in the *library* and used on stage as *instances*. Certain properties of instances can be changed without changing the original symbol thus allowing to use one symbol several times in a movie.

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Developing Web Applications at the Geological Survey of Norway and Results from the National "Geo-Data on the Net" Project

Sverre IVERSEN

1 Introduction

The Geological Survey of Norway (NGU) has built several Web Map Applications in different geological areas since 2000. The solutions are mainly based on the Internet Map Server from ESRI (ArcIMS). The Survey participated in a project named "Geo-Data on the Net" within a Norwegian Broadband communication program. The work from this project has resulted in solutions based on the Web Map Server specification (WMS) and a National Web Portal for Geo-Data. This article will focus on how to build applications with a view to maintenance and solutions from the Norwegian Geo-Data on the Net Project.

2 General Application Development

In ArcIMS a Map Service is predefined on the server in an editable ARCXML file (AXL). Legend Names, references to data and symbolism are described in this file. ArcIMS offers several clients as templates or functionality that generates application code (ArcIMS Designer). The generated code for thin client applications is editable, but generated code for thick client applications (Java) is not (without paying a lot of money). The Survey has initially focused on HTML and ASP clients to satisfy the "thin client" applications. We also believe that thin client applications have more widespread use. Since the generated code from ArcIMS for thin client applications is editable, it is indeed an important reason for using it.

The base Software contains several JavaScript libraries with standard functions. We have added several JavaScript libraries that contain new or altered functionality:

- General functionality
- Menu functionality
- URL argument functionality
- WMS functionality
- Language functionality
- Application specific functionality

A PERL program, developed at the Survey, changes the source code for the ArcIMS generated application. The PERL program reads a parameter file with all the "search-and-replace" statements:

- English text in the code for display will be replaced by variables, which contains values loaded from Language Resource Files (JavaScript).
- The overall design is changed with the replacement of code and the use of customised Cascading Style Sheets (CSS), which enforce different fonts and colours.
- Code is changed to call customised functions instead of ESRI functions where that is needed.

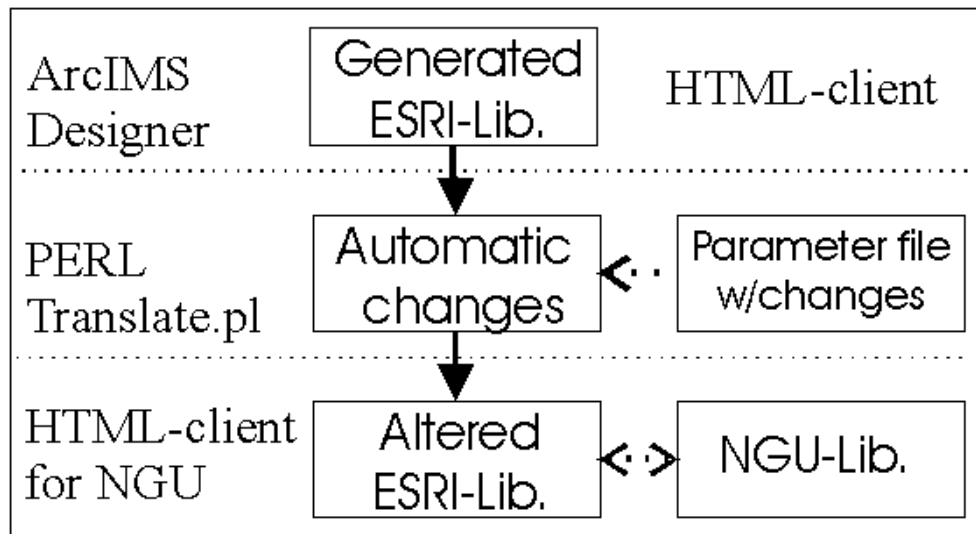


Fig. 1: Automatic change of the generated source code from ArcIMS Designer.

Why are we doing this? The reason is to help Geologists build applications with a minimum of technical assistance and to enforce a strict profile on building identical designs. When all applications are using the same libraries, the maintenance is reduced to a minimum.

In the future we will look at how we can do our applications even lighter with more help of server based programming (ASP/JSP), since the code that is transferred to the client requires too much processing at start up time on slow connections.

3 WMS and Web Application Developing

WMS is a very simple communication standard to receive map images and attribute information from a map server. Requests are carried out through URL addresses with arguments and values. The communication standard offers 3 types of requests:

- GetCapabilities: Request to see what the map service can offer.
- GetMap: Request that gives us a map image with one to many themes.
- GetFeatureInfo: Request to see attributes for one or several themes at a given coordinate.

The map images can be transparent and several map requests (GetMap) can constitute a composed map with several image layers.

The Survey has developed JavaScript libraries for general development of WMS clients. The JavaScript libraries make it easy to define:

- Map Services and themes
- Composed maps and legends
- Language

Contains functionality for:

- Map layers and themes
- Print out layout
- Status reports and Meta Data
- Attribute information

To enable full control over the presentation for attribute information, an extra WMS Servlet filter was developed. This filter enables formatting with the aid of XSL.

- Requires Servlet API 2.3+
- Requires Tomcat 4.x or ServletExec 4.1
- WMS-filter: Servlet Filter
- Formatting: XML/XSL
- Logging
- GetFeatureInfo result:
 - Adjustable table design
 - URL redirects.

Another reason to develop a WMS-filter was that the standard WMS Servlet in ArcIMS does not handle Norwegian characters well. This filter solves this problem. Results from WMS application development will be shown in section 4.2.

4 The Geo-Data on the Net Project

Participants of this project were mainly large public agencies in Norway with the Mapping Authority of Norway as the project manager. Our main goal was to:

- model and establish databases.
- establish an infrastructure to enable distributed access to data.
- build a national portal for geographic information.
- make the data easy available to the public through applications.

4.1 National Web Portal developed at the Mapping Authority

The national portal prototype contains both data and information for both the public and the private sector. The address to this portal is <http://www.geonorge.no> and it has unfortunately no English version yet. Maintenance costs for the Web portal should be covered by advertisement. The examples in this section are developed at the Mapping Authority of Norway.



Fig. 2: Home Page for the Norwegian portal for Geo-Data

The Portal has functionality to get information for WMS Services (see figure 3). This is only a prototype and has limited amount of data. With help of a registration service (see figure 4) a generic client (see figure 5) can be used to show all available map data of the registered servers.

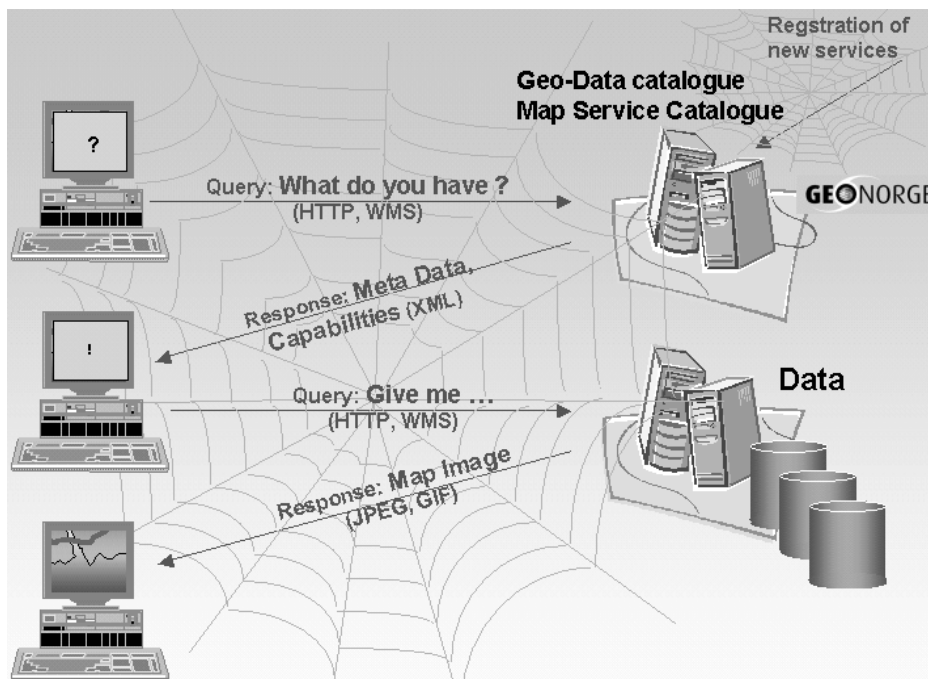


Fig. 3: Web Portal functionality: Information for available Map Services (WMS)

Registrering av WMS Server

Navnet på tjeneste	NGU: Gravel/aggregate - value	ServiceName URL
Navn på wms service (servicename)	grus_pukk_verdi_e	
Uri til wms service	http://www.ngu.no:80/servlet/com.esri.wms.Esrimap	
Beskrivelse	Evaluation of gravel and har rock aggregate.	
Restriksjoner	None	
Betaling		
Teknisk kontaktperson		
Navn på teknisk kontakt	Sverre Iversen	Detaljer...
Organisasjon	Geological Survey of Norway	
Epost adresse til teknisk kontakt	sverre.iversen@ngu.no	
Data kontaktperson		
Navn på data kontakt	Sverre Iversen	Detaljer...
Organisasjon	Geological Survey of Norway	
Epost adresse til data kontakt	sverre.iversen@ngu.no	
Lagre Slett		

Fig. 4: Web Portal functionality: WMS Service registration

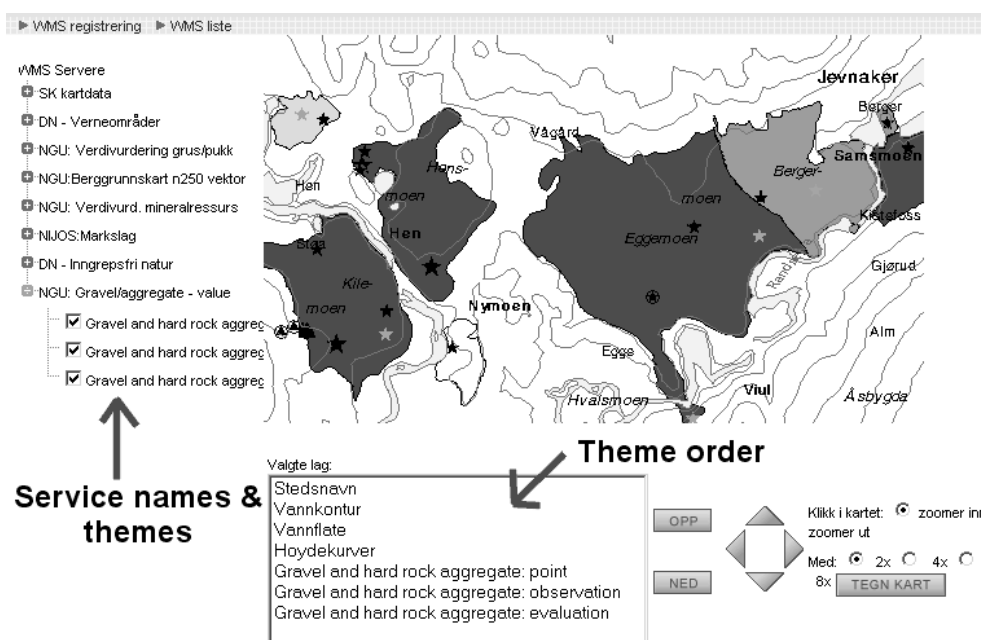


Fig. 5: Web Portal functionality: Display of Map data from different registered servers. The Application is a pure HTML/JavaScript-based (no applets).

4.2 WMS Applications developed at the Geological Survey

The Geological Survey of Norway made, together with the Norwegian Directorate for Nature Management, several applications. At the time of writing, only one of these is in English. The address to the developing site is <http://www.ngu.no/kart/wms>.

A Nature Resource client application shows possible area conflicts. We have unfortunately not yet an English version for this application. The application uses 12 map layers in total, and up to 6 map layers simultaneously in five different Map Presentations:

- Gravel and hard rock aggregate / Nature conservation areas
- Gravel and hard rock aggregate (value) / Engagement free area
- Mineral resources (value) / Nature conservation areas
- Bedrock / Nature conservation areas
- Bedrock / Mineral resources (value) / Nature conservation areas

A Map Presentation is a multi-layered image. Each layer represents a map service, which has a specific plot order on the screen. In this application all map presentations are predefined and cannot be altered. The overall functionality is restricted on purpose, so the user is not misled.

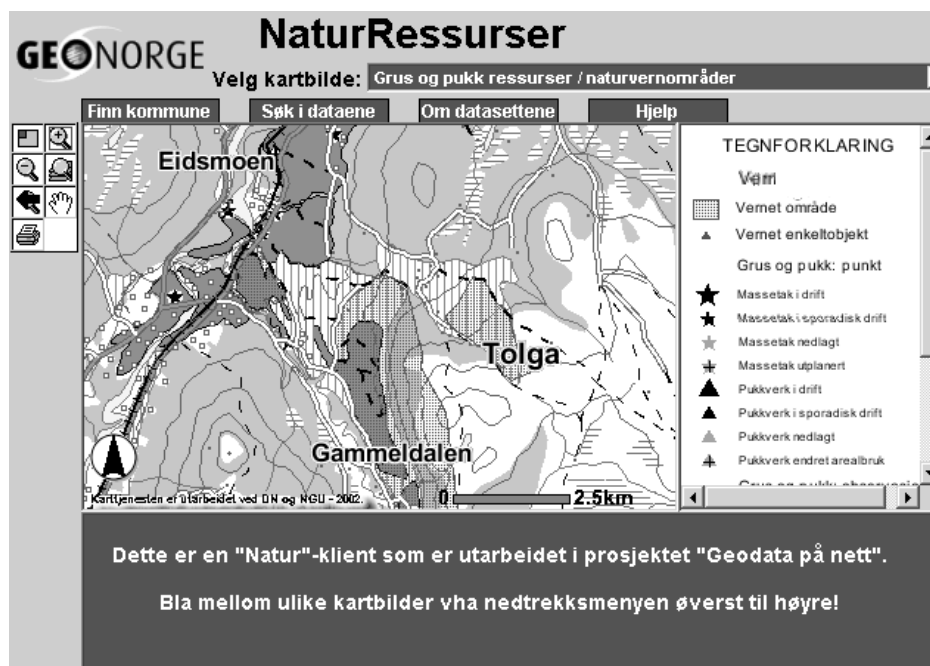


Fig. 6: Web application for nature resources. Map presentations are selected at the upper right.

It was natural to also build a more general application, because the developed WMS library constitutes much more functionality than shown above (See also chap 3.). A general application exposes all the functionality that the WMS library offers. And the best of all, an English version has been made. The English application is "physically" the same as the Norwegian one, but with different text values. That means no double maintenance. See fig. 7.

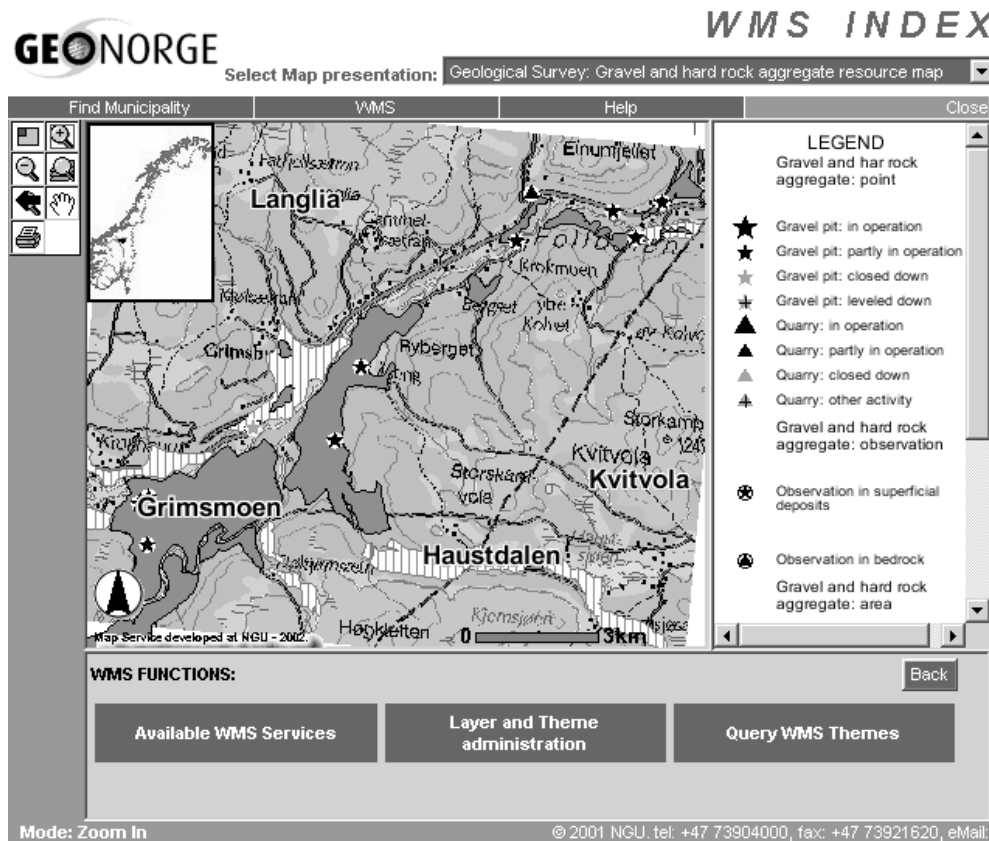


Fig. 7: Web application for general display of WMS Services. Map presentations are selected at the upper right corner. More customised display can also be done.

The application has three WMS buttons:

- Available WMS Services
- Layer and Theme administration
- Query WMS Themes

The "Available WMS Services"- button provides an alphabetic list of all services. Here you can turn services on/off or get general information for each service (see fig.8). The "Layer and Theme administration" button enables change of layer display order and change of visible themes within a service (see fig. 9) Finally the "Query WMS Themes" button provides attribute information for themes at a given coordinate (see fig. 10).



Fig. 8: WMS Services menu

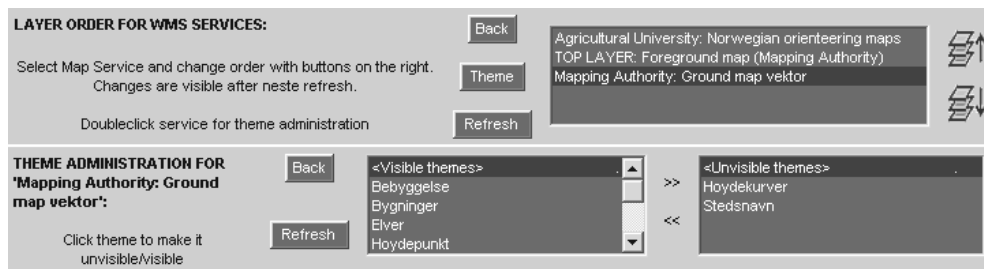


Fig. 9: Layer and Theme administration menus

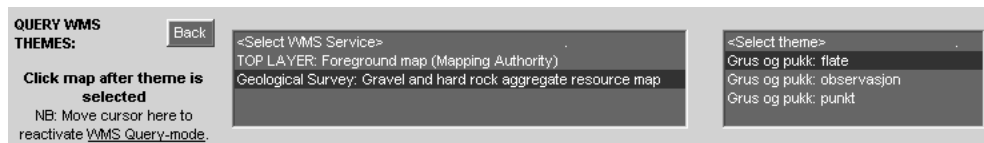


Fig. 10: Query WMS Themes menu

5 Conclusions & Outlook

Norway has taken a large step in implementing standards through the Geo-Data on the Net Project. The next step will be to involve the whole National mapping industry and implement the soon coming Web Feature Server specification (WFS) in future projects.

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Mobile Internet

Maps, Multimedia and the Mobile Internet

Georg GARTNER and Susanne UHLIRZ

1 Introduction

The expansion of the Internet on mobile clients is enabled by the development of telecommunication infrastructure (air interfaces, data protocols) and mobile wireless clients (cellular phones, PDA). The use of mobile devices as tools for interacting with maps or for distributing digital cartographic presentation forms offers new possibilities for cartographic communication and can therefore be seen as a major step in the digital revolution of cartography. Early working applications demonstrate challenges, possibilities and restrictions of such TeleCartography uses, especially in the field of Location Based Services and Pedestrian Navigation Systems. In this paper the context of cartographic communication processes and TeleCartography issues is discussed. It is argued, that by considering the extreme conditions and restrictions of mobile devices for displaying graphics, the applied use of multimedia techniques can increase the acceptance of related services. Examples from selected application development projects of the Department of Cartography of TU Vienna are given, including tries to integrate multimedia techniques.

2 TeleCartography

TeleCartography can be defined as the distribution of cartographic presentation forms via wireless air data transfer interfaces and mobile devices (GARTNER 2000).

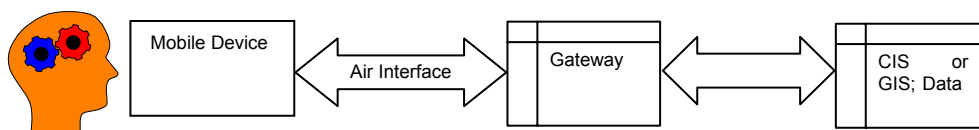


Fig. 1: TeleCartography

The development of TeleCartography has to be seen therefore in a close context with the development of telecommunication infrastructure, the further development of air interfaces and related data transfer protocols (e.g. Universal Mobile Telecommunications System UMTS), and finally the enhancement of mobile devices ("wireless information devices" WID) with functionalities for cartographic information presentation and retrieval (GARTNER 2000, PAMMER 2001, BRUNNER-FRIEDRICH et.al. 2001).

Cartographic information transmission can benefit from this development because it opens the possibility of serving actual and interactive cartographic products independent of time and the location of the user. Therefore the disadvantage of the immobility of digital I/O-devices by using desktop computers can be overcome while still taking advantage of the full functionalities and possibilities of digital cartography.

The cartographic processes used for designing and creating maps respective to cartographic information systems do not change in principle in TeleCartography environments. A WID map also has to be a perceivable, scale-dependent and graphically coded presentation of spatial information, and is therefore a product of generalization and symbolization processes. On mobile devices the conditions for presenting graphic information are even more restrictive and therefore require special strategies on communication methods, including the use of interactivity and multimedia.

Both the existing restrictions of mobile wireless devices and the methodical conceptions for increasing the efficiency of cartographic communication processes (cp. CARTWRIGHT & PETERSON 1999) can be seen as arguments for applying multimedia techniques in TeleCartography. The first application was developed in the context of Location-Based Services (GARTNER & UHLIRZ 2001) through the soon-to-be-available multimedia-enabled

telecommunication infrastructure (e.g. Universal Mobile Telecommunication System UMTS). The already realized applications, most of them developed in the context with the already existing Wireless Application Protocol (WAP), can be seen as restricted in their acceptance mainly due to the lack of support for multimedia formats. Therefore, only simplified communication and presentation forms are available (LADSTÄTTER 2001, BUZIEK 2001, SOLLBERGER 2001, MAGENSCHAB 2001).



Fig. 2: The simplistic form of interfaces and map presentations in WAP-applications as reason for missing acceptance: Examples from WIGEOGIS 2001, WEBRASKA 2000, Simulation of a "WML-deck").

Existing WAP-applications as shown in Figure 2, use extremely simplified presentation forms. As analyzed by LADSTÄTTER (2001) or SOLLBERGER (2001), services used in the context of WAP-cellular phones suffer in their acceptance and market penetration from the rudimentary geo-communication processes. It is argued in this paper that in such challenging environments as TeleCartography, the usage and support of multimedia for cartographic communication processes is crucial.

3 The Status Quo, Infrastructure and Devices of TeleCartography Environments

In Europe, the first generation of mobile telephones appeared in the mid 1970's in Scandinavia and was based on analogue techniques. The second generation of mobile handheld devices brought digital transfer technologies, such as GSM (Global System for Mobile Communications), and made wireless phones a mass market phenomenon. Today, multiple standards are used in worldwide mobile communications. Different standards serve different applications with different levels of mobility, capability and service area (paging systems, cordless telephone, wireless local loop, private mobile radio, cellular systems and mobile satellite systems). Many standards are used only in one country or region and most are incompatible. GSM is the most successful family of cellular standards, supporting some 250 million of the world's 450 million cellular subscribers with international roaming in approximately 140 countries and 400 networks. When WAP (Wireless application protocol) was introduced in the 1990's it was the first time that mobile devices allowed access to the Internet content prepared especially for use on mobile clients with small displays. Although WAP makes no provision for graphics other than in a very basic presentation (Prague City Guide, <http://wap.checkit.cz/GWEWap/default.wml>, A1 Mobile Guide without horrific maps), it has been used for initial attempts to present maps. With third generation technology, such as UMTS, it will be possible for the first time to give continuous access to most of the internet sites, with graphical presentations included.

3.1 The Status Quo

The Internet is changing the way maps are used. It acts as a stimulant for map production and map distribution. Applied web mapping techniques are often seen as a major step in the development of cartography (PETERSON 1999). The main advantages of Internet Cartography are in gaining better accessibility for the user, enabling higher actuality (VAN ELZAKKER 2000) or easier distribution of maps. But, the efficient use of Internet-based applications, as with any other digital mapping application, is determined and restricted by the main attributes of the machines, which are used for accessing and interacting with mapping systems. An important limitation, computers are usually not highly mobile. For a lot of cartographic applications, this lack of mobility is not a major disadvantage, even through the user has to find access to a machine in order to get his information or map. But in order to enable cartographic information systems to serve products independent of the position/location of a user, i.e. "giving you the information right there where you need the information", the availability of mobile input/output machines and an

infrastructure for wireless submission of information to any location are necessary preconditions (GARTNER 1999, 2000).

The infrastructure and technologies of telecommunication systems are developing rapidly. They have reached a stage where they are judged a mass market industry. In Austria, more than 5 million cellular phones are used by a total population of 8 million (<http://www.handy.at>). Currently the penetration rate in Austria is one of the highest worldwide (Fig.3). The currently developing protocols and network environments like WAP, General Packet Radio Service (GPRS) or UMTS can be seen as first test areas for developing TeleCartography applications, because they enable high transfer rates, graphic or even multimedia data transfer, and mobile client / server - interactivity. Together with the development of the so-called Wireless Information Devices (WID), mobile handheld devices with enriched functionalities (e.g. Smartphones, Communicators) (cp. GARTNER 2000) indicate that the fundamentals and pre-conditions for developing and testing TeleCartography applications are available now.

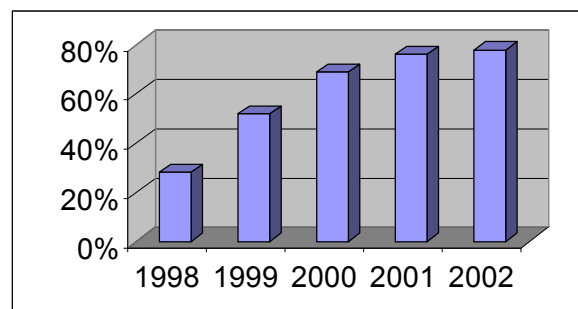


Fig. 3: Mobile Phones Penetration in Austria (<http://www.jet2web.at>)

3.2 Mobile Internet Infrastructure Environments

Like the Internet, the mobile Internet uses two network domains for applying services (Fig. 4). Beneath the core network domain, the access network domain is responsible for the submission of information to the terminal. Depending on the characteristics of the terminals - whether mobile or fixed - different submission technologies are used. For mobile terminal cellular phones and mobile radio networks, the supporting data transfer protocols are responsible for correct transmission.

Mobile radio networks are developing rapidly. Analogue systems, considered the "first generation of mobile radio networks", have been completely replaced by digital systems, that in Europe are the so-called "second generation networks", operating since 1991. Due to missing international standards different systems are used in different countries. The main systems include GSM (Global System for Mobile Communication), USDC (US Digital Cellular), PDC (Personal Digital Cellular; Japanese Standard) or ERMES (European Radio Message System). The "third generation" is about to be introduced, with European UMTS networks in conurbation areas in 2002. Digital mobile radio networks, in general, have the advantage of a higher quality (with less broadband noise and more efficient transmission) and quantity (with higher transfer rates) of data transmission. The third generation networks will continue to increase efficiency in both areas. Throughout Europe and more than 90 other countries, the Universal Mobile Telecommunication System (UMTS) is an accepted standard in the meantime (PAMMER & GARTNER 2002).

In order to enable a mobile internet access via a mobile radio network, a data protocol is necessary. The common basis for all protocols being used for transmission of internet documents is the Internet Protocol TCP/IP. In "mobile Internet" environments (access via a digital mobile radio), some protocol transformation is necessary (e.g., in GSM environments), simple protocols are realized (e.g. SMS, WAP) or direct support of TCP/IP is possible (as in the third generation networks such as UMTS).

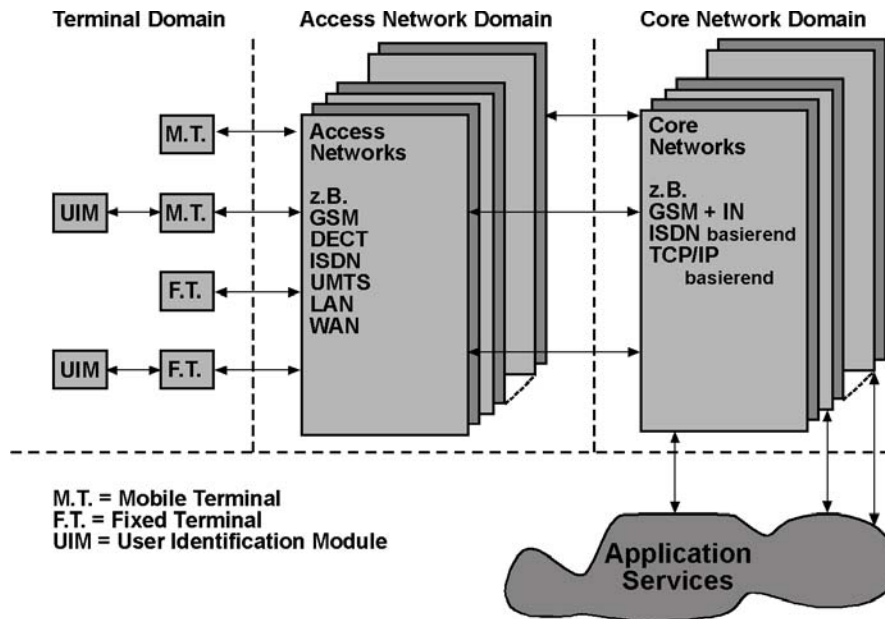


Fig. 4: Network Domains of the Mobile Internet (WALKE 2000)

In summary, to enable TeleCartography applications in mobile Internet environments, the following technical preconditions are necessary:

- Mobile radio networks / Cellular phone networks or other air interfaces
- Data transmission protocols
- Mobile Clients with adequate screen display
- Application Development Environments

3.3 Mobile Wireless Devices

Mobile wireless devices can be seen as applicable for TeleCartography purposes, if they are enabled to the following requirements:

- data sending / receiving via air interfaces
- graphic and alphanumeric display and handling of graphic data formats
- user interaction

Many new wireless devices are being developed recently. Further merging of computer and telecommunication industries is taking place. Mobile devices can be classified into two categories:

1. cellular phones with increasing computing capabilities, including the display of graphics and the enabling of interaction via graphics ("Smartphones", "Communicator"), and
2. portable computers, that can be upgraded to voice communication capabilities ("PDA", "PocketPC").

3.4 UMTS and Location Based Services

The new "third Generation" (3G) of mobile phones features not only an IP-based technology but for the first time allows "rich calls" that transfer several user data streams simultaneously. This is often referred to as "multimedia calls." Data transfer rates allowed only voice calls up to now. But the users and developers of wireless devices always had planned to transmit "simple" voice calls as well as all other forms of digital data. The upcoming technologies, such as GPRS (Global Packet Radio Switch) and the latest, expected in 2002, UMTS (Universal

Mobile Transmission System) seem to make this idea come true for the first time in mobile communication. The difference in speed between GSM and UMTS is a factor of 50, and in rare cases, up to a factor of 200. The factor is 6 when compared to ISDN, and enables the transmission of video as well as audio files. Because UMTS technology enables the transfer of many different data formats by fast growing transmission rates, the development of complete new and attractive applications becomes possible.

In contrast to GSM technology UMTS uses a different form data transfer and also another pay scale: There is no more a continuous connection over the whole time of the application is in use, but data is transferred in packages. Therefore the basis for payment is no longer the time of the open connection but the amount of data. This enables on the one hand to build up a connection one time and to pay only in case of data transfer on the other hand. This different form of data transfer and pay mode favour extensive use of internet applications and being on-line, both preconditions for extension of mobile internet applications.

One of the most promising applications in this context is seen by many as Location Based Services (GARTNER 2000). Such services can be characterized by the fact that the position of the user is somehow identified. The information selection, made at the user's requests, and the resulting presentation (e.g. the specific view on a map) is related to the identified position. The methods used to determine the position (Determination of Cell-Id, Measurement of Wavelength, Wave angles, Electric field strength, Combined Differential GPS) are producing a broad range of results in terms of quality (e.g. Cell-Id-Determination: 100-300m in urban areas, approximately 2-5m in combined methods like DGPS/long wave measurements, depending on the build-up situation). The state-of-the-art LBS applications, most of them WAP-based, can be characterized as follows:

- in most cases a non-graphic representation of results is used
- the positioning accuracy is poor
- there is no usage of multimedia features
- there are only low-level graphics used
- the interface design and interactivity functionalities have to be adapted to the restricted possibilities of current available devices.

A collection of WAP-based (UMTS environments are not available yet) LBS links can be found at http://www.ikgeom.tuwien.ac.at/links/wap_links.html. LBS for UMTS environments are in their starting phases at the moment, including Lol@, a cartographic LBS-application for Vienna City Tourists, among others developed by the Department of Cartography of TU Vienna.

4 Multimedia and TeleCartography: Application Context "Pedestrian Navigation Systems"

Applying multimedia techniques to TeleCartography applications like Location Based Services is based on the idea, that in order to achieve higher acceptance of LBS, a more user-oriented way to "communicate" route information is necessary. Multimedia Cartography techniques enable in this context the development of more suitable interfaces and adaptive presentation forms (REICHENBACHER 2001), in terms of considering aspects of

- device specifications
- user situation
- user abilities.

As shown by GARTNER (2000), the application flow of a map-based LBS can be seen as quite similar to WebCartography Applications, emphasized by issues of positioning (cp. Fig. 5).

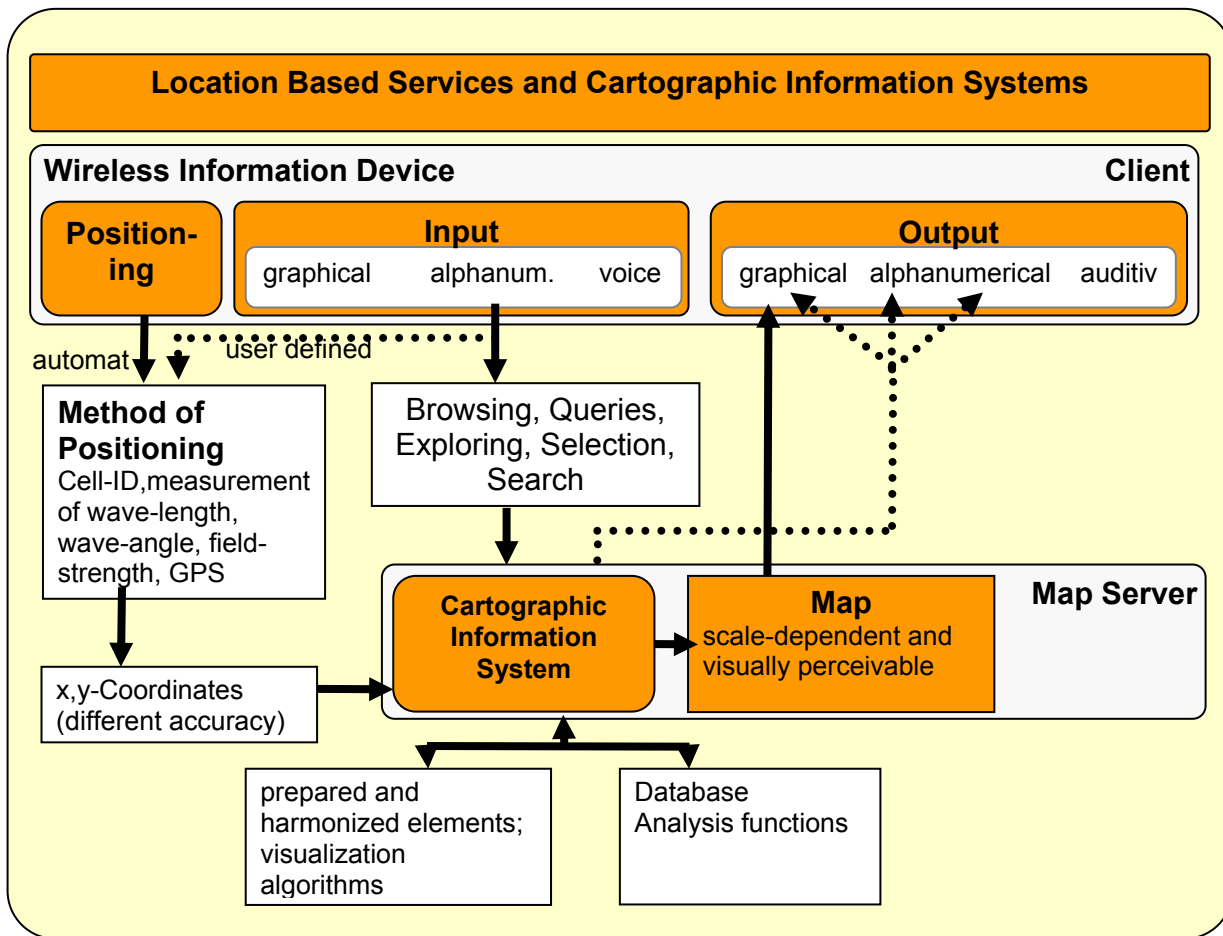


Fig. 5: Application Flow of map-based LBS (GARTNER 2000)

In order to develop a location based service in a UMTS environment, a project has to deal with four main parts: the specifications of technical prerequisites as well as the method used for localization, positioning and routing, application development, and application implementation (FTW 2000). Therefore, the scope of an application development includes the following main points:

- Automatic positioning is required by means of GPS and other methods, including user-supported localisation.
- Display of the entire route on maps, including several map scales.
- Depiction of "infopoints", the most important stops along the route. At these points, multimedia information (audio, video, images, webcam) is offered for user-browsing.
- Routing from point to point and/or to starting points of the route.
- User-defined queries for information retrieval are foreseen.

The Department of Cartography at the Vienna University of Technology takes part in a research group (Forschungszentrum Telekommunikation Wien), where UMTS-applications are developed as part of other projects. As a section of the FTW-project, the development of a prototype for a location-based service for an UMTS environment is in progress. The application "LOL@", a guided tour through Vienna's first district, is meant as a service for foreign tourists. The user is guided along a pre-defined route or, according to individual input, to some of the most interesting places in Vienna's city centre, where he can get multimedia (audio and visual) information about the tourist attractions via the Internet portal of the service. The application requires a wireless handheld input/output device.



Fig. 6: Lol@ - Interface (by using a design-draft for a UMTS-device of Nokia;
left figure: Reference Map Interface; right figure: Multimedia-Content-Interface)

The experiences and results of the "Lol@" project are developed further in follow-up projects, where the focus is more specifically on to aspects of communicating routing information in mixed "indoor/outdoor" environments. The goals include a more "user-defined" modeling of routes and a multimedia method of representing routes (GARTNER, RETSCHER & WINTER 2001). The initial prototype shows encouraging results (cp. Fig. 7).



Fig. 7: Different animated multimedia route presentation forms, linked in a Pedestrian Navigation System for a mixed indoor/outdoor environment: Application draft for TU Vienna - LBS

5 Summary

Existing TeleCartography applications can be characterized by extremely simplified communication and presentation forms. This has to be viewed in relation to the restrictions of used mobile clients. Therefore, the acceptance of such services is limited. In this paper, it has been argued, that an increase in the acceptance of Location Based Services, in terms of achieving mass market potential, can be achieved by applying multimedia through the use of synchronized and interactively linked presentation forms, and the development of corresponding user interfaces.

In this context, cartography is asked to develop theoretical and methodical concepts for multimedia-enabled TeleCartography - applications that are able to take advantage of the expected development of mobile radio systems and mobile clients.

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Maps without Wires: Wireless Geo-Information in Research and Education

Arend LIGTENBERG and Jandirk BULENS, Ron van LAMMEREN, Aldo BERGSMA

1 Introduction

Wireless data communication becomes an important new way of transferring information between devices, databases and humans (CRISLER et. al., in press). The introduction of the 2.5 generation mobile devices by the introduction of GPRS opens the possibility to set-up a relative fast and reliable data-connection. At the moment wireless communications and internet are converging (BARNES 2002). At the end of 2001 about 3 million GPRS devices has been sold in Europe and it is expected that 40 million Western Europeans will be using GPRS by the end of 2003. Now technology seems not to be a limiting factor anymore the question arises: what is it good for. It is likely that, as the result of not being limited by place and time, our lifestyle and behavioural patterns will change to meet a concept of total mobility in working and learning (CHAN et. al. 2001, OLLILA 1998).

The Centre for Geo-information (CGI) of Wageningen University and Research Centre (Wageningen-UR) in the Netherlands carries out two project that explore the merits of wireless data communication for students and researches. The first project "Maps without Wires" aims to provide researchers with wireless solutions for the querying, displaying and updating of geographic databases, mainly for purposes of fieldwork. The second project, "GYPSY" is carried out by the Centre for Geo-Information in cooperation with the Free University of Amsterdam and the Catholic University of Nijmegen. This project is aimed to support students with wireless devices in doing their fieldwork and acquiring information about Geo Information Systems (GIS).

In this paper we present part of the work done on constructing services to provide geo-information on mobile device (wireless geo-information) for the both mentioned projects. We start describing some of the backgrounds of wireless geo-information and discuss the used devices and protocols. The next section we present three pilots developed to explore the merits of wireless geo-information. In the final section we draw conclusions.

2 Wireless Geo-Information

With wireless geo-information we mean:

1. Distribution of data stored in a GIS by means of wireless devices, based upon the location of this device;
2. Presentation of GIS data using a textual or cartographic representation on a wireless device;
3. Adding, deleting or updating spatial objects in a database using a wireless device.

A user can interact with the data using a wireless device at various levels. At the first level users cannot interact directly. Data is send by a server on request to the device and then the connection is terminated. The use of this type of interaction is limited to simple queries, mainly to answer predefined question. A user should know in advance what information he or she requires.

The second level of interaction provides the user with means to interact locally with the data. Parts of the requested data are stored locally on a mobile device. A user can manipulate it locally. This means a user can zoom and pan the data and query for attributes in an interactive fashion. If data cannot be accessed locally a renewed query is issued to the server by the client automatically. The user however never works directly on the data stored in the geographic databases.

The last level of interaction requires on a full-fledged client-server connection with a geographic database. This opens the possibility to add, delete and update spatial objects in for example an oracle-spatial database directly without the need of replication or synchronization.

The required and supported levels of interaction are determined by several factors including: type of devices, connection and used protocols and the goal of the required services. For purely informational services like "where

is...” “and what is...” questions relative low levels of interaction are required. For the more advanced “tele-geomatics” like wireless data-collection, disaster management, mapping, planning and surveying and environmental monitoring reliable connections and more interaction with the geo-information is required (ZINGLER et. al. 1999).

2.1 Type of Devices

Basically there are three classes of devices that can be used for wireless-geo-information:

- mobile phones
- personal digital assistants (PDA)
- laptops

Two types of mobile phones are currently suitable to handle, besides voice, also data. The first type are mobile phones that use the Wireless Application Protocol (WAP). WAP is very limited in its graphical presentation. It only can handle black and white images in a very limited size. The Wireless Mark-up Language (WML), used to create WAP pages, only allows the WBMP (wireless bitmap format). No direct interaction possible with (cartographic) data. The WAP protocol is therefore hardly usable for displaying geo-information using a cartographic representation.

The second type are phones that are based upon the I-mode concept originally developed by the NTT-DoCoMo in Japan. I-mode is currently available in the Netherlands, Germany and Belgium. The I-mode phones have a large display with more colours (256) and a higher resolution (typical $< 120 \times 128$). This means that it offers more possibilities to display maps. I-Mode is based upon cHTML a subset of regular HTML and accepts images in the GIF format. This makes coupling with standard map-server relative straightforward. A limiting factor is however that the size of an I-mode page cannot exceed the maximum of 10 kb. Also, like with the WAP-phones direct interaction with the map is not possible as I-mode only supports 1-dimensional navigation.

At the time of writing the use of mobile phones is limited to the presentation of simple geo-information based upon a location that is inputted manually into the device by the user. Location based services (LBS) are not implemented yet (at least not in the Netherlands). This means you cannot determine a location using only a mobile phone. A GPS is required. Alternatively zip or address information provide sufficient accuracy for many applications.

PDA's offer more functionality for interacting with geo-information. The resolution is higher (about 240×320), have more computing power and better navigation and input functionality. They all include touch-screens, virtual keyboard and recognition of handwriting. Application often can be written using the normal development environment such known by windows programmers.

To connect to a GPRS network various solutions are available. A GPRS pc-card can be used, or a mobile phone can server as a modem using IRDA or Bluetooth (see 2.3). Also PDA's having integrated GPRS support are available.

If needed more computing power, laptops can be easily connected to a GSM or GPRS network using PC-Cards or a Bluetooth connection with a mobile phone.

2.2 Data Transmission

To create, what is often called, a wireless personal area networking (WPAN) (HÄNNIKÄINEN et. al. 2002) or a personal learning environment (LAMMEREN VAN et. al. 2002) number of protocols are available. We distinguish two categories:

1. protocols to connect devices;
2. protocols to connect to the internet (or, if you need it, other networks).

To connect devices, mostly an infrared connection (IrDa) is used. IrDa can connect devices up to a maximum distance of 1m. The Bluetooth protocol becomes a powerful alternative for IRDA. It can connect devices up to a distance of 10m and a maximum speed of about 1 mb/sec. It also can be used to create small ad-hoc network to

connect a number of devices. An important advantage of Bluetooth compared with IRDA for fieldwork is that it is a radio-protocol that not requires sight-connect.

To connect your mobile device to the internet the following protocols are relevant:

- GSM
- GPRS
- UMTS
- Wi-Fi (802.11b)

GSM and GPRS have full coverage availability in the Netherlands. UMTS is planned to be introduced within three years.

The GSM protocol is widely available over Europe. Although designed for voice it has limited possibilities to transmit data with (≈ 9.6 Kbit/sec).

GPRS is the current standard for transmitting data over a mobile network. Theoretically it has a maximum bandwidth of 171.2 Kbit/sec. Although in practice it depends on the number of timeslots assigned to you by the provider, the number of slots the device is able to handle and the used coding scheme. Most telecom operators provide a bandwidth of 56 Kbit/sec. Depending on the device this results mostly in an downstream speed of 30-40 Kbit/sec. The advantage of GPRS is that it is a so called packet switched technique. This means that it is possible to be continuously online and to pay only for the amount of data transmitted. GSM on the contrary is based upon so called circuit switching; the connection time determines the costs.

UMTS is promising because of its high bandwidth. However in Europe its only available in the island of Man. Within a few years it will probably be the new third generation standard for wireless data transmission.

WiFi was developed for indoor use to set-up a wireless LAN. WIFI is however increasingly used for outdoor application. Several initiatives are trying to provide for "hot spots", mainly in urban areas, where people can logon to the internet with a laptop or pda. Although providing a high bandwidth and a reliable cheap connection it is not to be expected that WIFI connections will become available at nation-wide scales.

What protocol is used depends on the both the spatial and communication context of a user. Inside the home or office often WiFi will be the most suitable protocol for transferring data and connecting to the internet, while for example DECT will be used for voice communication. Outside the office this will probable be GPRS/UMTS for data and GSM for voice.

3 Pilot Applications

To explore the above mentioned devices and techniques for the domain of wireless geo-information we set-up three pilot implementations:

1. A WAP application for simple presentation of geo-information;
2. An I-mode application for presentation and navigating geo-information ;
3. A PDA client for displaying and editing maps.

Several devices were tested ranging from the basic GSM phones, I-mode devices and various types of PDA's. To set-up data connection GSM and GPRS protocols where used (sometime IRDA for inter-device connections).

3.1 WAP

For the first pilot a dedicated WAP-map-server was build using Delphi, MapObjects and Active Server Pages (ASP). No standard solutions where available for wireless geo-information on a WAP device for the data

transmission the GSM protocol was used. Generation of maps and handling of spatial queries was done by a MapObjects/Delphi component. ASP in combination with VB-script is used to generate the WAP pages. The application provides information about recreational objects in an area around the location of the mobile phone. This area is input of the user. Fig. 1 shows this application.



Fig. 1: the WAP application

For the other two pilots the use the ArcIMS map-server software (ESRI 2000) combination with an Microsoft information server. The main argument for this choice was the experience gained with these software during the past years for serving geo-information on the regular internet.

Fig. 2 shows the general architecture for the wireless geo-information services. Geo-data can be stored in an oracle spatial database or in the native formats of ESRI (shapes, coverages or grids).

Depending on the type of application that needs to be served various types of “connectors” are available. In this project the active X connectors and Java Servlet connectors are used to connect to the application server. The application server is connected to the ArcIMS spatial server. The spatial server is the main engine that generates the required maps. The strength of the chosen approach is that one server application can server various devices and formats (a so called multi-channel approach). Data is delivered to a connector using ArcXML. Commands can be send to the server using ASP (in combination with visual basic script or java script) or arcXML commands.

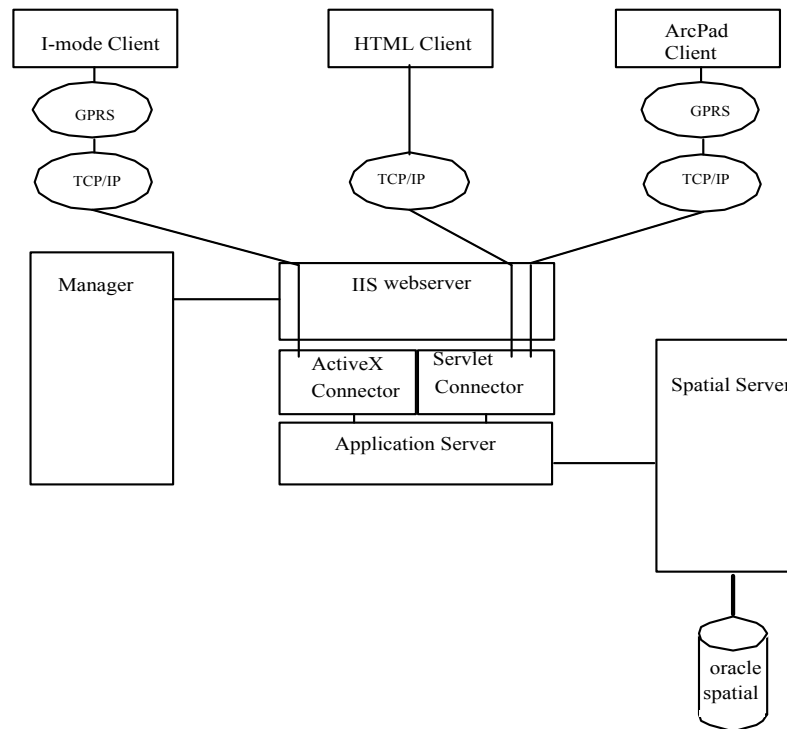


Fig. 2: Multi- channel approach for delivering geo-information

3.2 I-mode

An I-mode application was implemented to test its use for simply presenting geo-information. Its intended use is mainly for education. Areas of education that can benefit mostly from the wireless evolution are those that include outdoor activities such as environmental sciences, earth sciences, biology and natural sciences in general. A major limitation to the effectiveness of fieldwork is the ability to access information while in the field (VAN LAMMEREN et. al. 2002).

The application was built using Active Server Page (ASP) in combination with visual basic, ASP and active X components to generate cHTML pages suitable for displaying on an I-mode device. The ArcIMS server provides a rich collection of Active X controls to access, display and query geo-data.

At this moment the I-mode application is very basic (see Fig. 3). It consists of a number of dynamic cHTML pages. Users can select the database they like to open. Next they are asked how to want to determine their position. At this moment they need the name of a municipality, or if a larger scale is required they can enter a zip code or coordinates of they read from a GPS. One major disadvantage at the moment is that Location Based Service (LBS) are not available yet on the I-mode phones and networks. Neither is it possible to connect a GPS to the I-mode device as it does not provide for an interface for this.

The first experience with this type of devices is that especially limitations on navigation are a major restriction. Only scrolling is allowed and no interaction with the map is possible (no-clickable maps). This means that zooming, panning and selecting features is quite cumbersome.

Another restriction is the small size of the maps. Not only the screen dimensions ($\approx 100 * 100$ pixels) are limiting but also the maximum size allowed for an I-mode page (10 kb are preferably < 6 kb). I-mode only supports GIF format so the 10 Kb limit is reached relatively fast, especially when using graduate-colour images.

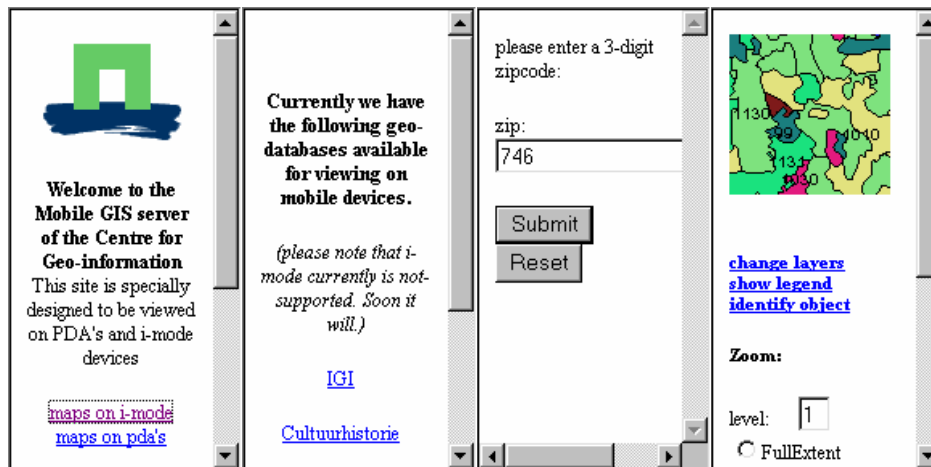


Fig. 3: I-mode application

The preliminary conclusion is that the use of I-mode for wireless geo-information is limited to simple information services. The limitations of the devices in supporting navigation, selecting features and connecting for example GPS restrict usability for applications that require more than simple presentation of a map.

3.3 PDA Client

To overcome the above mentioned restriction a more “rich” client application was used to connect to the Map Server. As client ArcPad was chosen. Using ArcPad it is possible to connect to an ArcIMS server. After choosing the desired database the maps are transfer to the client in a graphical format. The user can zoom, pan, query feature on the map using his stylus pen (see Fig. 4).

New spatial data can be added by manually inputting them using a stylus or by connection a GPS using the RC232 interface present on most PDA's.

A direct connection with for example an Oracle Spatial database is not possible using this configuration. Acquired data is stored locally an need to be synchronised manually on a regular basis.

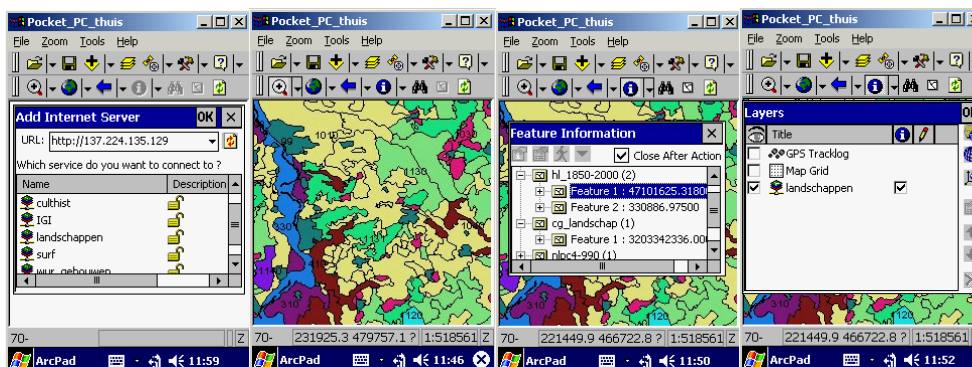


Fig. 4: the Arcpad client application

4 Conclusions

We presented three approaches to wireless geo-information. The major conclusions are:

- WAP based approach is hardly suitable for presenting geo-information using a cartographic representation. The limited graphical possibilities of the WAP protocol and the display size of the average mobile phone are simply insufficient.
- I-mode offers a richer environment to present for geo-information. However only for simple presentation of information. The limiting factor is the interaction with the geographical data. Panning, zooming and input of data is cumbersome. These type of devices are typically suitable to develop information services.
- PDA clients seem to offer the best opportunities to develop applications that are suitable to be applied during fieldwork.

A major bottleneck in the implementation of wireless geo-information is the lack of LBS. Currently GPS devices are necessary to determine the location. GPS however do not interface with mobile phones.

For more complex representations of geographical information and intensive interaction with a map-server the current bandwidth offered by the most GPRS operators is barely sufficient. Although usable, a higher transmission speed would benefit wireless geo-information. the promises made by UMTS seem to resolve this limitation.

5 Acknowledgements

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GiMoDig Project – Overview and System Architecture

Lassi LEHTO

1 Introduction

The project "Geospatial Info-Mobility Service by Real-Time Data-Integration and Generalisation" (GiMoDig) is funded by the European Union via the Information Society Technologies (IST) programme (GiMoDig 2002). The IST programme is a specific programme for research, technological development and demonstration on a user-friendly information society. The GiMoDig-project (IST-2000-30090) is a shared-cost RTD project, under the action line CPA3: Ubiquitous and intelligent info-mobility and geo-information systems.

GiMoDig started on the 1st of November, 2001 and its duration will be 3 years. The personal resources for the project cover 19 person years. The Finnish Geodetic Institute acts as a coordinator for the project. The other participants are University of Hanover, Federal Agency for Cartography and Geodesy (Germany), National Survey and Cadastre - Denmark, National Land Survey of Sweden and National Land Survey of Finland.

2 Overview of the Project

2.1 Objectives

The objective of the GiMoDig project is to develop and test methods for delivering geospatial data to a mobile user by means of real-time data-integration and generalisation. The project aims at the creation of a seamless data service providing access, through a common interface, to the primary topographic geo-databases maintained by the National Mapping Agencies in various countries. A special emphasis will be put on providing appropriately generalised map data to the user depending on a mobile terminal with limited display capabilities.

Sub-objectives of the project can be listed as follows

- Development of methods and usage practices for generalising the graphic representation of geospatial data in real-time, to be suited for display of the data in varying scales on small, mobile devices with different display resolutions.
- Investigating the problems between national primary geospatial databases, often mutually heterogeneous in thematic definitions, and developing means for real-time harmonisation of data.
- Analysis of mobile use cases to adapt real-time generalisation and harmonisation of geospatial data to the requirements of a user in varying usage situations.
- Development of methods for real-time transformation of spatial data from different national geo-databases to a common, EUREF-based co-ordinate system.
- Investigating and developing methods for transferring vector-formatted spatial data to a mobile user using emerging standards, like Extensible Markup Language (XML 2000), and testing the applicability of the standards for Web-based spatial services in a international pilot project involving national primary geodata sets.
- Development and implementation of a prototype system that can be used as a test-bed for the developed methods.

The scientific aims of the project lay on the development of methods for real-time generalisation of spatial data - a field of science so far not extensively researched, but becoming increasingly critical in the modern networked society where up-to-date databases are to be directly accessed by consumers using a widely varying set of terminal devices. The spatial datasets in the GiMoDig project will be served in an XML-based vector format to facilitate flexible data integration and processing by other parties in the higher levels of the value chain. Therefore, a specific goal in the research on generalisation is to employ XML-based computing technologies in the process.

2.2 Innovative Aspect of GiMoDig

Most of the existing map-related services on the Web are currently based on proprietary access interfaces and data formats. This situation exists largely due to protective measures taken by individual service providers or software vendors in order to defend the achieved position in the market place. Extensive specifications applicable to the on-line processing of geospatial data have also been virtually non-existent. Recently the situation has changed significantly, however. Now that first standardised interface specifications have been developed, the traditionally isolated spatial software vendors and service providers start seeing mutual benefits in supporting those specifications. It is of paramount importance that the new standards be tested in a concrete environment involving datasets with significant magnitude and national coverage, from several different countries. The GiMoDig project provides such an environment. The GiMoDig project involves a broad spectrum of central actors in the area of spatial data production and delivery. The project consortium includes major spatial data providers (National Mapping Agencies, NMAs) and research institutes specialising in geoinformatics as its members.

The encoding of spatial data being transferred across the network is going to be based on the Extensible Markup Language technology. The Open GIS Consortium (OGC 2002) has defined an XML application for spatial data, called Geography Markup Language (GML 2002). Many GIS software vendors are currently developing support for this new data encoding mechanism into their products. The GiMoDig project aims at testing this new encoding mechanism, applied in the context of primary geo-databases with nation-wide coverage.

The cartographic generalisation of spatial data has a long and well established tradition, also in a computerised environment. In most of the cases the developed methods are designed to the production of static, well-defined derived map products – typically a series of small-scale maps produced on the basis of a large-scale primary map. The generalisation methods related to the production of *ad hoc*, personalised maps in a real-time environment have not been extensively investigated. However, the future user of geospatial data services may expect means for defining, by himself, the contents, coverage, scale, and visual appearance of the product when data are accessed via a network by a mobile device.

XML allows for the structured coding and device-independent presentation of spatial data. This functionality will be exploited in the project, as it aims at a neutral realisation of the given task. In this way it is possible to easily change the appearance of a document. Furthermore, also the contents of a document can be changed by transforming one XML document into another, for instance by a mechanism called Extensible Stylesheet Language Transformations (XSLT 1999). This functionality could be exploited by using the transformation as a real-time generalisation function. Generalization operators requiring more sophisticated computing processes will be implemented in the Java Topology Suite platform (JTS 2002).

The methods for deriving map products in continuous scale would open up new opportunities for utilising topographic geo-databases. If operational methods for real-time generalisation were available, the number of different map databases could be reduced and their maintenance would be simpler and more economical. The need to produce various different representations from a single data source has been emphasised by the recent introduction of the mobile Internet. The drastically varying display characteristics of the new category of mobile devices, going to be used in accessing spatial services, set a new challenge for the real-time generalisation of geo-data. These challenges are to be tackled in the GiMoDig project.

2.3 System Architecture

The system architecture of the GiMoDig service is to be based on a multi-tiered processing model in a networked environment. In this architecture primary geodata is retrieved directly from the data provider's database on the moment the service is accessed. In most of the current existing service solutions massive a-priori data transfers are needed from data provider to service provider, creating unnecessary data duplication and making data updates difficult. In the GiMoDig system architecture spatial data is maintained in the NMA's server and provided to the network through a standardised access interface. The communication between actors in various levels of the system hierarchy are to be based on the emerging spatial Web-standards, especially those developed by the OGC.

A schematic model of the system architecture is shown in the Figure 1.

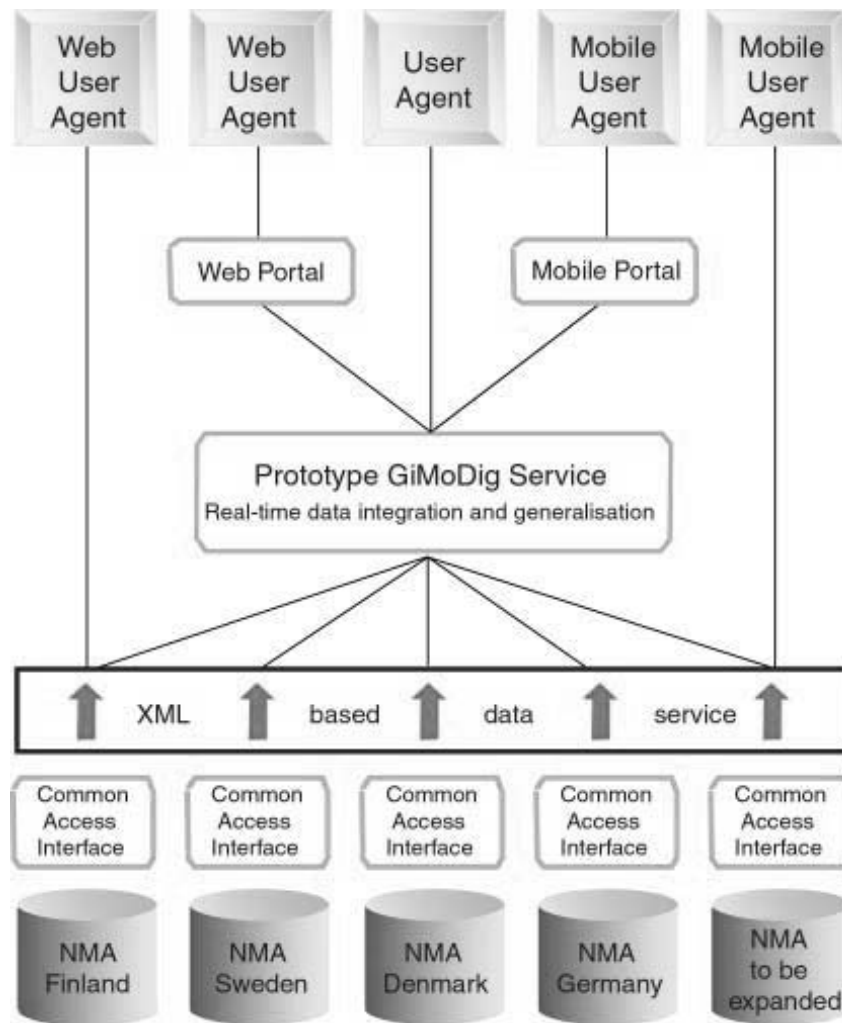


Fig. 1: Tentative system architecture of the GiMoDig project

3 Detailed System Architecture

3.1 Layered Approach

The GiMoDig architecture is based on a layered service stack, in which a service would make queries to the service below it, do some processing on the data received as a response, and provide the results of its processing as a service to the service layer above it. The level of detail in specifying the layers is a matter of discussion, but if the services are to be run on separate computers communicating through network, too fine-grained service definition would create a significant disadvantage in terms of overall system performance.

For the above mentioned reason a four-level system architecture has been proposed. In the first level the NMAs would run a Data Service providing raw spatial data in an XML –encoded form. Above the data services is the Application Service layer. In the case of GiMoDig the responsibilities of this layer include coordinate transformations to a common reference frame and generalization of spatial data. Possibly there will be a need for schema transformations as well.

The third layer in the system architecture is called Portal Service. The main responsibilities of this layer consist of providing basic metadata service to the client, processing the service requests coming from the client, forwarding the request in an appropriate form to the GiMoDig Application Service layer, and transforming the resulting map according to the capabilities of the client platform in question.

On the fourth layer are finally the client applications. The idea in the GiMoDig service is to provide the results to a set of different client environments. At the very minimum the following three client platforms are to be supported: 1. The traditional Web browsing on a PC platform, 2. Personal Java based clients on PDA devices (Personal Java 1998), 3. Java MIDP (Mobile Information Device Profile) clients on mobile phones (JAVA MIDP 2002).

3.2 Standardized Interfaces

The communication from layer to layer is to be based on internationally accepted interface standards. At the moment the main interface specifications to be implemented in the GiMoDig architecture are: 1. Web Feature Service (WFS, 2001) specification of the OGC as the access interface in the Data Service layer, 2. Web Map Service (WMS 2002) specification of the OGC as the query interface of the Portal Layer, 3. Presentation Service of the Open Location Services initiative as an alternative access interface on the Portal Layer (OPENLS 2002). A GiMoDig –specific service interface, that so far does not have a widely accepted specification, is evidently the Generalization Service.

As the standardized interfaces are to be applied on different layers of the service architecture, the system provides a flexible setup in which clients do not necessarily need to go through all the levels of the hierarchy but can rather communicate with the service that provides best support for the task in hand. So more powerful clients might consult the WFS interface directly to process GML data, whereas some client applications might prefer to communicate with Generalization Service directly, and the most restricted platforms might require the client application to rely on the standard WMS service providing raster images.

The data encoding between the Data Service and the Application Service layers is to be based on the Geography Markup Language (GML) as the WFS specification dictates. The version of GML to be applied in the GiMoDig service is the upcoming release 3.0. In addition to the traditional raster images, the visual representation of the spatial data is to be based on the different profiles of the Scalable Vector Graphics (SVG 2001) vector format, and specially on the Mobile profiles of it (SVG MOBILE 2002).

The GiMoDig architecture, together with the most important processing modules, interfaces and data encodings is shown in the Figure 2. The interfaces depicted with dashed outline represent services where open implementations are improbable in the case of GiMoDig. An interesting opportunity for a contribution to the standards setting activity is present in the case of the Generalization Service interface, an area where no standardization actions have so far been taken.

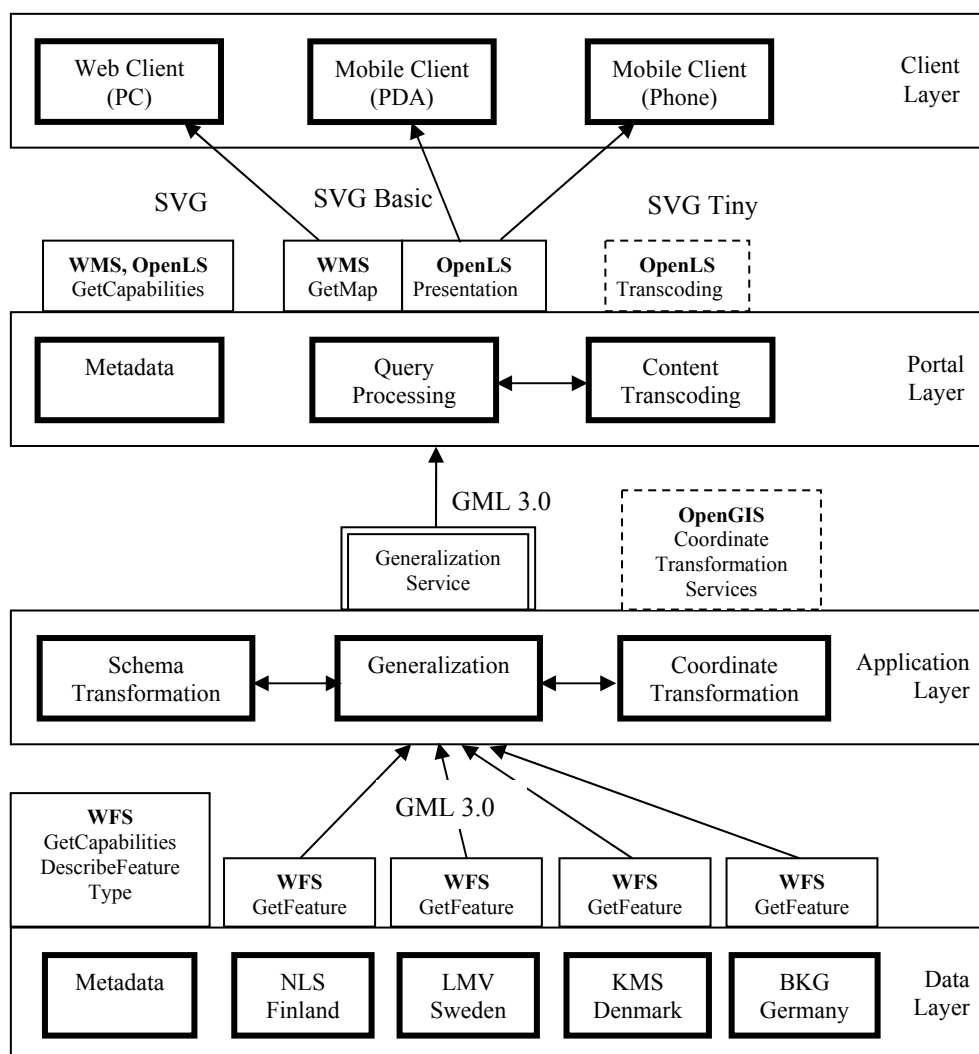


Fig. 2: A detailed view of the GiMoDig Architecture, together with the most important access interfaces and data Encodings.

3.3 Control Flow in GiMoDig Architecture

A service request initiated by a client application would start up a rather complicated process. In the following control flow scheme (Figure 3) the main steps involved in the fulfilling the request are depicted.

Requestor	Message	Control flow	Target
Client Application	GetCapabilities request	1 →	Portal Metadata
	GetCapabilities document	← 2	
Client Application	GetMap request	3 →	Portal WMS, OpenLS Presentation
	SVG image	← 15	
Portal WMS	<i>Init</i>	4 →	Content Transcoding
Portal WMS	<i>Generalize</i>	5 →	Generalization Service
	Generalized GML	← 12	
Generalization Service	GetFeature	6 →	WFS, NMA A WFS, NMA B
	GetFeature	- - - - -	
	GML data	← 7	
Generalization Service	<i>TransformSchema</i>	8 →	Schema Transformation
	GML, GiMoDig Schema	← 9	
Generalization Service	<i>TransformCoord</i>	10 →	Coordinate Transformation
	GML, EUREF	← 11	
Portal WMS	<i>Transcode</i>	13 →	Content Transcoding
	SVG image	← 14	

Fig. 3: Request control flow in the GiMoDig Architecture

To be able to formulate a relevant query, a GiMoDig client application would first consult the metadata service for the Capabilities document (defined in the WMS specification). After that the client would call either the WMS or the OpenLS Presentation Service interfaces implemented by the GiMoDig portal. Upon receiving the request the GiMoDig portal service would process the query parameters, start the initialisation of the content transcoding service and then proceed to send an appropriate query to the GiMoDig generalization service (according to the interface specification to be designed in the project). The generalization service is then supposed to construct all the needed WFS queries to fulfil the request, and forward them to the relevant WFS servers in various NMAs. The returned GML datasets will then be integrated, transformed and generalized by the generalization service, and the

resulting GML file returned to the GiMoDig portal. Finally, the portal will transcode the GML code into an appropriate visual form to be sent back to the requesting client.

4 Conclusions & Outlook

The GiMoDig project can be seen as a case study, covering a representative subset of EC nations, and yielding results that would readily be adaptable into the whole Europe. The main practical result of the project is a prototype of a cross-border spatial data service providing access through a common interface, conformant with international spatial Web standards, into the primary national geo-databases. The provision of a standards-compliant service will promote creation of third-party, value-added mobile information services needed in the position-dependent applications, like traffic guidance, rescue operation management and personal navigation. The GiMoDig project thus aims at facilitating efficient use of the extensive amount of resources invested in the creation of nation-wide topographic databases, and at the same time advancing the exploitation of the multimedia-capabilities available in the technically advanced telecommunication networks in Europe.

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Real-Time Integration and Generalization of Spatial Data for Mobile Applications

Mark HAMPE and Monika SESTER

1 Introduction

The EU-project GiMoDig, an acronym for „Geospatial Info-mobility Service by Realtime Data-Integration and Generalisation”, aims at developing the spatial data delivery from national primary geo-databases for mobile use. The project started in November 2001. The following partners are involved in this project:

- Finnish Geodetic Institute (FGI) as coordinator,
- University of Hannover, institute for cartography and geoinformatics (ikg),
- Federal Agency for Cartography and Geodesy (BKG),
- National Survey and Cadastre Denmark (KMS),
- National Land Survey of Sweden (LMV) and
- National Land Survey of Finland (NLS).

The main vision of GiMoDig is a mobile user, travelling within a European country and receiving on-line information of his or her environment on the mobile device. Even when crossing a border, the type of information presented does not change, thus having the situation, that seamless topographic information is available.

The project deals with issues like user requirements analysis and small-display cartography constraints. On the one hand the data from the national databases have to be provided, on the other hand the user must be able to state his requirements. Because of the limited display size and resolution it is important to transmit only the required information to the user. This will include the selection of the desired objects and features as well as the desired resolution of the presentation.

Due to these requirements, one sub-objective of the project is the development of methods for generalising the graphic representation of geospatial data in real-time, to be suited for display of the data at varying scales on small, mobile devices. The presentation on the mobile display will be dependent on the special user requirements i.e. data resolution and content.

Because of the complexity of the processes involved going from a large scale to a small scale (say 1:10k to 1:Mio) it is obvious, that (at least today) the generation and visualisation of ad hoc personalised products of spatial data in arbitrary scales on a mobile platform cannot be solved without any pre-generalised datasets. Only the real-time generalisation can be restricted to operations of minor complexity that can be solved completely automatically.

The second major issue in the project is the harmonisation of data sets of the partner National Mapping Agencies (NMA's) in order to allow for a seamless data provision (workpackage “Global Schema”). This presumes that (topographic) data sets of the different countries are analysed with respect to their contents and that a semantic harmonisation is performed in order to guarantee the same “world view” when traversing the borders. Also here, the necessity of providing different data sets with different views of the same physical entities, as well as means to link these data sets is given.

Thus, in order to solve the problems of data generalisation and harmonisation, the concept of a MRDB (Multi Resolution / Representation Database) is used. On the one hand, the MRDB (Multi Resolution Database) serves as a pre-generalised and pre-harmonised data structure with spatial data in given scales. To minimise the effort of computation work during the real-time generalisation process, the GiMoDig-service selects a scale close to the desired scale requested by the mobile user. Based on this neighbouring scale, only small scale transitions are necessary, that can be handled in real-time. In this way the need for complex algorithms, for example simplification or displacement, can be minimised or even excluded.

In the course of the project, the merits of pre-computed datasets with various levels of detail (LoD's) in a multiple representation database in conjunction with methods for real-time generalisation will be investigated.

In a first step, the structure of the MRDB has to be developed, in compliance with the future generalisation and harmonisation work.

The paper is structured as follows: after an overview on MRDB and related work in general, the aims and the approach of the GiMoDig project are described and first issues for the solution of the problems are presented. A summary and an overview on future work conclude the paper.

2 Multi-Representation Database

2.1 Related Work on MRDB

A MRDB can be described as a spatial database, which can be used to store the same real-world-phenomena at different levels of precision, accuracy and resolution (DEVOGELE et al. 1996, WEIBEL 1999). Furthermore these phenomena can be stored in different ways of presentation or symbolisation.

It can be understood as a *multiple representation database* as well as a *multiple resolution database*. Regarding to the project in the first sense, the data integration is treated, whereas in the second meaning, the provision of different levels of detail, i.e. generalisation will be worked on.

In a MRDB, different views on the same physical objects or phenomena can be stored and linked. This variety of sights can stem from different views of the world, different applications, as well as different resolutions. These lead to differences in the objects as such, i.e. in the semantics and in the geometry. Also the graphic representation can be taken into account, leading to geometric, semantic and graphic multiplicities (BERNIER et al. 2002).

There are two main features that characterise a MRDB (see Fig. 1):

- a) different levels of detail (LoD's) are stored in one database and
- b) the objects in the different levels are linked.

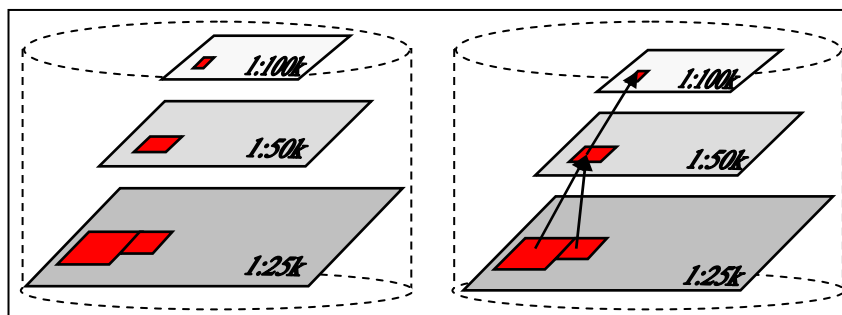


Fig. 1: a) MRDB with separate scales b) objects linked between the LoD's

The first feature can be compared to the analogue map series of the NMA's: these maps of different scales exist separately, only linked by the common geometry. In the second case, however, individual objects are linked with each other and thus allow for a detailed inspection of individual objects via several scales: BADARD ET AL. (2002) use the notion of "drilling" objects through the scale space.

There are several existing concepts of MRDB's who depend on the specific needs and requirements. Research projects aiming at combining real-time generalisation with multiple representation databases can be found in BADARD (2002) AND CECCONI (2002). VANGENOT et al. (2002) describe modelling concepts which support not only

the multiresolution view but also the different views on the object features like object types, attributes and their values. KREITER (2002) describes the concept of a MRDB from the NMA's point of view.

Important questions concerning the implementation of a MRDB are:

- (a) The number of layers to be provided:
It depends on the application area, typically at factor two to four the appearance of spatial phenomena changes so dramatically, that intermediate layers have to be introduced.
- (b) The necessity of links between layers:
The question concerning whether explicit links should be established depends on the application; also the way these links are designed is of importance (uni-directional or bi-directional). If there is only the requirement to visualise the spatial data, separate scales may be sufficient (see Fig. 1a). In order to offer more functionality (i.e. GIS-functionality) it is necessary to compute the link (Fig. 1b).

There are several reasons for introducing a MRDB: On the one hand it allows for a multi-scale analysis of the data: Information in one resolution can be analysed with respect to information given on another resolution. E.g. GABAY & SESTER (2001) present an example where a topographic data of lower resolution containing only settlement areas is queried concerning the buildings in that area – an information that can be derived from a more detailed data set, whose objects are directly linked. A major reason for National Mapping Agencies to investigate and implement MRDB is the possibility of propagating updates between the scales: the actual information is only updated in the most detailed data set, this new information can then be propagated through the links in MRDB to all the other scales (KILPELÄINEN (1997), HARRIE et al. (1999)). CECCONI (2002) discusses the possibility of creating intermediate scales based on a MRDB using a set of rules.

DEVOGELE et al. (1997) classify three different stages when designing a MRDB:

- (a) *Correspondence between abstractions*: Database schemata translate phenomena of the real world into abstracted instances of databases by focusing only on relevant parts of these phenomena; integration of abstractions thus requires methods for schema integration on the semantic level.
- (b) *Correspondence between objects* of different representations: Data models are required to describe the links between corresponding individual objects of the different representations.
- (c) *Defining the matching process* between objects: in order to identify corresponding (homologous) objects, two sets of geographical data must be searched for objects that represent the same real-world objects; methods for this purpose are subsumed under the term 'data matching' (BADARD (1999), SESTER et al. (1998)). In the case of multiple resolutions, the correspondences between different objects can also be established by generalisation operations.

2.2 The GiMoDig Approach for Integration and Generalisation in a MRDB

Concerning the three stages of designing and populating a MRDB, the first problem (a) will be treated in GiMoDig in the workpackage "Global Schema" and will be described in section three. For every selected scale an own semantic schema has to be established. Besides the re-classification procedures are required for harmonisation of the conceptual models. The operations include also tools for adaptation of geometry (e.g. conversion of geometry type) and adaptation of resolution (e.g. aggregation of features). Such tools are elements of model generalisation, thus linking the work in workpackage "Global Schema" and workpackage "MRDB / real-time generalisation".

In section four ideas for establishing links between objects in different scales will be presented. The *ikg* participates mainly in these two workpackages dealing with semantic harmonisation ("Global Schema") and generalisation based on MRDB ("MRDB / real-time generalisation"). The research on real-time generalisation will be mainly accomplished at the Finnish Geodetic Institute (FGI) and the National Land Survey of Sweden (LMV).

To derive the objects of the less detailed LoDs two cases are conceivable:

The first option is the case to combine existing datasets of different scales to an MRDB by a matching process, as pointed out in the third problem (c) above.

- The other is to derive the less detailed LoDs from a base-level of higher LoDs, in our case from the core datasets of the NMAs (i.e. ATKIS Basis-DLM in Germany). This will be the approach pursued in the project using generalisation operations to link different resolutions, which leads to the following problems.

By implementing the second solution, new problems occur (spotted so far):

- There are no existing generalisation-tools who allow an automatic generalisation of a given dataset,
- besides model generalisation also cartographic generalisation has to be taken into account, as the objects have to be clearly visualised and symbolised on the computer screen.

These are open research questions that also will be tackled within GiMoDig.

3 The Global Schema

The ideas presented in this section were mainly developed at the Federal Agency for Cartography and Geodesy (BKG) as the main partner in the workpackage “Global Schema”.

The raw data for the MRDB in GiMoDig comes from the National Mapping Agencies (NMAs) of Germany, Sweden, Denmark and Finland, as the aim of GiMoDig is to provide access to the national (primary) topographic geo-databases.

Because of the dissimilitude of these datasets, the first step will be to transfer them into an integrative data-schema. This schema has not only to be developed for the highest LoD but also for every layer in the database.

All of these countries can provide national data at resolutions 1:5k to 1:10k, 1:250k and 1:1.000k. Data at resolution 1:25k to 1:50k is available in Finland and Sweden only, but is planned also in Germany and Denmark for the near future.

The specifications for the EuroRegionalMap and EuroGlobalMap, two projects developed by Eurogeographics (2002), the organisation of European National Mapping Agencies, do already pave the way for pan-European topographic databases at medium and low resolution (1: 250k and 1: 1.000k). Therefore, GiMoDig will concentrate on the higher resolution datasets up to a scale of 1: 100k.

The workpackage “global schema” deals with the data integration. Inspecting the databases of the NMAs reveals different views onto the same real world phenomena. The different feature-catalogues and representations of the same real world objects mirror these differences. Looking, for example, at the object “grassland”: In Germany “grassland” is an object of the objectclass “vegetation” and is presented as an area feature (to be found in the ATKIS-OK25). In Denmark land-use is not registered in the topographic data base and in the Swedish database “grassland” can be interpreted as all open land that is not defined as “forest” or “arable land”, so “grassland” is not mapped explicitly.

Because of their dissimilitude these data have to be harmonised before they can be used in the info-mobility service. To harmonise means in this case to design a common schema and to transform the various models and data-sets into this schema.

The preliminary global schema, devised by ILLERT & AFFLERBACH (2002) for the project, is based on the selection of object feature types from the national core databases.

The distributed feature groups will be as follows. They are ordered according to the EuroRegionalMap specification (EUROGEOGRAPHICS 2002):

- Boundaries,
- Hydrography,
- Miscellaneous (including feature types like parks, buildings, cropland etc.),
- Settlements,
- Transport,
- Vegetation and soils.

For the harmonisation of the national core databases into a global schema several rules have to be defined in order to find a schema that minimises the harmonisation efforts and at the same time is consistent with the EuroRegionalMap. A proposal for the rules according to the principle of the least common denominator is the following set (defined in ILLERT & AFFLERBACH 2002):

- Feature type: The semantic model is a subset of the semantic model of the EuroRegionalMap.
- Geometry type: That geometry type (point, line, area) with the majority among the national datasets is chosen.
- Collection criteria:
 - Case A: same selection expression but different thresholds.
For example feature type *Park*:
DE All green areas with a size of more than 10.000 m² are recorded
DK Recreational areas larger than 2.500 m² are included
FI The minimum size of a park is 5.000 m²
In this case the least common denominator has to be chosen, therefore all parks with more than 1 ha are recorded.
 - Case B: different selection expressions:
Use only those collection criteria that are common to a majority of national databases and connect the expressions with Boolean OR.
- Attributes: Attributes of the EuroGlobalMap are only included to the GiMoDig global schema, if they are supported by the majority of the countries or are of great importance.

In part, this can imply that data has to be captured by the respective partners, in order to comply with the common global schema. This (preliminary) data-schema with its objects and features serves as the data-schema for the base-level of the database.

Additional models have to be developed for the following levels of the database by model-generalisation.

4 The Multi-Resolution Database in GiMoDig

The workpackage “MRDB / real-time generalisation“ relies on the schemas developed in the workpackage “Global Schema”. Therefore, the semantic multiplicity will be eliminated before the data are stored in the project-database. As the data models will be harmonised the database will contain only a geometric and graphic multiplicity and can thus be defined as a Multi Resolution Database.

The MRDB in the project is used to facilitate the real-time generalisation process.

In the project, a seamless generalisation is aimed at, i.e. any scale can be generated depending on the application (See Figure 2). This will be achieved by integrating pre-generalised data and on-the-fly generalisation operations. The latter is based on using XML and XSLT (LEHTO et al. 2000).

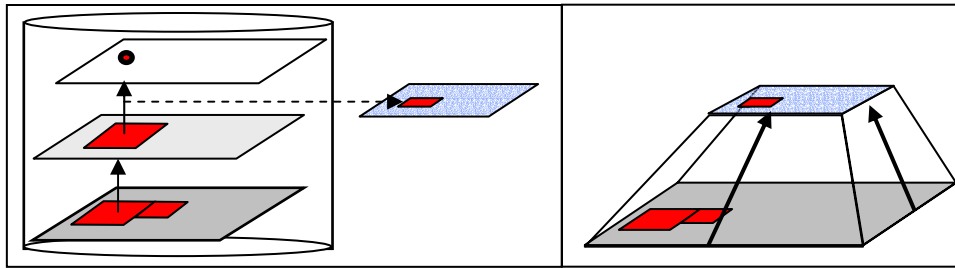


Fig. 2: real-time-generalisation by a) pre-generalised data or b) in one step

4.1 The Database Schema

The database-software used in the project is an open-source, unix-based and object-relational DBMS called *PostgreSQL* (POSTGRESQL 2002). It supports almost all SQL constructs, including subselects, transactions and user-defined types and functions. It will be used together with an extension called *PostGIS* (postgis 2002), which adds support for geographic objects to the PostgreSQL object-relational database. PostGIS follows the OpenGIS "Simple Features Specification for SQL" (OPENGIS 2002).

The work has started with the two feature types roads and building. This work and concept is inspired by work of N. KREITER (2001).

For our first experiments we are using a cadastral data set of approximate scale 1:1k and the ATKIS Basis-DLM (1:25k) that will be integrated in the database (Figure 3).



Fig. 3: The stored ATKIS[®]-dataset. Presented as a SVG-graphic.

The existing datasets, which are available in the ESRI-conform *shape*-format, can be imported to the database by the simple tool *shp2sql*, distributed by PostGIS. The *shp2sql* data loader converts ESRI Shape-files into SQL suitable for insertion into a PostGIS/PostgreSQL database. This tool facilitates a conversion and uploads to the database.

Figure 3 shows an example of the ATKIS data set. The corresponding representation in a PostGIS table is shown in Figure 4.

gid	aobjid	text	the_geom
53	N01AB AQ	N01AB AQ014N01AE	SRID=-1;MULTILINESTRING((3547632.93 580
54	N01AB AQ	N01AB AQ014N01AE	SRID=-1;MULTILINESTRING((3547619.32 580
55	N20GR7A	N01FUF7	SRID=-1;MULTILINESTRING((3547570.77 580
56	N01FUHH	KN0320100000400	SRID=-1;MULTILINESTRING((3548130.87 580
57	N01FUHG	GNOffensteinstraße	SRID=-1;MULTILINESTRING((3548065.06 580
58	N20C8N2	KN0320100001810	SRID=-1;MULTILINESTRING((3547811.35 580
59	N01FUH4	GNFröbelstraße	SRID=-1;MULTILINESTRING((3547927.09 580
60	N01FUHD	KN0320100002857	SRID=-1;MULTILINESTRING((3547982.2 5804
61	N01FUH6	KN0320100000435	SRID=-1;MULTILINESTRING((3547906.18 580
62	N01FUH7	KN0320100003259	SRID=-1;MULTILINESTRING((3547982.2 5804
63	N01FUHD	KN0320100002857	SRID=-1;MULTILINESTRING((3548018.92 580

Fig. 4: Part of the PostgreSQL / PostGIS database-model

To link the two datasets, first of all, the possible relations between objects at different scales have to be identified. The following kinds of links will be possible between the objects:

- $1:1$ relation: one object in scale A refers to one object in scale B (the object may however be simplified in shape)
- $n:1$ relation: more than one object in scale A will be aggregated to one object in scale B
- $1:0$ or $n:0$ relation: one or more objects will be omitted in the lower LoD
- $0:1$ or $0:n$ relation: objects will appear only in the lower LoD.
- $1:n$ relation: more than one object in a lower LoD arised from one object in the higher LoD: i.e. displacement

The links are represented in the tables that have to be enhanced with additional attributes.

The first idea is be to extend every table, representing the objects of one scale-level, by two more columns. An ID-Number of the object in the actual level and the ID-Number of the object in the following level has to be added.

ID1k	ID25k	the_geom	...
1	10	Linestring (...)	
2	10	Linestring (...)	
3	10	Linestring (...)	

ID50k	ID100k	the_geom	Dx	Dy	...
10	50	Linestring (...)	12,5	7,8	
11	50	Linestring (...)	3,7	5,5	
12		Linestring (...)	7,8	5,3	

Fig. 5: First possibility to compute the linking structure

In this case two problems can occur. There are empty fields for those objects that do not appear in the following LoD. The other problem is, that one or more objects in the level 1k can only be linked with one object in the level 25k, although there are cases where more than one link is required. For that case an additional line has to be inserted and that means that the whole object had to be duplicated.

Another approach is to generate an additional linking table for every link between two scales. Each row of this table indicates a relation between two objects.

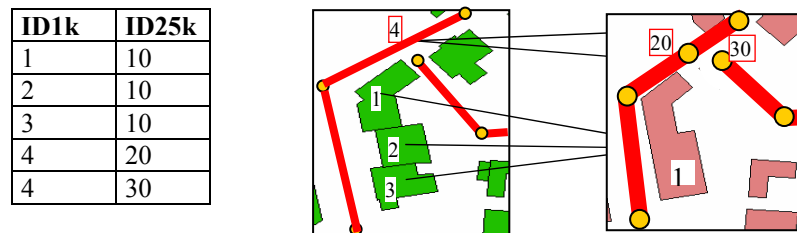


Fig. 6: Alternative possibility to link corresponding objects by using an extra table

This solution covers the case of a 1:n relation, shown in figure 6, as well. These cases occur for instance when two datasets of different sources with different data models are combined (i.e. ALK and ATKIS in Germany) as shown in GABAY & SESTER (2002).

As shown in this table all kinds of relations can be modelled. In the case of a 1:0-relation, i.e. an object disappears, no relation has to be stored.

5 Conclusion and Further Work

The idea of the GiMoDig-project is to bring the topographic data of the national mapping agencies to a mobile user. This user will have the possibility to freely specify his / her needs for the delivered map, i.e. scale, accuracy and features.

It is shown in this paper that for setting up such an info-mobility service there is a necessity to integrate the inhomogeneous data of the NMA's. In a first step these data have to be translated into a global schema.

To generate the required data as fast as possible the data should be generalised and harmonised in real-time. In order to this real-time-service the service-provider must have the possibility to resort to prepared data. Only a selection of features and minimal changings has to be computed, that can be accomplished in real-time. This paper showed the advantages of storing these data in a MRDB and an approach to model this database.

The paper could only show preliminary ideas and concepts. In the near future, these concepts will be implemented and tested. Firstly the data model will be established and populated with data, i.e. two linked datasets will be generated by manual linking.

After intensive testing of these structures, some selected datasets with streets and buildings have to be generalised automatic or semi-automatic. During this process the corresponding objects of two scales have to be linked automatically. The relationships are generated based on the generalisation operations performed on the objects.

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Geo-Data Visualization on Personal Digital Assistants (PDA)

Theodor WINTGES

1 Introduction

The present taking place, technical development of mobile computers, personal digital assistants (PDA) and handhelds and their excellent equipment in the sense of mobile telecommunication tools led to our consideration to make a design for user interfaces and to create a presentation of the geodata for the day by day use and the orientation in space for a modern user between age 26 to 40.

The small display size, a simple attendance, self explaining user guidance but also an optimized visualization of the geoinformation stood in the focus of the given task. Beside a description of the user profile, the intersection of the information as well as the communication between the equipment and the user were of importance. At the end we have different suggestions for the user interface design. The main question was to find several variants (solutions) for the page design, for the navigation as well as for the map design and the lettering.

2 Technical Assumptions

For the extensive attempts of a design for the user interface, the navigation and interaction with the user interface we brought into action the Compaq PDA iPAQ 3870 Pocket PC with the operating system Microsoft Pocket PC 2002. This PDA has a 206 Mhz Intel ARM processor, a memory of 64 MB and uses the best colour display which is at present on the market. After the switch at the power button all following operations are carried out available with a plastic pen directly above the toolbar which appears on the display or with the help of navigation of tools of the user interface. Beside those soft keys the equipment also uses hard keys which are the main control keys for scrolling in four directions. Four further quick start buttons are programmable for the navigation and interaction. Using a phone card makes the mobile data transfer possible.

The usable display is a touch sensitive screen constructed like a flat screen model. It has a width of 240 and a length of 320 pixels that responds to 57,6 x 76,82 mm. That means the equipment has a resolution of 106 dpi. This is a pixel size of 0,24 mm. Its brightness is assessable or fully automatically regulated. The high reflecting screen which is illuminated lateral is corresponding with the construction of the TFT principle. Its profit is the reflection through the falling environmental light. This guarantees a good readable display surface even outside under a bright sky. Because the display is constructed like a touch screen, the easy of using the user interface with the touch of a finger or a pencil is possible. We used the software of Microsoft for pocket PC 's „Windows CE, CE for consumer electronics“, which is installed on the operating system of the PDA. With the actual version pocket PC 2002 we could set in the software Macromedia Flash Pocket Player as well as the multimedia software Media - Player 8 and MS Word however MS Excel. Strictly considered the operating system is comparable with a simplified version of Windows 98. The data transfer technology will not be described in detail, for this was not the major task of the development. The same statement is hold for the different localization possibilities which are attainable with the PDA.

3 User Profile

The first aim of a software application is to develop a product which is „user friendly“ and efficient at the same time. For those applications on a pocket PC it is not sufficient to use the feed back which comes from that technical equipment like mobile phones, laptops, car phones or car navigation systems. For using those equipments we need quite different criteria for the layout of a user profile. That means we have to think about the high operating costs, necessary computer knowledge and the experience in the use of geographical, cartographical as well as other software products. Such restrictions stand at present for a user group aged between 25 to 45 years. For those users

the user interface should be easily understandable and quickly and simply to use. Measured on the necessity of information the content used with the software application has at least to be orientated to the user's profile. In this case it should be possible that the following coarse structure of a structural navigation in a space - like a city - should be guaranteed:

- Points of interest
- Routing
- Extras
- Areas
- Locations.

For these mentioned main themes it is important to have a selection of consecutive map scales.

4 Data Base

To give the user of the application a clear and familiar picture to compare with the surroundings found by him we have to solve the problem, that with the PDA display we have restricted design possibilities, which must be used for the design of the user interface. The basis information for the orientation in space could be high resolution satellite images or aerial photographs. Abstract, thematic maps have to be developed for the user in an easily understandable, intimate key of symbols and type faces used in the map. For this map design these can be included in the different map scales, special raised geometry data which could be overlaid, too, in a special case with raster data. The realized map design was built up on vector data by TeleAtlas in the version MultiNet 01.1. These vector data were collected out of different map scales like 1: 12 Mio, 1: 575.000, 1: 200.000 and 1: 15.000. The recording of the geometry data (vector data) in this different scale makes it possible to use the data like an intelligent zoom through the whole application without any generalization of the keys for the symbols like lines, point information or areas. As we know most of the visualization problems we have in every applications is the generalization for the use in different map scales. MultiNet is the most extensive, digital, vector based map product that is obtainable in Europe. The used coordinate system is based on the WGS 84 - ellipsoid. The above mentioned coarse structure for the structural navigation can be fulfilled sufficiently. The data have a different road system, numerous points of interest and administration districts. Relative to additional orientation possibilities like those on the base of pedestrians will be possible, too, by integration of other large - scale maps into the application.

5 Map design

Except of direction depending aliasing effects the deformation of areas with different pictorial points and the deformation of circles (pictograms) have to be avoided. As well known one can renounce the antialiasing as an image improvement method, if one can use a very good screen resolution like those of the PDA equipment. The results described in this paper did not renounce the mentioned image improvement method. The well known problem of a necessary generalization was avoided through a strong uniform design of the used geo - objects and the above described use of the restriction imposed by scale for the vector data.

As the screen only has a resolution of 106 dpi, we had to have respect to the visualized minimum size of the graphic parameters of the geo - objects as well as to the lettering. For this we had to think about the absolute size of the presentation area, the raster size of the frame buffer and the raster size of the presentation and the output media. Also we had to regard a consideration distance of about 50 cm to the operation with the PDA. This led to a minimum size of 0,24, 0,48 and 0,72 mm for different width linear signatures. In the application of type fonts we used preinstalled Microsoft Mobile PC type fonts like Verdana, Trebuchet and Geneva. For an optimized readable lettering beside the usual possibilities of the lettering the design type sizes of 12 and 10 points were favoured. For the mediation of the geoinformation the interface has to be developed in a way which allows the user a time of learning in a speed that would be a strong reduction of mistakes in using the user interface.

In the foreground of the development stood to create something that is different from the usual development in most cases where interaction is not produced by intuition over the user interface. But in our application the intuitive use

of the interface is produced by the special design of the application. That means for instance the optimizing of colours which are attuned to one after another through a corresponding colour match. But also the use of colours which call for special perceptions like the use of differences in brightness for small and large areas. We also had to regard the tiredness of the eyes reading the information on a bright radiant screen. With the most important kind of shaping the use of high contrasts for the colours tuned harmoniously stood in the centre of interest for the solution. We worked with colour association, with a reduction to 5 to 8 colour classes, which was possible through the aimed use of colour or brightness. This kind of coding makes it easy to search information parallel. Beyond it was also used, to find the sequence of the faster noticed colours and the effect of visual suspended colours sorted after the intensity of its effect.

First attempts in the mean of assistance in perception (map face versus natural surroundings) were based on the communication produced by the application and the use of complementary media types. Beside the sound, language was only used very restrictedly. More distinct focus was laid on a double encoding through the use of a high quality of the word - and the picture - information. In front of the development stood the cognitive information process of the user and to provide him logical and interest taking photographs or links to a website. The habit of the user was supported by value of recognition which is controlled by the user interface in the way the brain in reaction to present irritation (short term memory control) could be retained.

6 User Guidance

It is possible to separate the design of the user interface of the application into navigation and interaction variants. We have to distinguish the navigation into a structural and a content navigation. The structural navigation makes it possible that the user will be led through the whole application. That means he can change from one page to another, but also, that he will be guided into other main themes, and that it will be possible, too, to leap over contents and to use general functions. The content navigation however allows the user to activate themes, moving run offs on the screen, which means for instance the zooming of a map within the screen page.

With regard to the design of the user interface from this a force arises, that the content as well as the structural navigation have to be separated definitively optically one to another. In this case it is a question of the separation of elements of page contents and those of navigation. That means that the application needs an unmistakable marking of the elements like the content control only over device keys. With such a design user interfaces obtain the aim of an optimized applicability which guarantees a harmonized simplicity and logic in the use and allow highest efficiency and short training periods for the user.

As well known the interaction is the intervened steering of the user into the linear program run down. For the development of the software, the orientation on the knowledge and the qualification of the user it is important for the user not to be overtaxed or undertaxed. But beside this, the succession of the contents or their possibilities of combination like the used map layers or the complement or the deletion of contents should be strictly observed. The safe move through the application can be guaranteed only, if it is attainable that unnecessary learning processes within consistent user interface guidance can be eliminated. For this we can use a recognizable hierarchy of the elements of navigation as well as a distinct separation of the navigation elements from the page content. Similar functions should be accessed in the same way. The status of the reaction time should be recognizable or the interaction taking place should be indicated to the user in an optical or acoustical way. Beside this the user must be allowed to go backward within the application as well as the animation to special perception stimulus which allows to go deeper into the application. For that interactive work it is of decisive importance that the software has an uniform design. As there can be used only a few device keys, since function keys will not be offered by the user interface (the screen is too small). It would be important to design buttons which could be used with the finger (touch screen) or in the same way interactively with a pencil. That means that within the content conception of the application there should not be renounced on screen buttons or menu items. Since a mouse - over status does not exist it should be replaced expediently by a click action or a stop action. Those maps used in the software help only within the orientation in geospace. The carrier of information is the map and the map guarantees the visualization within a limited area with its character set. The single map elements carry beside their primary information also secondary information which can be called by clicking the map elements. The information reception can take place acoustically or visually, if there is a need for two - channel encoding.

7 Solution Suggestions

Within the variants of the mentioned suggestions concerning the page design, the structural navigation as well as the map design and the lettering, the developed concepts deal with:

- the arrangement of the theme buttons
- the external and the interior map design like the selection and specification of colours and the result of the colour contrast
- the readability, especially of the lettering
- the background colour to avoid glimmer effects
- the problems of the colour reversal (activation and non activation of hard- and soft-keys)
- a harmonious texture of the design elements
- the optical equivalent of the different buttons
- the design of the user interface in the sense of necessary accessory themes
- the selection of accessory themes via input mask and via input field
- the use of symbols and pictograms - pictorial symbols for an intuitive navigation
- the design of tool bars, display window and of pull down menus
- the installation of an image area as a help of recognition for a special part in the application.

Beside the navigation over the map areas, we have also regarded the design of the pop - up menu windows which allows to control the information reception. The vector data were accessed by MapInfo Professional and ArcView and were exported into a DXF - as well as an AI - format. The raster data processing was made by Adobe Photoshop. The DXF - and AI - files were prepared with Macromedia Freehand and we used the authoring program Macromedia Flash for the animations. Based on the oscillating quality of the illumination, we used high contrasts for the representation of the geoobjects and for the realizing of clear sharpening of the geoobjects we returned to the use of anti - aliasing. Signatures and pictograms were defined in pixel and in R G B colours in dependence on the display quality. Only for the largest scale we used the lettering of map elements. Road names are either permanent or in case of overlay the name appears only by a click on that object. Further information which explain details or are in relation to a special content are accessed by pop - up menus. For the lettering of the map elements for instance a 12 pt big Verdena was used, but for the lettering of the buttons we used italic Futura Md Bt.

A special built up master - story - board helped to make clear the content navigation and the interaction within the application. The application content is built up modular to make an up - date easier. Return functionality leads the user back to last used page. On the storage medium the actually content of the application will be stored before switching off the equipment.

The design of the buttons is arranged clearly. The symbols are readable, familiar pictures are easily to identify and we set a high value on an optical clearness as well as on an optimal short - and long - term memory effect. To guarantee a work without scrolling and also with a display area of activity we worked with pop - up menus and information frames which fall back to a structural layer model. This makes it possible to use simplicity, clearness of design, short learning phases and a certain automatization for the user in working with the user interface. If the user is uncertain, he gets help functions. For the lack of processor power we renounced extensively use of sound. These restrictions are allowed for the use of animations, which can last only a few seconds using equipment on the present state of the technical development.

8 Outlook

The development of a screen design for an user interface for mobile computers like a personal digital assistants is made. The upcoming months we will need to program the application. First steps are tackled together with a company, but it is not easy to find a market for such a new product. It will be necessary in the future to look for a good product management and marketing. That is only possible together with a distributor for such specialized hard - and software, since the market for these products is at present very small. For the future market we will broaden sound, animation and an internet connection within the application.

You will find one example of the solution suggestions in the appendix of this paper.

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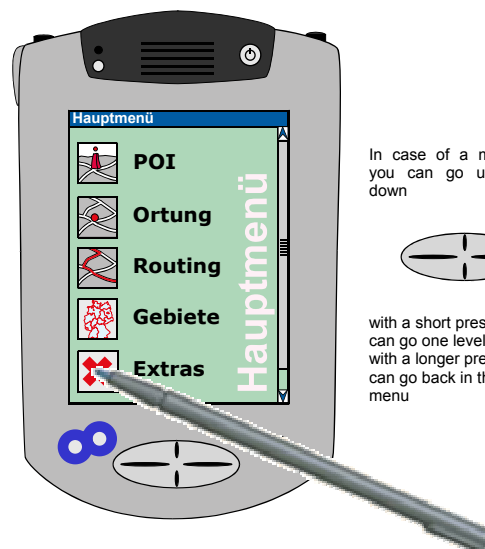
Appendix

Demonstration for design and navigation of the menu option „Extras“



Extras

button or
on the text



In case of a mistake
you can go up and
down



with a short press you
can go one level back;
with a longer press you
can go back in the main
menu

Fig. 1: Design of an user interface

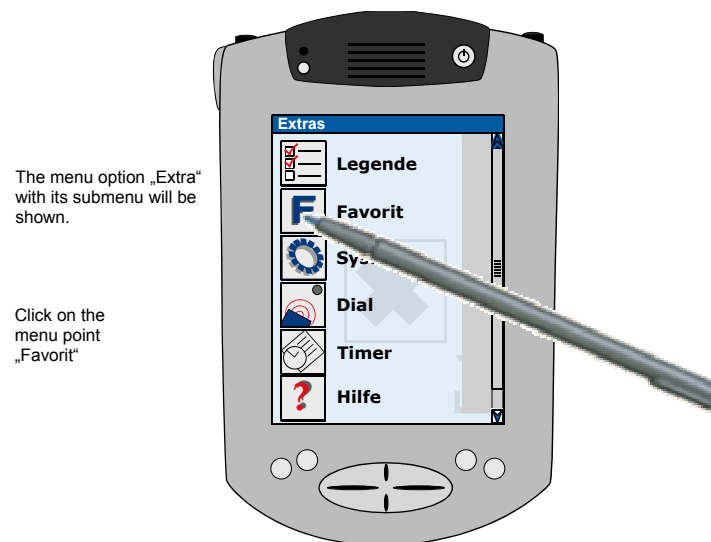


Fig. 2: Design of a structural navigation and the recognizable hierarchy of the elements of navigation (see background of the screen design)

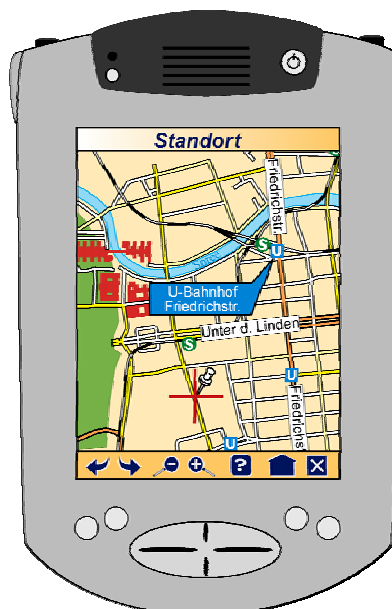


Fig. 3: Lettering of a map with the scale 1 : 15.000



Fig. 4: Design for a point of interest (POI), in this case a special location



Fig. 5: Animated point of interest with the possibility of an internet connection

Additional Papers

GeoInfo.online: Geographic Information in the Intranet of the City of Hamburg

Ekkehard MATTHIAS

1 Geodata as an Infrastructure

Geographic information are economic goods. Within a lot of tasks they serve the preparation of decisions. A meanwhile often-quoted statement is that for more than 80% of all activities and decisions in administration and economy data with geographic connection are called on. Consequently, in the Hamburg administration as well the spreading of geodata has won more and more importance during the last few years in the form of digital maps and their use in geographic information systems (GIS). GIS have found access to many authorities and the basic data of the Office for Geoinformation and Survey of the Hamburg Ministry for Building and Public Transport are widely used: While some years ago only a few authorities used to work with geodata, today there is no authority without the equipment with corresponding data and software.

Nowadays Hamburg has made a big step closer to the aim „to provide geodata as a generally available infrastructure“. Nevertheless we must realize that the different parts of the Hamburg administration don't use one standardized system, but on account of their respective demands they have different tools for the treatment of the data. The „Information and Communication Architecture Directive“ of Hamburg enumerates a series of standards. Although this is only a low number of possible systems, it causes various problems within the data exchange between the authorities, so that important information can get lost on their way through the offices.

However, many users don't need special software which is often very expensive with regard to financial means and qualification of the staff, but they would like to see "only" existing data and use simple functions as for example "print" or "distance measurement". Here it is advisable to create an authority-wide general solution which manages without training for the staff and expenditure for maintenance.

Collect the interesting fruits from the different cultivation areas, put them in a pot without much stirring and place them on the table. The whole menu is arranged in buffet form - everybody helps himself. Fork and knife are enclosed, but nobody has to use complicated lobster tools.

Seriously: geobasic data (digital city base map DCBM, digital city map DCM, aerial photographs DOP etc.) and geobranch data of general importance (e.g. development plans, statistic data) should not be hidden in only a few specialized software systems, but be of advantage to all authority members.

This is the reason why GeoInfo.online was developed and at present is in production.

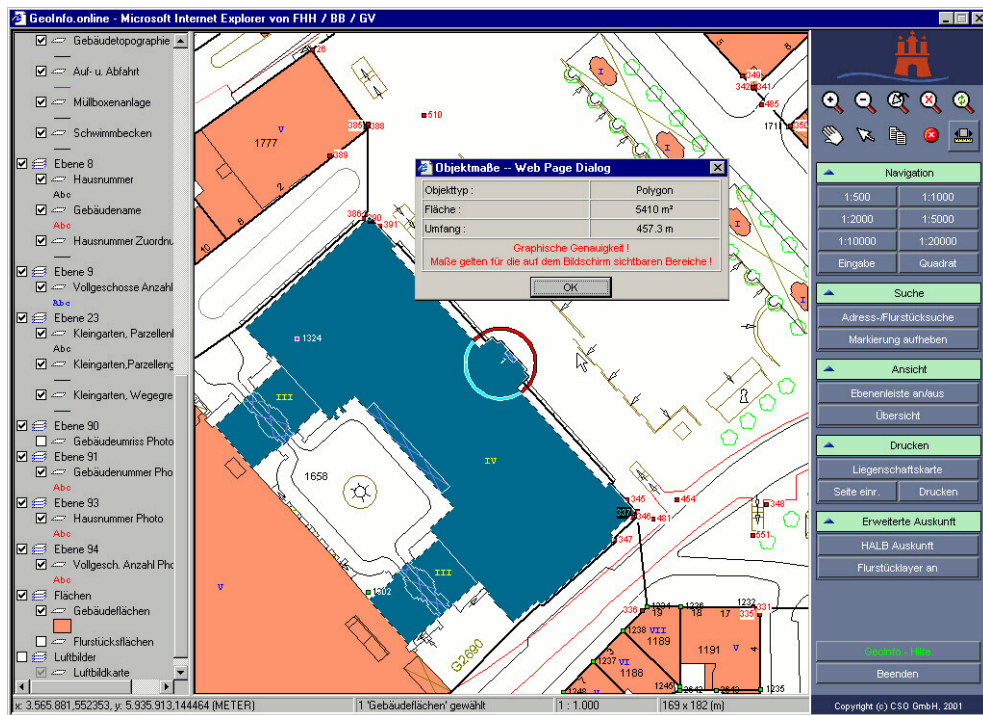


Fig. 1: Screenshot GeoInfo.online with object sizes

2 A Fast and Simple Information System

To give simple access, orientated by the customer's wishes, GeoInfo.online was developed as a browser-based application on Autodesk MapGuide® in the FHHinfoNET (Intranet of the City of Hamburg with approx. 30,000 PCs). For it nobody has to install special CAD- or GIS-software. Some of its essential functions are

- the choice of different maps and displaying them within seconds,
- the overlay of map and aerial photograph,
- zoom, pan,
- the search for addresses and real estate / parcel numbers,
- the measurement of distances and floorspaces,
- tool tips with additional non-geometric data,
- simple digitizing features for line, text, symbol,
- scale printing,
- the download of autocad dwg formatted data,
- the integration of real estate cadastre for searching parcel-owners (only for legitimated users).

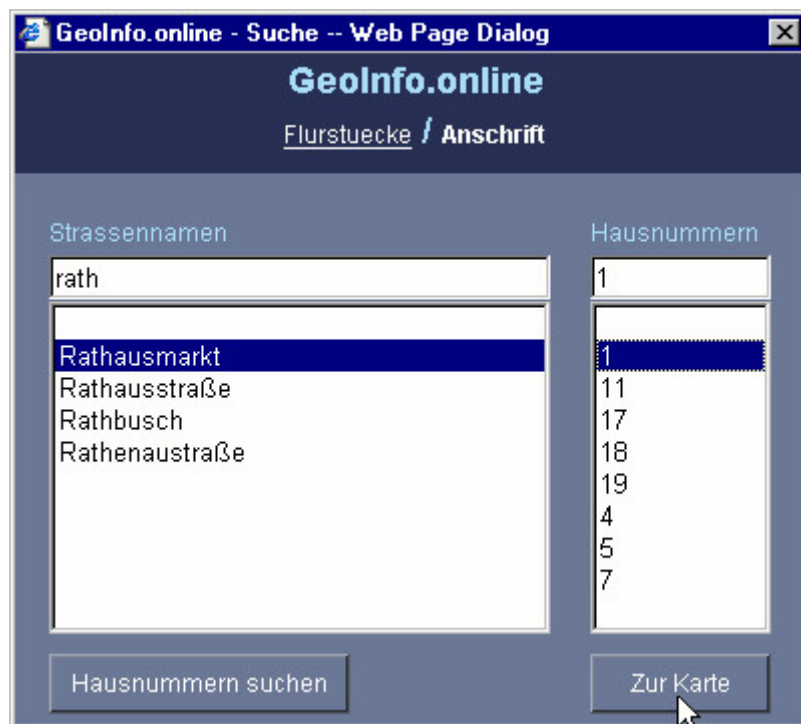


Fig. 2: Entrance by street & house number

In addition we are planning to integrate data from arcGIS® without any transformation and data from any schedule. This will allow an elegant extension with various geobranche data to make GeoInfo.online an extensive information and presentation system of Hamburg geodata: from Hamburg authorities for Hamburg authorities.

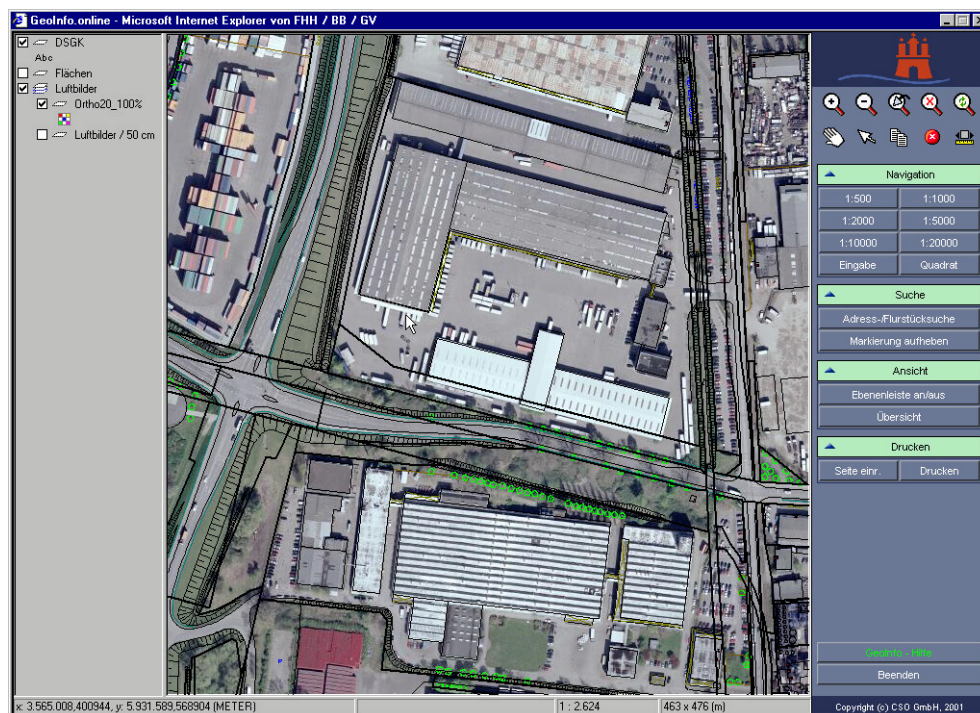


Fig. 3: DCBM plus aerial photograph

3 How to Put Other Geodata into GeoInfo.online?

At present the data are stored on servers at the Office for Geoinformation and Survey (GV). The connection to several - also distributed - geographic datasets and RDBMS (e.g. MS SQL-Server®, MS Access®, Oracle®) is possible. The supported data formats are various (dxf, dwg, shape, tiff, jpeg etc.). So it is possible to store geodata on the server of the surveying authority or on the server of the special branch itself. In both cases the owner of the data remains responsible for who should have access to their data and who should not, i.e. also office-internal applications can be run by GeoInfo.online.

4 Further Developments

Currently more than 1,000 users from different authorities are connected. Other departments will gradually follow. A commercial expansion on the Internet is planned.

With that, GeoInfo.online is a component of a future geodata infrastructure of Hamburg (GDI-HH) and is embedded in the eGovernment efforts of the city as well as the nation-wide GDI activities. This includes technical aspects like the installation and providing of a geodata server, the creation of a standardized geodata model and the integration of the Hamburg Metadata Catalogue (HMDK®) as well as organizational and political measures for the durable consolidation of the GDI.

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Concepts for User-Oriented Cartographic Presentation on Mobile Devices – a Pedestrian Guidance Service for the TU Vienna

Beatrix BRUNNER-FRIEDRICH and Clemens NOTHEGGER

1 Introduction

In this paper a concept for a user interface of a pedestrian guidance service is presented. The service is intended to work on any currently available WAP-enabled mobile phone (display resolution approximately 90x90 pixels). The possibilities of other mobile devices with extended display capabilities, especially PDA or phone/organiser devices like the Nokia Communicator are not considered. The design goal was that the service should provide navigation information in an efficient and user-friendly way.

The motivation for this work is that even the next generation devices might, mainly for cost reasons, not all have high resolution, brightly coloured displays and the current generation of mobile phones will be around longer than telecom operators and mobile phone producers hoped. Today's purely text-based guidance solutions work reasonably well, and, if well done, adequately support the navigation task. However, to facilitate the acquisition of survey knowledge, a map showing the route layout including en-route landmarks is better suited.

We intend to show that the presentation of route information in the form of route maps, if supplemented by textual information, can be advantageous even on extremely small, monochrome displays that would ordinarily be considered much too small for meaningful cartographic communication.

In the following sections we first look at related work on visualisation on mobile devices and on route directions. A brief overview on some commercially available services follows and a presentation of how a navigation service using cartographic presentation could look like is given. After that the implementation of a prototype is presented. Finally, the experiences made by planning a pedestrian navigation service are discussed.

2 Cartographic Visualisation on Mobile Devices

Apart from other restrictions a minimal dimension of the cartographic symbols has to be considered as it is necessary for every map. These minimal sizes ensure a good visibility and readability in common maps. Table 1 shows some of these dimensions.

Signature	Criterion of Size	Size b/w (mm)
circle	diameter	3,0
square, filled	edge	1,5 – 2,0
lines	width	0,4
lines	distance	0,4
letters, horizontal	type size	3,6

Table 1: (Neudeck 2001)

The measures presented in Table 1 can't be taken one by one but have to be translated for the displays of mobile devices. This results into the sizes presented in Table 2.

Signature	Criterion of Size	Size b/w (pixel)	Example
circle	diameter	10	●
square, filled	edge	6	■
square, unfilled	edge	8	□
rectangle, filled	edge x edge	6 x 8	■
triangle, unfilled	edge	10	△
symbol	edges	15 x 15 to 30 x 30	η
lines	width	2 to 3	—
letters, horizontal	type size	10	A B C D

Table 2: (Neudeck 2001)

The table above shows the minimum useful sizes of various graphical elements. Due to the size and the rectangular shape of each pixel a remarkable disturbance might be introduced into the displayed content when the minimum sizes are used. A detailed description of these distortions and the resulting consequences for cartographic visualisations is given in (NEUDECK 2001).

Thus, the most important considerations are (BRUNNER 2002a):

- Rectangular elements placed in parallel to the dot-matrix lines of the display are easy to recognise, if they are rotated they might become crumbled. The same problems occur when triangular shapes are used.
- Rotated lines drawn with the minimum measures (see Table 2) may decompose into a series of loose connected single dots.
- Small shapes with an outline are hard to recognise because the outline is reduced to a width of just one pixel. This results into a reduction of the outline's details.
- Concatenated graphical symbols used in conventional maps are hard to recognise because the single elements merge together when they are shown on a dot-matrix display.
- To small distances between single signatures leads as well to a merging of the single symbols.
- Small fonts are very hard to read because there are a lot of disturbances in the visualisation.

3 Route Directions

The structure of route directions given by humans has been analysed by psychologists, computer scientist and geographers (ALLEN 1997, DENIS 1997, DENIS et al. 1999, LOVELACE et al. 1999). Verbal route directions usually consist of a sequence of 'view-action pairs' (KUIPERS 1978). These contain a description of a location – using landmarks, street names, etc - and a directive what action should take place (ALLEN 1997). There is, however, no consensus about how to structure a given route, or what the descriptions have to include (LOVELACE et al. 1999).

Important elements of all route directions given by humans are visual landmarks. A study, where human subjects were asked to rate route directions, showed that the descriptions that included a high number of landmarks were rated better than those that did not. Descriptions that lacked information about landmarks altogether were unanimously rated as poor (DENIS et al. 1997).

In an experiment where human subjects were asked to both, draw and describe a familiar route, TVERSKY & LEE (1999) showed that the structures of the verbal and the pictorial directions are essentially the same. It might even be possible to automatically translate from the one representation to the other one.

4 Route Maps

Because of the restrictions mentioned above it's very difficult to design maps for small displays. One possibility to show important information and still obtain legible maps is to work with topographs, which are schematic maps.

Topographs are strongly simplified and schematised cartographic representations. They are not scaled, but they show the correct topologic relationship (BRUNNER 2002b).

Because of the use of topographs the information density is reduced to important elements. (MENG 2002). They are often used to show for example a railway network. A disadvantage is that there can't be a positioning of the user in the map (BRUNNER 2002b). In the following paragraphs topographs that are intended to describe a route are referred to as 'route maps'.

A toolkit to construct such route maps has been presented in TVERSKY & LEE (1999). It essentially consists of lines for the streets, arrows to indicate the directions, landmarks as ellipses/rectangles and text. It was, however, intended to be used by human subjects sketching maps by hand.

5 Landmarks in Route Descriptions

Landmarks play a key role in the human wayfinding process. There have been, however, several distinct definitions of the term landmark in the literature, each highlighting different aspects of the concept. In this paper we will use KAPLAN's (1976) definition of a landmark as 'a known place for which the individual has a well formed representation'. Essential in this concept of landmarks is the prominence and distinctiveness of the feature (GOLLEDGE 1993). An overview over literature on the structure of landmarks can be found in (BURNETT 1998) or (RAUBAL & WINTER 2002).

Several researchers have pointed out the importance of landmarks in the formation of 'cognitive maps', a cognitive representation of space that we form when learning how to navigate in a new environment (Lynch 1960, TOLMAN 1948). There are several theories about how landmarks are used in the organisation of these mental maps (Taylor & TVERSKY 1992, ALLEN et al. 1978), but an interesting consequence seems to be that the distance relations contained in the cognitive map are distorted around landmarks (MCDONALD & PELLEGRINO 1993; HOLDING 1992).

Landmarks are also extensively used by humans when communicating routes (WERNER et al. 1997; LOVELACE et al. 1999). It is not entirely clear when landmarks should be used. Some results (DENIS et al. 1999) indicate that landmarks are only required at decision points when a reorientation is required. Others, however, found that the quality of a route description is improved by also giving landmarks between decision points that act as reassurance, especially when the segment is longer (LOVELACE et al. 1999). The way, how the landmarks are presented to the user is of little importance (DEAKIN 1996).

Databases commonly used by navigation services do usually not contain data about landmarks at the level of detail that is required when using references to landmarks to enrich wayfinding instructions. Current research efforts are exploring the possibility to extract landmark information from topographic maps, the cadastre (ELIAS & SESTER 2002), images and georeferenced non-spatial databases (RAUBAL & WINTER 2002).

6 Existing Services

There are already a few services developed to communicate spatial information on mobile devices. One has to distinguish between a routing service designed for motorists or one designed for pedestrians. This determines the scale and the look of the displayed maps.

For example Lol@ (Local Location Assistant) is a service addressed to tourists. The user is guided along a predefined sightseeing-tour in the first district of the city of Vienna. Dependent on one's position one receives map-clippings and moreover one can get some multimedia information about chosen sights. The maps presented by Lol@ are adjusted to pedestrian's needs. (BRUNNER-FRIEDRICH et al. 2001)

The Austrian mobile service provider A1 features a routing service called MobilGuide. The position of the user is determined automatically and location based information is transmitted to the mobile device. The MobilGuide can be used with both, SMS and WAP. (MAGENSCHAB 2002)

Most of the existing services which are designed for pedestrians are using data which was intentionally created for motorist guiding systems. This data lacks of information because maps for motorists contain usually coarse structures. Pedestrians instead need more detailed maps with a higher information density.

There is a gap between the concepts of most of the nowadays services and the capabilities of the existing mobile devices. For example most concepts rely on a high resolution display but these are not available on most of the nowadays common mobile devices.

7 Visualisation Concept

The purpose of the routing-service is to guide the user from any starting point to any target point in the most convenient and user-friendly way. On one hand the navigation through such a service has to be very simple and easy to use, on the other hand one has to look for a good presentation of the spatial information.

The navigation within the routing-service must not have too much branches because it is usually not very convenient on a mobile's keypad to navigate through menus (UHLIRZ 2002). Another problem is introduced due to the use of interactive maps with embedded „hot spots“. One has to find a possibility to activate such a „hot spot“ without the common used pointing devices (mouse, touchpad) or the use of a touch-screen in a convenient way to get, for example, the description corresponding to a landmark. Although most of the mobile devices feature keys which could be used to replace a pointing device (function keys, jog dials), the software usually does not support this kind of usage. A conceivable solution is to tag the landmarks with letters or numbers in the map. So the user can type this tag into his device to receive more information.

There are several ways to mark a route and its surrounding. It is possible to use a variety of different graphical symbols like dots, lines and shapes. Furthermore, combined signs or concatenated graphical symbols can be used as signatures. In this way a graphical structure is build. When one uses graphical variables, signs can be varied, e.g. in altering the size, shape, texture, hue, colour and direction of the sign. (HAKE 1994)

Because of technical limitations some of the variations are not possible when a mobile device is used. Variation of hue and colour is only possible if the mobile device features a colour display. Most monochrome displays are just capable of displaying black or white colours but not greyscale information. Due to the small displays and the low resolution of most devices it is usually not possible to implement textures or vary the direction of a symbol.

The above discussed points have to be considered very careful when designing the graphical content of a routing service.

Also the representation of the content should be considered. It's very important to choose symbols that can be easily interpreted because often a legend can't be added to the map. So the used symbols should be self explaining.

All these aspects lead to a simplification of the representation. So it is necessary and very important to reduce the content of the display to a minimum.

8 Implementation

In this chapter an implementation of a pedestrian navigation service providing guiding between two points is presented. It was designed with the above concept in mind and should serve to proof this concept. The implementation was done, however, using off-the-shelf software available to the authors and no attempt was made to overcome the restrictions imposed by its use.

The data was derived from the digital Vienna 'multi-purpose map'. The pathways accessible to pedestrians were calculated by computing the voronoi diagram of the areas that were classified as obstacles (CHEN 1999). Addresses and names of public places were also extracted from this map.

The user can choose a starting point and a target and then the route is calculated by the service. The input of the starting point can happen in two different ways: The user can be located automatically or the current position is input by the user.

In some cases automatic localisation of the user might be inaccurate or not possible at all. So the user has to check the automatic derived information upon his location and correct it by hand or, in the latter case, input it completely manually.

If the current position is input manually not only addresses but also the names of famous buildings, public places or sights might be entered to determine the current location.

The destination location has to be always input manually. An automatic completion of the user's input may be considered. Any textual information (like addresses or names of sights) defining the start or end location of the route has to be geocoded to deserve geographic co-ordinates. These co-ordinates are used to calculate the route by using the A-Star (A*) shortest path algorithm. Then the resulting maps – the tiles cover approximately one quarter of a square kilometre – are generated on-the-fly and stored in the database (Oracle Spatial). The on-the-fly generalisation has several advantages over predefined rendering. The map can be optimised to make the most efficient use of the very limited space available on small mobile displays by displaying only the information selected for the individual route. This selection could be the result of an optimisation of the route directions by a model of the wayfinding process, or could include a customisation of the information displayed. Thus additional information, such as public transportation, restaurants, etc. could thus only be included if necessary, because on a 90x90 pixel display the inclusion of such information comes at a high cost.

Another advantage is that even though the displayed route map is heavily generalised, it is nonetheless possible to use automatic positioning and tracking, once a sufficiently accurate positioning technology is available. In our implementation the generalised route segments are still linked to the original large scale geometry, where the actual position can easily be determined.

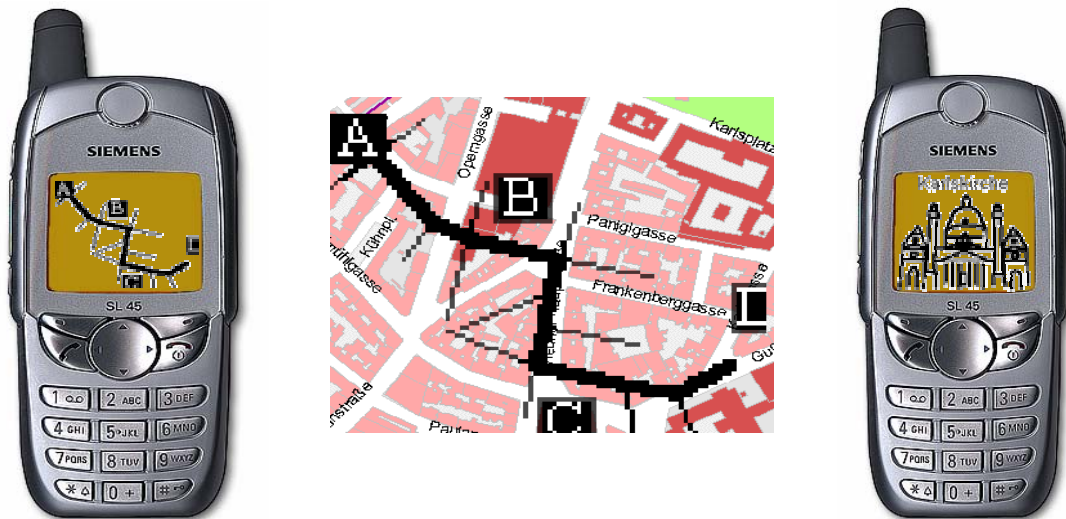


Fig. 1: Look and Feel of a Pedestrian Navigation Service of TU Vienna

The generalisation algorithm used in this implementation – implemented as a set of PL/SQL procedures – is very crude as this is not the focus of this work. However, efficient algorithms for this kind of generalisation are currently being developed. It should be noted, however, that this should be a fairly simple problem, since routes are linear. Pedestrian's shortest paths also never include circles, since there are no turn restrictions for pedestrians.

In a next step the maps are converted into a graphical format called wireless-bitmap (WBMP) which can be displayed on most WAP-enabled cellular phones. These bitmaps are limited to a colour depth of one bit. To convert the images into the WBMP-format the free available software 2WBMP was used.

The maps which have been generated in this way contain the route, adjacent streets and important points/landmarks which are shown as letters. The individual segments are drawn such, that they are at least 8 pixels (~ 50m) and at most 20 pixels (~500 m) long. Segments that are between these two thresholds are scaled linearly. If there is a landmark to be placed along one segment, this segment is extended accordingly. To be useful, the direction of the route will have to be included. This can easily be accomplished by marking the segments of the route with arrows.

Apart from the landmark symbols, which are predefined bitmaps containing the letter, no text is used. The reason why there are no street names is that the software that was used, Geomedia Web Map Enterprise, does not allow the extreme level of control that is needed when placing and rendering text. Although the map lacks street names it is possible to effectively use the service, since the street names are still available when the user requests the textual detail view.

To get further information about the landmarks the user has to type the respective letter from the map into the device. As a result a picture and/or text (as available) and the name of the landmark appear on the display.

Another possibility to use this service is to take a look at the textual description of the route. This description contains street names, landmark names, names of public places and turn instructions ('take the second street left').

For a better fit to the user's needs a user-profile could be implemented. Then, for example, landmarks could be adjusted to each user – for example one user prefers public buildings as an orientation hint, another orients oneself rather on restaurants or cafés.

9 Conclusion

With this prototype of a pedestrian guidance service it was possible to show that using maps, albeit very simple ones, is indeed possible, even on the smallest mobile devices. Research in spatial cognition indicates that by using these kinds of maps the formation of a mental map in the mind of the user better supported than with a pure textual description.

However, technology that is currently commercially available does not support the implementation of such a service sufficiently. There are currently no datasets available, which have the level of granularity needed for pedestrian guidance. No datasets describe navigational landmarks for use in pedestrian navigation. Web mapping servers are generally not designed for producing legible graphics at extremely low resolutions.

What is especially badly supported is the rendering of text. The displays of current mobile phones are too small to display any text, but on displays that are a bit larger, for example on PDAs or possibly UMTS devices, enriching the route map with street names would be quite beneficial. This would, however, require a level of control over the rendering of text that is not yet available. This means that for detailed information it is necessary to switch to a text-only screen. In this example a kind of multimedia concept was integrated: starting from a map more information about the route is given in a textual way and with pictures. Interactivity can be realised, however, the implementation of "hot spots" is only possible by matching letters or numbers, respectively.

Finally, usability studies still need to be carried out, to support our claim that such a service is actually appreciated by the users. Carrying out such a study will also yield insights into what should be improved further.

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