USABILITY AND IMPLEMENTATION ISSUES FOR CARTOGRAPHIC INFORMATION SYSTEMS IN INTERDISCIPLINARY ENVIRONMENTS

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Introduction:

The University of Vienna, Department of Geography and Regional Research has a long-time experience in the design and implementation of Internet-based information systems with strong focus on the usage of spatial information.

Whereas a GIS enables the capturing, modelling, manipulation, retrieval, analysis and presentation of geographic data, the emphasis of a cartographic information system is primarily on the high-quality presentation of such data. Likewise, a Cartographic Information System (CIS) often refers to a certain area or topic in conjunction with a given purpose and has an additional narrative faculty (Ormeling, 1995). These facts make Cartographic Information Systems an adequate platform for interdisciplinary research.

Currently, a series of research and implementation projects in interdisciplinary environments is under development at the University of Vienna, aiming at the creation of such systems. The involved domains range from cultural history, disaster management to isotope hydrology and wastewater engineering. The diversity of the various domain experts in terms of experience, demands and prerequisites poses a challenge to cartographers when it comes to the design of an integrated cartographic decision-support tool. The collection, analysis and visualization of information gathered from multiple resources in the form of a user-centred Cartographic Information System can provide a communal repository of information and geo-coded artifacts for interdisciplinary environments.

A variety of Internet-based applications is today characterized by the employment of spatial information (Cartwright, et al., 2007). However a relatively small number of such information systems in the Internet obtain high acceptance. Besides specific – mostly thematically or spatially very particular examples – these systems do not have the broad public recognition which should be entitled to them from the point of view of modern cartography and geo-information. This seems to be not so much an issue of the availability of appropriate geographic and thematic information and functionalities, but rather with unsatisfactory to bad presentation of the information itself to the user.

From the Cartographic Information System users' perspective, the aspect of information is in the centre of attention. The workflow of mostly inexperienced users in inter-disciplinary environments is not as structured, compared to experienced users working with a full-fletched GIS. Questions are posted randomly, interaction and navigation has to be simple and intuitive. Individual analysis is of minor importance. Information has to be pre-processed and pre-formatted to ensure efficient information retrieval. All these facts lead to the conclusion that a user-centred development is an essential methodology to fulfill both cartographers as well as domain expert's requirements (Norman, 1986).

Methodology:

The purposeful employment of methods and concepts of information architecture leads to a better and more efficient knowledge transfer in the context of Internet-based, spatial information systems, thus increasing the usability and acceptance of such systems (Wodtke, 2003). The principles of information architecture for the employment in Internet-based cartography can be applied to bridge the gap between individual domain expertise and geo-coded, cartographic communication (Garrett, 2003).

To build an efficient system, several issues regarding usability and implementation have to be considered. In interdisciplinary background environments, the exact definition of user groups, user requirements and objectives can be seen as crucial for the decision of the functional and content scope.

Experience from several projects clearly showed the focus on two major user groups at a very early stage of the system design process:

- Domain Experts: Specialists working in the associated fields of the interdisciplinary environment. These users can be considered as the core target user group, since they represent the thematic domain knowledge of the systems content.

- General public: The system must however be able to give an informative overview to the general public, by delivering pre-processed information. For this purpose, the information incorporated must be prepared by domain experts and delivered to the general public via clear and comprehensive methods.

Following the definition of the main user groups of the CIS, the basic and fundamental functional scope as well as the content of the system has to be defined. On a very coarse level, an Internet-based information system has multiple tasks, among them the most essential are:

- Information storage
- Information management
- Information display
- User interaction

These fundamental objectives have to seen in connection with Nielsen's argument, that "The Web is an attention economy where the ultimate currency is the users' time." (Nielsen, 1999) and have to be linked to the special prerequisites of the defined user groups. The overall premise therefore has to be to build a system that represents the common workflow of the domain experts as much as possible. Besides getting a closer look at the working procedures of the disciplines involved, a set of essential questions have to be addressed:

- What are the questions to be answered by the Cartographic Information System?
- How shall the information be address within the Cartographic Information System?

Besides these statements regarding the conceptional orientation of the system, the domain content has to be evaluated:

- What kind of objects from the involved disciplines have to be dealt with?
- Is there a spatial, temporal or thematic relationship between particular objects?
- Is the spatial component of the objects relevant for its analysis?

These three statements have a clear connection to the use of geographic information, which effect in a first set of functional objectives:

- Geographic information context is the core issue of the overall system.
- Graphic visualization, in form of maps or other cartographic representations is the conceptual centre of the application.

Most of the information used in an interdisciplinary CIS is known and widely used by the respective domain experts. The goal of the system development is therefore not to create “another” archive of factual information, but provide new and different insights of existing as well as yet to be collected data. Likewise, the adaptive design and purposeful implementation of appropriate tools and functionalities for the diverse expert fields has to be guaranteed to achieve a considerable and suitable result (Gartner, et al., 2005).

Based on the general functional objectives, more detailed design and implementation guidelines in terms of system design and technical implementation can be set up. This results in a series of requirements, a Cartographic Information System has to cover. Besides the fact, that the system is geo-oriented, Internet-based and map-centred, the integration of different content types must be guaranteed. To enable the user to retrieve information in an effective and intuitive manner, a strict object hierarchy and structure must be maintained. Furthermore, search capabilities form an important entry point to the information landscape (Kriz, et al., 2007).

Online geo-oriented information system:
Cartographic Information Systems are online applications. The system used for several projects at the University of Vienna, Department of Geography and Regional Research is based on a three-tier system architecture, consisting of a backend database(s) layer, an intermediate application layer and a graphical frontend. Both locally stored information as well as data from external data sources is utilized. The surplus of a CIS is the extensive use of geographic information, which expands the knowledge space of conventional information systems using only thematic and temporal metadata.

Map-centred:
All objects stored in a CIS have a spatial component. This objective is not only necessary for the presentation, but also for simple analysis methods (e.g. Point-in-polygon, distance measurements). A Cartographic Information System must be a map-centred system. The map functions as an interface to the underlying information. All query and search results will be directly displayed on a map. Special focus within the implementation is put on creating a series of high quality topographic base maps. These maps function as reference and underlying layer for all visualization purposes. Maps in appropriate scales have to be developed and integrated into the system.

Multimedia content:
Within an interdisciplinary environment, the integration of external data with different multimedia content, such as pictures, audio and videos files must be guaranteed.

Strict object hierarchy and structure:
The data structure of a CIS foresees a clear and strict hierarchy of the objects involved. Although it must not be strictly an object-oriented system, all information items are stored as objects along with their respective metadata. Objects can be ordered, structured, linked to each other and put into a hierarchy. By this approach, objects are logically connected to each other. This is essential for information management and retrieval.

Search capabilities:
One of the major benefits of digital information systems is its capability to retrieve information by querying available data. Effective systems enables the user to perform enhanced search procedures, not only by thematic, but also by geographic context. Search procedures can be performed on different levels of granularity and/or combine different dimensions of the information space.

Unlike many existing examples of digital information collections in interdisciplinary environments, usability and implementation strategies for cartographic information systems in interdisciplinary environments have to put extensive focus on the two main characteristics of geodata – space and time. This results in a system that is able to connect the stored items based on a variety of parameters (contextual, spatial and temporal). The special challenge of these environments is to bring different data sources together to facilitate a holistic view of the information. Apart from possible technical obstacles that may occur, the overall homogenization and generalization of the heterogeneous information items is crucial. The (carto)graphical visualization of all available information is therefore the leitmotif of a Cartographic Information System architecture. All information items are connected via a centralized mapping representation, giving the user the ability to understand the connections between objects in an efficient and holistic way.

The conceptional information architecture of the system is based on two components, the horizontal and vertical structure of the information:

	Horizontal structure		
Vertical structure	Top-down linear	Top-down hierarchic	Top-down network
	Bottom-up linear	Bottom-up hierarchic	Bottom-up network

Figure 1: Information architecture structure

The vertical component defines the overall approach of the content organization, whereas the horizontal component describes the user guidance side of the structure. Within interdisciplinary project environments, all possible combinations are feasible. A top-down linear structure can be seen as the simplest structure, since it leads the user on a well defined path through the system. On the contrary side, network structures can be used very efficient to "map" complex information landscape through appropriate system functionalities.

On the technical side, a three layer information architecture has proven its value in recent CIS implementation at the University of Vienna, Department of Geography and Regional Research. The basis of the system is the *Information archive layer*, holding all objects, along with their metadata. Put on this base, the *Preprocessed views layer* offers the user the possibility to retrieve pre-processed and -defined information. As the top level, the *Target application layer* focuses on thematically and/or geographically limited solutions. This architecture enables the user to work on different levels of complexity within the system.

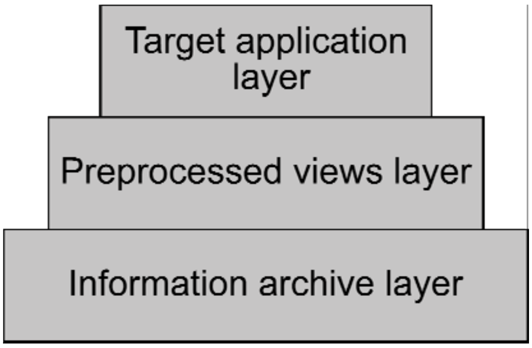

Figure 2: Three layer information architecture

The *Information archive layer* stores all information items in a well-defined data structure. Besides storing, direct retrieval of the raw data is one major purpose of this layer. This will be enabled by a graphic user interface, offering different system approaches, such as database or map search functionalities. Collections of information items, edited and formatted by experts are situated in the *Preprocessed views layer*. These preprocessed views function as a wrapper around the underlying information and enhance the system usability by serving the general public with preprocessed information views, avoid complicated and/or complex data queries and give the users the possibility to save queries in the information archive layer by creating individual, personal views.

Build "on top" of the *Preprocessed views layer*, the *Target application layer* enriches the information system by offering new and innovative ways of dealing with the available multidisciplinary information. These solutions focus on specific topics and can vary in their technical implementation from symbol maps, dasymetric maps, animated maps and 3D visualizations, mapserver based applications to including multimedia context (e.g. geotagged movies in Google Earth).

Conclusion:

To facilitate interdisciplinary environments, a system must be designed in a way that comes as close as possible to the users real-world working environment. The major and most crucial usability and implementation issues for the design and development of interdisciplinary cartographic information systems at the University of Vienna, Department of Geography and Regional Research have been evaluated and followed in a series of projects. Special focus was put on the processing of the individual requirements as well as the linkage to cartographic visualization and communication of non-cartographic areas of research. An implementation example of a recent research and development project (*Cultural History Information System of the Western Himalayas*) following the presented issues in this paper is given to show the "visual" result of the various aspects of the design and implementation process.

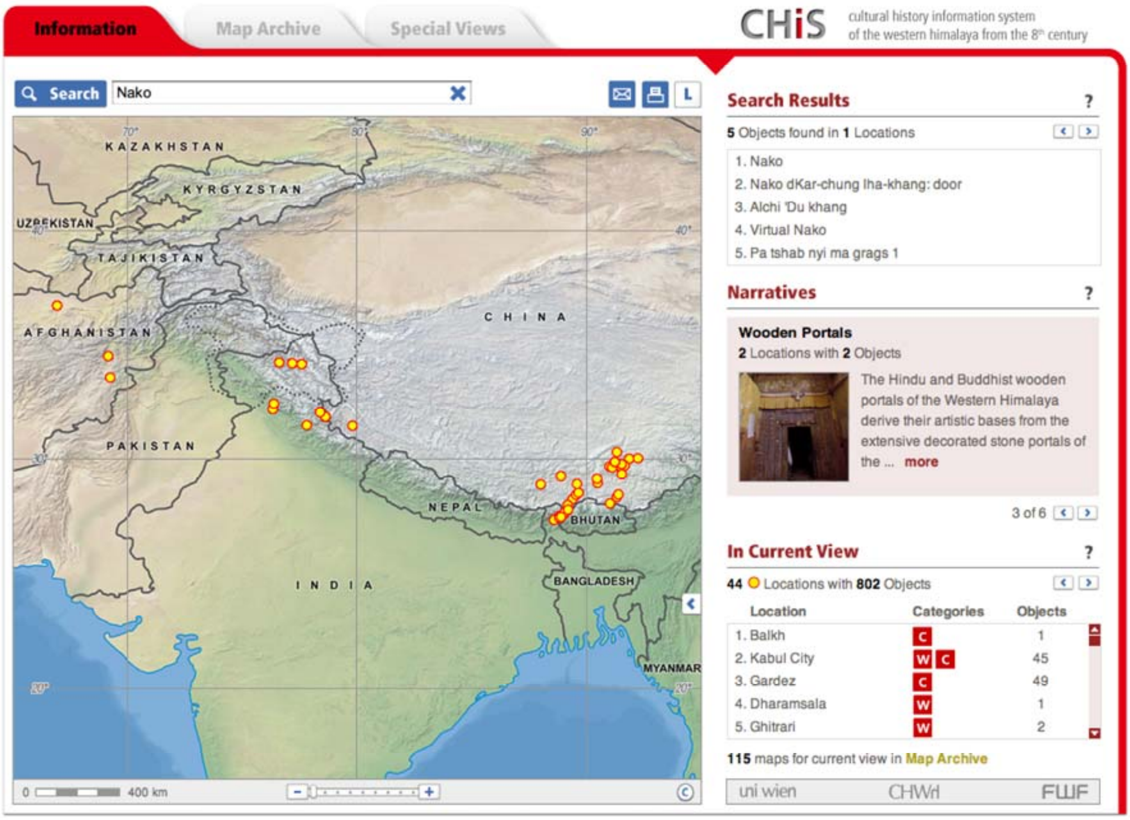

Figure 3: The *Cultural History Information System of the Western Himalayas*

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