13 AIS-Austria – An Atlas Information System of Austria

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13.1 General Overview

"AIS-Austria – Atlas Information System Austria" is a cooperative scientific project with the goal of developing an online system that enables the user to explore national (Austrian) as well as international (European) statistical information. Users can compare and analyse data and visualise the selected information in a high-quality cartographic environment. AIS-Austria is a synthesis of Cartography, Geographic Information Technology, Multimedia and Statistical Analysis. The integration of these domains is being developed in an environment where interface design, map design and multimedia programming operate independently and coherently. To ensure that this can happen, access to up-to-date and homogenised, spatially distributed statistical data is essential. AIS-Austria offers a powerful and efficient way to view various spatial aspects of Austria and the European Union.

The pressure on specialists, dealing with geo-data nowadays is steadily increasing, due to the ever increasing amount of information being processed. This can result in an overload of information with little use for specific queries. In order to alleviate the mounting frustrations created when trying to locate certain details using conventional methods, information systems can offer suitable solutions by applying systematic extraction. In order to evaluate the output in an appropriate, spatial way, it has to be displayed in a suitable and adequate cartographic manner. One of the crucial aspects of cartographic visualisation is to emphasise and stress optical representation. The aim therefore is to provide insight in variable spatial data and point out their connectivity.

New technologies have an increasing impact on the way we perceive things and obtain information. The Internet based “Atlas Information System Austria” is an innovative example of this development.

On behalf of the Austrian Conference on Regional Planning (ÖROK), the AIS-Austria consortium members (University of Vienna - Department of Geography and Regional Research, Technical University Vienna – Research Group Geoinformation and the Austrian Institute for Regional Studies and Spatial Planning) have assembled a prototype that provides a unique multimedia-based application. This tool is being used for developing a feasible approach for further improvements including a framework to present national statistical information at various regional levels. The primary source for this data is based on federal statistical and environmental data. AIS-Austria is a product that, as well as providing a number of possibilities for statistical data processing also considers spatial aspects and ensures high-quality cartographic visualisation of the subsequent results.

Cartographic design issues as well as the visualisation of geodata play an important role in an atlas information system. They are essential for spatial communication and for effective perception of information. Therefore, high quality cartographic visualisation is fundamental to ensure an optimum usability of available geodata. For these reasons cartographic design issues have to be addressed in order to control spatial depiction. Cartographic design and composition of specified signatures as well as the means of presentation should fit all representations and must always guarantee construable and legible visualisation. On the basis of these specific cartographic considerations the general conception of an atlas information system as well as the AIS-Austria portal will be discussed.

Geographic Information Systems (GIS) and cartographic visualisation incorporate an elaborate way of capturing, analysing and visualising georelevant phenomena. The symbiosis of cartography and GIS is the perfect approach for dealing with complex thematic data, enriched with spatial information. The intention of using GIS functionalities is to provide analysis tools which allow the user to integrate a spatial component into his/her examinations and thereby raise the information content of the existing data.

However, major focus in the development of an atlas information system should be focused on cartographic aspects, concentrating on a cartographic visualisation environment for thematic data, rather than merely producing a geographic/statistical toolkit with map output. This approach towards high quality cartography is accomplished with contemporary technical solutions to develop an online atlas as such, rather than another arbitrary selection of GIS tools and functionalities as in conventional Web-GIS applications.

High quality cartographic output, based on a dual-media concept (digital/analogue), helps the user to derive a holistic view of the entire data, combining thematic and spatial characteristics of global and regional context. These spatial manipulation tools allow a variety of possibilities for analysing as well as visualising highly complex geodata in an effective and sophisticated way.

Recent existing atlas information systems (for example, the Tirol Atlas and the Atlas of Canada (see the chapter on the Atlas of Canada by Kramers elsewhere in this book) clearly show this development towards a cartographic information system, functioning as a gateway to a variety of information, where the distinction between layman and expert can not be defined on the basis of a clear separation line. In fact, such systems take care of individual user abilities and skills by adapting themselves to user needs.

13.2 AIS-Austria Concept

Cartography and geo-information can offer a promotive function in the amalgamation of heterogeneous information sources. Therefore, an important task of AIS-Austria is to provide comprehensive documentation of spatial statistical information in a concise, as well as intuitive method of information storage and analysis. Interactive cartographic forms of information presentation function as an interface to the user. This is realised in an easily visible and accessible structure to perform a sustainable way of information networking.

AIS-Austria allows to reference all objects in space (3-dimensional) and time (4-dimensional) and to assign other thematic or behavioural attributes (multidimensional). Furthermore, the dimensionality is being extended by the level of detail or granularity of information, allowing the description and access of features on different levels of scale and aggregation.

Data characteristics besides the mere position in space, such as time and other meta-information demand unique modelling, structuring and maintenance. Usually, when describing or modelling these features in an atlas information system content is registered and presented as a single, point-like information (0-dimensional). It can however have additional, rather restricted set of describing attributes, such as time information (age, date of occurrence, owner, etc.). Such multi-dimensional processing and representation of spatial information is being examined and implemented in AIS-Austria.

The major aim is to stimulate and support this development by providing a multidimensional framework, allowing to compile, homogenise, manage, analyse, query, compare and visualise spatial statistical data in a comprehensive and user- friendly way.

From the conception to the completion of building a successful cartographic online product, designing the presentation of information to facilitate understanding is an essential task. Cartographic information architecture, the purposeful structuring of spatial-related information in the sense of 'architecture of information' is a key issue in developing an interactive system.

Major focus of development in such systems can therefore be seen in a concise user-centred design, where the modelling of problem solving methods must have higher priority than technical restrictions. One dominant aspect is to define, what the system should be able of, and often more important than that, what not. Methods of information architecture have been widely adopted for the creation of web pages. Insight in this field, such as the extensive use of metaphors and conventions can be adopted by developers of cartographic focused, atlas information systems, to enhance the usability of their applications.

Cartographic design issues as well as visualisation of geodata play an important role. They are essential for spatial communication and for effective perception of information. Therefore, high quality cartographic visualisation is fundamental to ensure an optimum usability of the available data.

Graphical design and management of data sources with spatial reference can be efficiently realised by using sophisticated cartographic and Geographical Information System (GIS) methods. Cartography has a long tradition in visualising geo-relevant phenomena and uses many different types of approaches for representing spatial information. These can range from classical printed maps with a single dimensional appearance, all the way to multidimensional, interactive online representations, such as Web mapping or interactive GIS-applications.

13.3 AIS-Austria Requirements

The requirements on AIS-Austria are complex, both in terms of thematic content management as well as technical implementation. Based on – and existing alongside – a printed version of the ÖROK Atlas, the Internet product had to match the thematic and cartographic quality of the analogue

version. To fulfil all prerequisites, AIS-Austria was built upon special system architecture considerations, based on the following key issues:

Modularity: The modular aspect of the system architecture offers the possibility to work in a decentralised environment and enable high efficiency for the implementation of specific system functionalities;

Flexibility: Not the technical environment is of importance, but the definition of standardised interfaces between various system components.)This approach results in a system, which can be considered as a "thin"-implementation, compared to monolithic 'fat'-systems.);

Extensibility: Due to the chosen system architecture, it is possible to extend the framework with additional expert module at any time;

Distributed resources: The creation of a multi-national Internet atlas needed the cooperation of several domain experts. (The thematic linkage of heterogeneous expert modules into a homogeneous application was one of the main challenges of the project.); and

Heterogeneous working environments: Following the basic principles of modularity and efficiency, resulted in a diverse landscape of operating systems (Linux, Windows, MacOS) and programming languages (C/C++, Java, PHP, Perl). All modules had to be exchangeable throughout operating systems and programming language boundaries.

Besides these requirements, limitations and constraints had to be identified and taken into account. These constraints had a strong influence on the system integration and implementation.

It is clear that from these basic ideas, several forms of implementation were imaginable. In the case of AIS-Austria, major focus was put on the cartographic issue. The backbone of the system is a database-driven map server, enriched with a high performance system interface module.

In its basic function a map server is an interface between a geodatabase on the server side and an Internet browser on the client side. A map server offers basic spatial and thematic navigational functions with certain possibilities for query. The advantages of map servers lie in the graphical processing and presentation of spatial data, which allow a fast and visually attractive transfer of information in the Internet. (Dickmann, 1999).

Evaluation of practical software solutions for cartographic projects not only focuses on price. Besides the cost of a tool, various other decision criteria have to be considered. Two of the most important are functionality and availability. In other words, finding suitable answers to the following questions: "Can the software fulfil my functional requirements?" and "Can I afford it?"

The evaluation of several possible map server solutions led to the decision to build AIS-Austria on a free software technical basis. The variety of free software for the use in online cartography and Web mapping is ex-

panding daily and product quality can definitely bear a comparison with commercial products. Free software - often used as a synonym for Open Source software - is software without encumbrances, but not necessarily free of cost. Unlike commercial oriented software, Open Source software is developed by a multiplicity of independent contributors worldwide. The intention is to create applications that are free to use for everybody. The basic idea behind Open Source is very simple: When programmers can read, redistribute, and modify the source code for a piece of software, the software evolves. People improve it, people adapt it and people fix bugs. And this can happen at a speed that, if one is used to the slow pace of conventional software development, seems astonishing. Application developers in general, cartographers in particular can benefit from the use of Open Source software.

Being a rather small group with limited impact on the global software market, cartographers often use tools that were not specifically developed for cartography, but for graphic design or DeskTop Publishing. Adapting the software to meet the demands of cartography is a hard task, if not an impossible one. Update cycles for implementation of desired functionalities are long-winded and above all software vendor business does not view cartography is as a driving force. In this context, Open Source shows its full potential for cartographic use.

The whole AIS-Austria system thus consists of several free Open Source software modules which can be exchanged individually without having to change the overall concept of the prototype. This configuration is very economical and it easily allows for further extension of the project.

13.4 AIS-Austria Functionality

Within AIS-Austria, two main approaches to begin the application were implemented. The first approach uses the search metaphor. Analogue to Google, the user can enter any search string. The system returns all information concerning this string from maps to diagrams, tables or texts. Furthermore, the user can enter the application by choosing from a list of predefined maps. This list consists of pre-processed maps, defined by cartographers. All maps consist of one or more layers representing point, line or polygon data. Based on this fact, multilayered maps using different cartographic representations can be displayed in the system. All selected maps are stored in a map-pool, giving the user the possibility to switch between utilised maps.

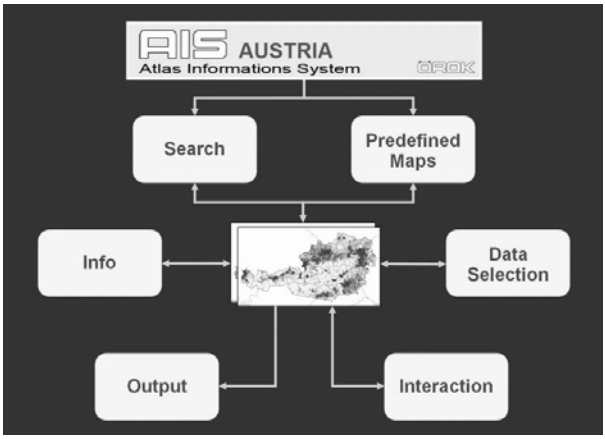

Fig. 1. AIS-Austria System Approach

AIS-Austria addresses three types of geoinformation layers that are embedded within the system. These layers are described in the following sections.

In an atlas information system topographic information must be structured as components of map elements. Therefore topographic information is determined according to the accuracy of their geometry as well as in the semantics of their objects determined by map scale. AIS-Austria utilises three map scales for topographic information. The first represents Austria in total, the second corresponds to a regional view of the federal states of Austria and, finally, the local level covers individual districts.

Geoinformation that can be related to socio-economic phenomena is called thematic information and encompasses data that is referred to positions, line segments or polygons. The visualisation of this data results in thematic maps or cartograms.

All information that does not use cartographic methods for visualisation can be summarised under the term ‘additional components’. This is primarily information such as text, diagrams etc. which is attached to specially marked symbols, lines or areas in different scales of topographic maps.

The system uses a unique approach for storing thematic data. Data is not stored in flat files but in a multi-dimensional cube-like structure, which allows the user to access all the different dimensions of a dataset. All calculated values (e.g.” inhabitants per area”) are calculated on-the-fly and visualised in the map. The user can access all detailed datasets by choosing

dimensions, enter their own calculation methods and show results in the map or as a table.

From the beginning, AIS-Austria was designed as a dual output system. This means that besides the digital interactive Web mapping option, a high quality vector map output was incorporated as well.

The presentation of cartographic information on computer displays more often suffers from certain graphical restrictions. The screen resolution is still very poor for cartographic needs. Some cartographers have suggested developing new graphic designs for maps to compensate for these visualisation restrictions. If screen resolution would be identical to that of printed maps, nobody would be interested in producing an unattractive and simple design for maps. A further handicap for cartographic visualisation is the dimension of the screen.

It is a fundamental issue that the legibility of cartographic information must be ensured for cartographic information transfer. Therefore, cartographic information transfer must be divided in different levels of information which enable the user to choose between base and local information in order to support the user in getting the desired information. A contrary position in cartographic information transfer would be the presentation of cartographic information without taking legibility into account. In such a case only one cartographic information level would be available.

The editorial staff of AIS-Austria decided that legibility of cartographic information is of such importance that cartographic design of screen maps always had to take this fact into account. In connection with this consideration, a further decision had to be seen, namely, to use the same graphic design for the interactive screen maps as for the printed maps. The reason for this decision was to provide a familiar map 'look' for the user. This decision, to come up with ensured screen legibility for maps can be seen as a restriction in terms of an information system. It is proposed to enable the map user to perceive the presented information in a flexible way without any additional action.

A further predicament is map scale dependent visualisation of thematic data. In AIS-Austria, a database query is usually linked to the representation of nearly 2,500 geometric units (communities), which have to be computed and depicted. Without doubt, graduated symbols for example cannot be an optimal solution for characterising different value steps, due to the fact that such a representation would not be legible. Therefore in the first step of the visualisation process, only an overview of Austria is given, without using an equivalent symbolisation. In other words, the database query can only be visualised by using an ordinal or nominal scale level. In the next step the user defines the region of interest whereby the map scale will be changed and the adequate cartographic symbolisation can be dis-

played. The problem of this two-step method is that users possibly may lose the spatial interdependencies of the represented data because they can only see a small section of the whole map. Of course, the user can apply scroll functions to change the displayed map sections but this possibility cannot really compensate for the overview available when using a printed map.

13.5 AIS-Austria System Structure

AIS-Austria is based on modular system architecture. A combination of GIS, geodatabase and a map server visualisation environment, consisting of GRASS GIS, PostGIS object oriented, spatially enabled relational database and UMN MapServer prove to be a complete online cartographic information framework on a free software basis. The use of this framework enables the user to work on a state-of-the-art Web mapping environment without the need for licensed software. Functionality, scalability and efficiency of these free software packages are combined with the power of holding the code source in one's hands.

13.5.1 Visualisation environment

The open source map server of the University of Minnesota (UMN *MapServer*) is used as a visualisation tool, fulfilling all required criteria for the AIS-Austria prototype. The heart of the UMN *MapServer* is a CGI-based application for delivering dynamic GIS and image processing content via the Web. The package also contains a number of stand alone applications for building maps, scale-bars and legends offline. The *MapServer* system supports *MapScript*, which allows popular scripting languages such as Perl, PHP, Python, Tk/Tcl, Guile and even Java to access the *MapServer* C API. *MapScript* provides a rich environment for developing applications that integrate disparate data. In the case of AIS-Austria, the system interpreter had to be enriched with the programming language PHP to gain full access to the scripting interface of the visualisation environment. UMN *MapServer* is not a fully-featured GIS, nor does it aspire to be so. It does, however, provide enough core functionality to support a wide variety of Web applications. Beyond browsing GIS data, UMN *MapServer* allows the creation of ‘geographic image maps’ - maps that can direct users to content.

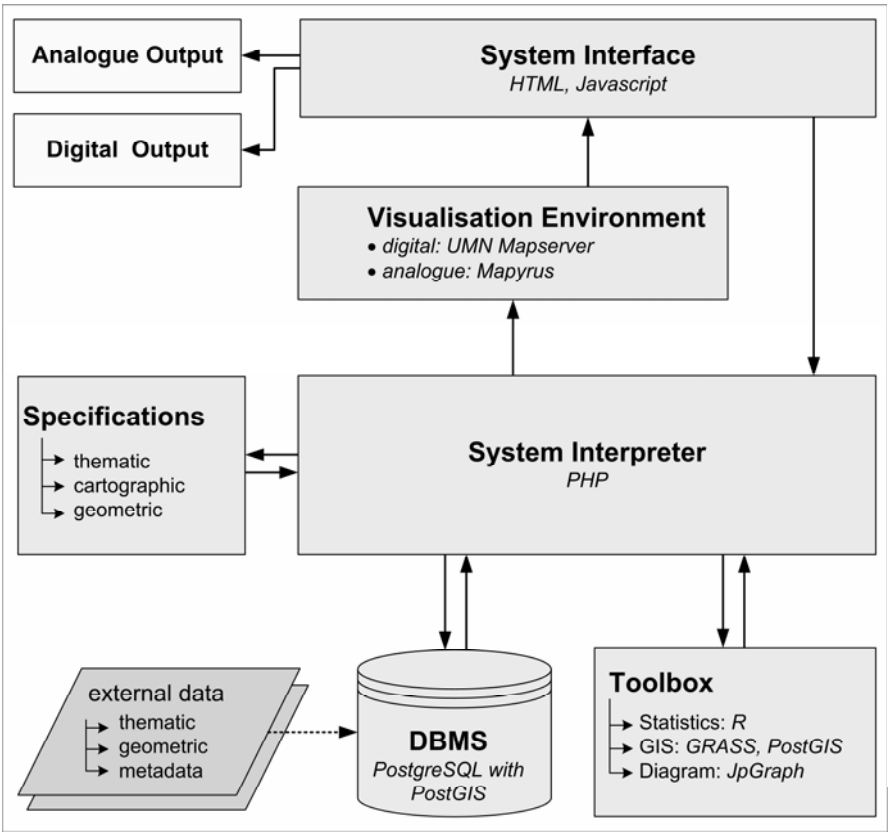

Fig. 2. AIS-Austria System Architecture

UMN *MapServer* is used for digital visualisation; the 'analogue' PDF output is created using *Mapyrus*. *Mapyrus* can create plots of points, lines, polygons and labels to PostScript (high resolution, up to A0 paper size), Portable Document Format (PDF) and Web image output formats.

13.5.2 Geodatabase

For the database backend, *PostgreSQL* was chosen which provides all advantages of a spatially enabled relational database. It has a strong linkage with the UMN *MapServer* and – as Open Source solution – is available without further costs or license fees. *PostGIS* adds support for geographic objects to the *PostgreSQL* object-relational database. In effect, *PostGIS* "spatially enables" the *PostgreSQL* server, allowing it to be used as a backend spatial database for geographic information systems, much like ESRI's *SDE* or Oracle's *Spatial Extension*. *PostGIS* follows the OpenGIS "Simple Features Specification for SQL".

13.5.3 Spatial analysis

GRASS (Geographic Resources Analysis Support System) is used to perform spatial operations, primarily in batch mode. *GRASS* is a raster/vector GIS, image processing system, and graphics production system. *GRASS* contains over 350 programs and tools to render maps and images on monitor and paper, manipulate raster, vector, and site data, process multi spectral image data and create, manage, and store spatial data. *GRASS* uses an intuitive windows interface and a command line syntax for ease of operations. *GRASS* can interface with commercial printers, plotters, digitisers, and databases to develop new data as well as manage existing data.

13.5.4 System interpreter

In order to ensure technical modularity and flexibility, standardised interfaces were developed to connect all system modules and ensure proper input/output communication between each other. This fact brings up the necessity of a centralised system component, that handles all input and output operations within the system. To ensure correct content data processing and presentation to the user, the system interpreter must be able to supervise all information concerning its thematic, cartographic and geometric correctness. To serve this purpose, the correctness of the data has to be tested on the basis of content information specifications, stored alongside the system interpreter. If any plausibility check fails in any stage of a user query system workflow, the application will terminate this query and send a failure message to the user via the graphic user interface.

13.6 Conclusion and Outlook

Cartography and GIS incorporate elaborate ways of capturing, analysing and visualising geo-relevant phenomena. Combined with powerful datbase management systems (DBMS), cartography and GIS in concert is an ideal approach for dealing with multidimensional, spatial statistical information.

Interactive information systems facilitate a sustainable way of multidisciplinary research and communication for a co-ordinate interdisciplinary approach. This procedure allows a dynamic interface for a close collaboration between the system and user. This should strengthen the synergy within the scientific community as well as raise the public awareness of the overall project and of atlas information systems in general.

Based on the experiences with AIS-Austria, several other system implementations have been also realised by the University of Vienna, De-

partment of Geography and Regional Research using free software, underlining the quality of such software packages in operational use. The integration and incorporation of several additional modules, such as *R* for statistical analysis, *JpGraph* for on-the-fly diagram creation and *Mapyrus* for high quality postscript vector output highlight the critical framework abilities and demonstrate flexibility, extensibility and sustainability.

The decision of using free software as a basis of a Web mapping environment turned out to be very successful. Free access to the source code gives the developer the possibility to implement required functions and thus have full control over the software, enabling the user to adapt the product to his/her own personal needs. The fact that almost all Open Source software is also free of charge - to guarantee the software's free availability - is another strong advantage over licensed software packages. The existence of this open environment gives everybody, especially financially limited organisations full control over a state-of-the-art cartographic information system.

References

Bär HR, Sieber R (1997):Atlas of Switzerland - Multimedia Version. Concepts, Functionality and Interactive Techniques. In: Proceedings of the 18th Intenational Cartographic Conference, vol. 2, pp. 1141-1149

Cecconi A., Shenton C., Weibl R. (2000) Verwendung von Java für die kartographische Visualisierung von statistischen Daten auf dem Internet. In: Kartographische Nachrichten, 50, S. 151-162

Dickmann F. (1999) Internet Map Server – Zur Funktionalität und Anwendung eines neuen kartographischen Mediums. In: Erdkunde – Archiv für wissenschaftliche Geographie, Bd.53, S. 65-75

Dickmann F. (2000) Geodaten im Netz - Die Bedeutung von Geodatenservern für Kartographie und Fernerkundung. In: Kartographische Nachrichten, 50, S. 169-175

Ditz R (1997) An Interactive Cartographic Information System of Austria - Conceptual Design and Requirements for Visualization on Screen. In: Proceedings of the 18th International Cartographic Conference, vol. 1, pp. 571-578, Stockholm

Kelnhofer F (1996) Geographische und/oder Kartographische Informationssysteme. In: Kartographie im Umbruch - neue Herausforderungen, neue Technologien. Beiträge zum Kartographiekongreß Interlaken 1996, pp. 9-27

Pucher, A.(2003) Open Source Cartography. Status quo, recent trends and limitations of free cartographic software. In: Proceedings of the 21th International Cartographic Conference, Durban, South-Africa