INTERNET-GIS DEVELOPMENT FOR MUNICIPALITIES AND COUNTIES BASED ON OPEN SOURCE SOFTWARE

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ABSTRACT:

Many market surveys in Germany are indicating that the GIS usage in smaller municipalities and counties will increase in future. This is due to the fact that Internet technologies are offering advanced solutions, not only for eGovernment but also for GIS problems. Nevertheless costs are playing an important role. The concept of a cost-effective Internet-GIS solutions for communes and counties based on Open-Source-software is described. The principle ideas of Open-Source software and Internet-GIS technologies are presented and the technical realisation is described in more detail.
The potential of such solutions is explained based on an example developed with the UMN Map Server for the administration in a county in Germany. *UMN Map Server* was originally developed at *University of Minnesota* (UMN) in the ForNet-project in cooperation with NASA and Minnesota Department of Natural Resources. It is currently one of the most prominent Internet-GIS solutions besides the commercial products. In our research and development we are investigating different user scenarios and user interfaces, e.g. one for the cadastral office in the county, one for specific branches services on county level, one on the municipality level. Various GIS data sets (such as land register, topography, specific thematical maps) are integrated. Ortho photos created from low-cost aerial flight technique are a very important data source besides the legal data sets. The developed solution is now going into practical usage in the county Bad Doberan in the eastern part of Germany.
The technical solution is realised mainly using open source software (WAMP architecture and *UMN Map Server*).

1. INTRODUCTION

With Internet-GIS (often also called WebGIS or online GIS) spatial and property datasets can be provided to a broad range of users. Based on the technology of the Internet data can be used in small company area networks (Intranet), in large world-wide information systems (Internet) as well as within the mobile range with the employment by Location-based-Services. More and more information can be integrated through the constant capturing and storing of spatial information bringing it into broader ranges of the Internet. A classification however, what an Internet-GIS constitutes, is hardly possible, since the technical realisation were made by different free committees and product vendors. Thus, the range and the quality of individual applications are very different. Thereby the Internet technology was adapted in such a way that nearly all functionalities of a Geo-Information System (GIS, cf. Bill, 1999a, 1999b) may be delivered in the net. At the same time it will become possible to access different data sets from different data providers and products with common access over the Internet.
A large part of the data in the public administration of the municipalities and counties has spatial relations. That concerns text data such as addresses or street kilometres (so-called secondary metrics, Bill, 1999a) as well as coordinate-based data (so-called primary metrics, Bill, 1999a) in maps like the cadastral maps or the topographic maps.
Nearly all municipalities have severe financial problems. The necessity exists more than ever for saving money. By a meaningful linkage of the geographical base data with the different technical and administrative data using the common spatial reference the access and the actualization may be facilitated substantially. A new term currently develops for such a linkage of eGovernment and GIS technologies, named GeoGovernment.
Due to the general availability the Internet technology gets increasingly important for the official administrations. Workload and operating time can be shortened and thus also resources can be saved. From the combination and intersection of the different information levels a new quality of data and workmanship may result.
The local agenda process puts additional pressure on the administrative offices, because of its requirement to inform citizens about social, ecological and economical facts in the municipality or county. Here the employment of Internet technology and Open-Source-software represents a profitable solution.
The Internet is based on Client-Server architecture. This offers the possibility that the data remain, can be administered and maintained at the place, where they are produced due to their competence. Additionally also the programs on the server can remain and run there, so that the user of the data does not need to worry about specific software requirements at his PC. The user needs to run only the standard Web Browser on a thin Client and can achieve his goal by simply visualising and querying the data. This saves much time regarding training into programs, for the data management and the costs of hardware and software. In addition the responsibility for the data is still in

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the hand of the data producer and provider. They have to prepare a user-friendly human interface to their complex data. Usually a major developing effort becomes necessary for the individual governmental offices. However making use of Open-Source software supports participation at developments made by other software developers or administrative offices. The solution very often fits better to the needs of the users.
In this contribution such a solution is presented: The concept and development of an Internet-GIS for the county administration in Bad Doberan. The solution was realised with the MapServer of the *University of Minnesota* (UMN) on top of the generally wide-spread Internet Client-Server architecture WAMP (*Windows*, *Apache*, *MySQL*, *PHP*).
The data from the authority were prepared partially before their publication in the Internet with respect to data formats and the kind of data storage. This part of the work, which has to be done at the authorities themselves, is excluded in this paper, even if it is likewise very important to set up this type of geodata infrastructure. Currently we are developing additional conversion software especially for that purpose.
In the first part of the contribution necessary terms are defined, a comparison of Internet-GIS versus conventional GIS is made and general ranges of application are pointed out. Subsequently, the functionality of Internet-GIS is presented and technology configurations used in practice are illustrated. In the next section the concept of the Map Server for the district administration and its technical realisation is described. Thus the presented solution can be arranged well in the technology. At the end a summary follows and an outlook is given in particular with respect to the advancement of interoperable solutions with several distributed data providers.

2. TERMS AND RANGE OF APPLICATION

The principal difference between a GIS and an Internet-GIS is that in the latter case the data are made available over the Internet. While a GIS can be a stand alone solution, i.e. only one program on a computer, an Internet-GIS is always a Client-Server solution. Nevertheless the term Internet-GIS is understood with different meanings, range of applications and functionality (Piepel, 2002). Other terms such as Online-GIS, Web-GIS or MapServer are also often equated with the term Internet-GIS. There is no consensus on the use of the term referred to the functions and application possibilities lying behind. To keep the individual solutions apart and to be able to classify it, a classification related to functionality and technology may help for differentiation.
Depending upon the range of applications of the Internet-GIS a set of functionalities is needed. Simple functionalities like interactive mapping (zoom and pan) with spatial queries of the actual data and a visual overlay of the information can be regarded as the technological standard. The following ranges of application can roughly be differentiated:

- *Simple Information and Query Systems*, which present interactive maps with different themes and thematic data in a standard internet environment (browser) or with extensions (Plug-in). These are useful e.g. within the municipal range for the publication of information via Internet, especially for the citizen and visitors.
- *Specialized Geo-Information Systems*, which make additional services available for the public or only for a reduced circle of users. Functionalities would be something like address detection, route finding or simple analyses of data.
- *WWW-based GI-Clients* with access to a central resource, which provide a number of extended functionalities like measuring distances, analysis and intersection of the data, export, changing attributes, and diagrams etc. Such types of systems are usually used in the Intranet and Extranet, because it requires a support/training of the users and a user administration. The clients can be used in authorities being a more economical alternative to proprietary GI-Viewers and Desktop-GIS and allowing a data exchange over locations as well as to mobile stations.
- *Geodata Portals*: Internet applications to provide and/or sell large data sets. The data usually are coming from different geodata servers. Applications are within the municipal range e.g. in the trade area marketing or in the sales of cadastral data.

A crucial criterion for the choice and development of an Internet-GIS is the available speed and the quantity of the data which can be transported. The optimum would be a fast connection line and few data, but in reality the exact opposite is often the case. The setting up of the appropriate parameters often results in an optimization task. The functionality being made available depends however only on the requirements with respect to system and the available resources for financing and/or development costs. The requirements by the users rise fast. Problems often result in that certain desires and/or functions can not be operated within the same existing technology, with which the Internet-GIS originally was introduced.
For the estimation of the effort to supply certain functionality the following aspects have to be considered:

- What do the users want to do with the Internet-GIS?
- Which groups of users will exist (Intranet/ Internet/Extranet)?
- Which speed is available (net parameters)?
- Which extensions are necessary for clients and servers (plug in, script support)?
- For client and servers, if necessary, separate license costs have to be paid (use of Open Source as an alternative?).
- Which Internet browser and operating systems have to be used?
- Which data formats are available and/or have to be used?
- Which personnel expenditure for the development, service and maintenance of the system can be expected?

The requirements usually rise by using the system. The designed system should be flexible enough to fulfil current demands and to be extended in future.

3. FUNCTIONALITY AND TECHNOLOGY

The client-server technology, by which geo data and functions are made available in an Internet-GIS, may have the following characteristics:

- The speed depends on the quantity of the data which will be transported.
- The quantity depends again on the data type.
- The load of the data processing can be distributed on client and servers.
- Client-server technology offers multi-user ability for reading and possibly writing access.

3.1 Functionality of an Internet-GIS

For the demarcation of typical functionality of Internet-GIS roughly the following 5 groups can be formed:

- Static maps
- Dynamic maps
- Editors
- Complete Internet-GIS
- Data management servers

Static maps often come along as so-called clickable maps. By skillful linking of different pre-prepared maps, also in different scales, already quite suitable effects can be reached. Such a solution delivers the linkage of thematic data with simple navigation/visualisation functionality such as zoom and pan. Special forms are so-called tiled maps, where a larger map area is divided into individual tiles, which are linked together by hyperlinks. Both solutions present raster data, which are statically prepared in advance and can not be adapted to the demands of the users on-the fly. Tools for the generation and publication of clickable maps are available already for many usual GI systems. An example is the HTML-ImageMapper of Alta4 for ArcView, allowing to produce already quite useful solutions. This kind of Internet maps is more or less a standard, but because of its limited functionality and dynamics it should not be called an Internet-GIS. Everything the user sees, has to be physically presented and generated before. The expenditure for the care, maintenance, and extension is accordingly large.

Dynamic maps represent the next stage. These are characterized by the fact that the maps are generated from an existing amount of data based on an inquiry from a client. This volume of data may consist of vector or raster data. In the result raster data are often delivered, but also, solutions, which generate vector data dynamically e.g. in the SVG format, are found. By default the following functionality belongs to such systems:

- Reference Map as overview map
- Zoom and pan
- Queries from thematically data over map elements
- Object search based on thematic data inquiries
- Export of graphics
- Measure in the map
- Display from position and end-to-end measurement

Technically the dynamic maps are often realised by a MapServer program. The solution can be used ideally as information desk system because of its excellent speed and minimum requirements at the client side.

If updating of the data has to be made or more extensive GIS analysis functions to be added, another extended form of the Internet-GIS is to be used or the Map Server solution must be extended by additional programming effort. The Map Server of the UMN is a typical representative from the Open Source range, which is well suitable for the dynamic map production. It can be extended with additional functions and is programmable. With the help of provided script languages full-functional Internet-GIS can be developed from Map Servers. Functionalities, which go beyond the functions usual Map Server GIS offer, is represented in the following list:

- Spatial query polygon
- Measurement of area sizes
- Print function
- Export of attribute information
- Export of the geo data
- Next neighbourhood search
- Map annotation
- Thematic classification
- Routing/Shortest path
- 3D visualisation

If only semantic data has to be changed and no graphic display is necessary, e.g. for the change of postal addresses or the updating of the digital cadastral data, simple *editor functions* for data bases, using SQL, are sufficient. These are realised usually on top of web data base clients or via form-supported solutions. For adding or editing map elements a graphic component is necessary and the actualization of the data sets is no longer trivial. This belongs rather to the group of the *full-functional Internet-GIS*.

Due to its special position the *terminal server* solution will be pointed out still here. Thereby a stand alone GIS is only connected by the periphery with the Client. Terminals servers are based on server based computing. Well-known solutions are Windows terminals server and Citrix. Thus no new development of GIS functionality or Internet compatibility is needed.

In addition software solutions such as *data management servers* should be added in the list of Internet-GIS architectures. These partially deliver similar components as the previously mentioned groups, but because of its special architecture this group should be regarded separate. The following functionalities are offered by (geo)data management servers:

- Overview of spatial, thematic and temporal properties of the data sets as well as the available functionality.
- Data retrieval making use of a thesaurus and gazetteer
- Export of metadata related to the indicated view, layer or object in the representation.
- Generalization of metadata, geodata and thematic data sets for different levels of detail and different users.
- Support of open standards.
- User-referred hints for actualization of large volume of data.
- Subscription functions and newsletter.
- Wide area cross-linking.

New standards, developed by the OGC, allow to combine the different solutions described here. For the user in future it will be no longer evident, which type of Internet-GIS solution is serving the individual applications.

3.2 Internet-GIS technologies

Depending upon the requirements at the data (extent, quality, topicality) and the functionality of the application different expenditure for the development is necessary. One has to consider the costs of the software, hardware and their maintenance as well as of the qualified technical personnel. Simple information systems can already be realised with minor effort. The most simple form is the representation of static maps in HTML-pages, which are connected with the pertinent actual data simply by clicking in the web surface. The next stage is the realisation of an application as Web server, also named Web Mapping (Herrmann/Asche, 2001). The maps are generated upon request on the server side. Here script-languages are used such as ASP, PHP or CGI. More fastidious applications with functionality on the client-side are developed with Javascript, Java, Flash and/or SVG, relatively low-priced or free supplementary product lines. Pre-condition is an existing GIS, in which the data must be regenerated accordingly. The data presented in the Internet-GIS do have the topicality of the supply in application. Hardly additional requirement are placed against the Web server and client here.

An interactive map server with a central geo data server as backbone becomes necessary if current information from spatial analyses has to visualised via Internet. Here one can find monolithic proprietary architectures, which contain the geo data servers and the necessary map server as part of the standard GI systems family. A nearly unrestricted number of WWW-based GI clients can be constructed based on this map server philosophy offering the appropriate functionality to the users.
The OpenGIS Consortium (OGC) defined a web mapping specification (WMS) and web feature specification (WFS) to allow interoperability between systems of different vendors. Already most of the well-known GIS-vendors support this standard and deliver product lines based on this standard. Thus data of different GIS services can be merged into any Internet/Intranet portal.

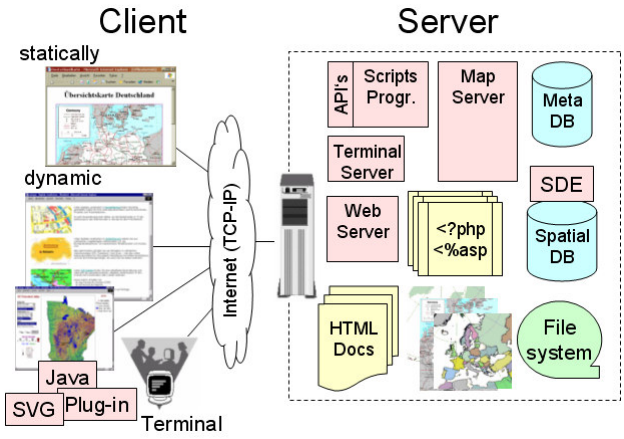

Fig. 1: Overview of architectures by Internet-GIS

Herewith one can construct simple information system as well as fairly complex technical system (Strobl, Blaschke, Griesebner, 2002). Distributed GIS solutions are specified by the OpenGIS and realised for example with Common Object Request broker architecture (CORBA).

4. CONCEPT AND DEVELOPMENT OF THE INTERNET-GIS FOR THE COUNTY ADMINISTRATION

4.1 Introduction

By legislation in Germany the cadastral office of a municipality or county has to set up a digital cadastral data set. For this land registration process a more or less unique approach is foreseen for whole Germany. The graphical data set is called ALK (Automatisierte Liegenschaftskarte, Automated real estate map), it handles spatial and graphical data of parcels, buildings and other geodetic information in a true-to-scale representation usually in map scales between 1:1.000 to 1:2.500. The tabular digital property data are called ALB (Automatisiertes Liegenschaftsbuch, Automated real estate tables) covering ownership, parcel size, land usage and other legal rights related to parcels and buildings as attributes. The content and the structure of the local GIS solutions should be finished until 2007 for the whole federal state of Mecklenburg-Western Pomerania. By legislation it is also defined that other spatial information systems created in municipalities and counties such as environmental information systems or planning information systems (see Bill, 1999b) should be based on these so-called geo base data sets such as ALK and ALB. This is the reason why district administrations, which acquire and update these base data, are increasingly on the search for solutions, how to publish and deliver these data as easy and uncomplicated as possible to other users. Cadastral offices are placing themselves in the role of data service providers. This would create positive impacts on the geo-data market in general. In the district administration many data have a common spatial reference. The linkage of these data would result in a new quality for the access to the data. It would improve the data management, e.g. by reducing redundancies. A further substantial aspect linking the data of the public administration with the spatial reference data, represented by ALK, ALB, and the coordinated addresses from the residents' registration office, is the improvement of the topicality of the data.
In the context of a diploma thesis and some R&D-projects an Internet-GIS prototype was developed for the county administration in Bad Doberan, a district surrounding the city of Rostock in the northern part of Germany. We used the UMN map server and PHP MapScript, an open source product. On the basis of the developed prototype the opportunities of the application of an Internet-GIS should be investigated. The principle steps and the experiences gained with this system are described in the following chapters.

4.2 Data collection and conversion

In the first phase of the realisation of this Internet-GIS for the county administration all information, which should be published via Internet, need to be converted. This is valid for the ALK and ALB and other data sets on the county level. The ALK data, which are captured with the GIS DAVID, are stored in a data base at the cadastral office of the county. For safety reasons in the Internet solution the ALK data should be published as a copy of the original data set. Thus it was easier to convert the data into the well-known ESRI shape format which is supported by the UMN Map Server. The ALB data are maintained and stored in the computing centre at the federal level of Mecklenburg-Western Pomerania. Usually they are delivered online to the user based on his individual query. The transfer of the ALB data from the WLDG file into a data base format was done. This concept needed modifications because in future ALK and ALB will be merged together to one common geo-information system. This is called ALKIS (Automatisiertes Liegenschaftskataster-Informationssystem, Automated real estate information system). This makes it necessary that the data are stored and delivered at one place. For our prototype we realized this with a copy of the original data, both for the graphic and the attribute data. This process of preparing the data sets for publishing via Internet has to be done at the official place, it may be automated and can be done on a periodical base e.g. each night, each week, each month dependent on the updating cycle and the users demands. The solution achieved should give different users access to the common data base, both on the county level and the municipality level. Additional data sets might be integrated: e.g. at the county level environmental data and at the municipality level zoning plans. In many municipalities zoning plans are still available in an analogue format, i.e. it was necessary to scan and georeference these maps. The map server delivers these maps as georeferenced raster data sets. In addition we integrated digital orthophotos captured with our low-cost aerial flight system PFIFF. In the prototypical implementation we prepared all these different data sets for a small municipality named Elmenhorst-Lichtenhagen, just to analyse performance and user acceptance issues.
Currently many data sets have to be specifically prepared and converted for the purpose of publication via Internet. In future

with the existence of larger information volumes and a better technical infrastructure at the various administrative offices the conversion steps should become obsolete using the OGC concepts of interoperability via WMS/WFS middleware mentioned before.

4.3 Technical realisation and effort

The implementation of the Internet-GIS took place on the basis of the UMN Map Server. The human interface was realised in HTML. One specific selection menu was programmed in JavaScript for the improvement of clarity. The Internet-GIS is separated into two levels, the *county level* and the *municipality level*. At both levels of the Internet-GIS the following basic functions are available:

- Zoom in different gradation and with fixed number of scale
- Pan by clicking into the image
- Thematical data queries
- Reference map in the background
- Switching on and off of thematic layers
- Scale bar
- Presentation of thematical data of the current view, starting from certain zoom stages.

The Internet application starts for both levels with an overview map of the entire county Bad Doberan (see fig. 2). Beside the administrative borders of the municipalities further data sets to be used on the *county level* are integrated here. Typical map scales presented here are in the range of 1:2.500 to 1:50.000. Topographic raster maps are presented in the background. Thematic data are for instance maps on contaminated sites or maps on natural monuments. Within the Internet environment at the county level other departments may use these data, in future they might be interested and might technically have the feasibility to publish their own data on that level. This Internet-GIS solution should later become a standard for querying interdisciplinary data sets on the county level. This could reduce redundancies, make information flows transparent and avoid paper and digital copies between the different specialised offices in the counties administration. At this level data security or data protection are not such critical. Later this level might also be used as a starting point for a citizen information system for the whole county.

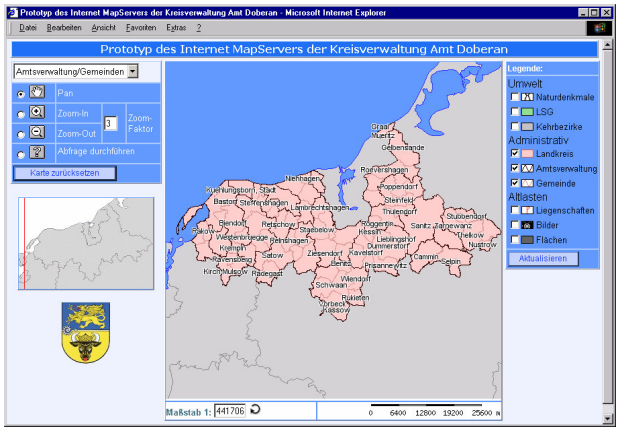

Figure 2: Human interface prototype on county level

From this county level the individual communes participating of this Internet-GIS are also starting. Just by clicking in the menu or selecting the communes name in the menu the user reaches the *municipality level*. At this level data protection is getting very important. By user name and password only allowed user can reach this protected level. There are quite simple reasons for that higher protection level: Cadastral data on ownership are protected by law, only user such as the owner or collaborators of the administrative offices are allowed to see property data.
Within the protected range for the representatives of the municipality again the Internet-GIS starts with an overview map of the commune showing municipality borders and further administrative subdivisions of the commune such as meadow borders. For special users at municipality level different views may be generated.
In a *cadastral shell* we offer the land register data ALK/ALB (parcels and buildings, land usage). Beside the vector data of the ALK we embedded the scanned cadastral maps as raster data just to show that dependent on the different status of the data acquisition in the communes one can easily start with the raster data and exchange this step by step as vector data. Simply by querying the ALK data of individual parcels or buildings at the appropriate zoom level the user retrieves the information of the ALB. The query results on the ALB are prepared in a questionnaire exactly of the same layout, format and design the user would see when working with analogue data. This pdf-document is created with Pdf Lib in different variants with or without specific ownership information. Exemplarily the internal forms 30 and 35 of the land registry were realised. Using the icons in the menus at the top margin of the map display the user can jump directly into the representation of certain detailed information on cadastral level. This is realised using on the one hand the address of the buildings in the ALK and on the other hand taking the meadows name and/or parcel number.
At this step we fulfil nearly all demands an official user at the municipality level would require, i.e. the local administration officer no longer needs a stand-alone GIS simply for querying ownership information from the cadastral office. Without any additional costs (hardware/software) and additional efforts (data conversion, training etc.) he is now able to query the cadastral data using his standard web browser. This is a major benefit for the municipalities exchequer.
In the *topographic section* we integrated topographic maps at scale 1:25.000 as raster map and georeferenced aerial photographs with a ground resolution of approximately 30cm. With our low-cost flight system PFIFF the images may be captured on demand. Thus the topicality is very good. In many use cases, especially for planning and topographical purposes, this image data set may replace the official cadastral map.
In the *planning section* the generic zoning plan (scale 1:5.000 to 1:25.000 dependent on the communes size) and the detailed individual zoning plans of the municipalities, usually in a scale of 1:2.500 to 1:1.000, are simply visualised by their borders and a text placement. The scanned and georeferenced detailed zoning plan is integrated here as a raster data set and is selected for visualisation by just clicking on the text annotation. If this plan is available in vector format it could also be embedded. In addition the textual part of the detailed zoning plan, the plan notation and explanation of the signatures etc. are presented as text documents.
Beside these three realisations for different users on a municipality level other sections (environment, technical infrastructure etc.) may easily be integrated with the existence of digital data. For all the various users and their section we offer different user access modi and different layout based on access rights related to their work profile or based on spatial or temporal partitioning.

The Internet representation at municipality level is realised in a completely different layout than on the county level (see fig. 3). This gives the municipalities the chance to have their own Internet design. On the other hand it allows the communes to create different Internet services on top of these data sets such as fingerposts to the administrative offices, for advertisement and so on. For this a uniform Internet appearance is desirable within the municipality.

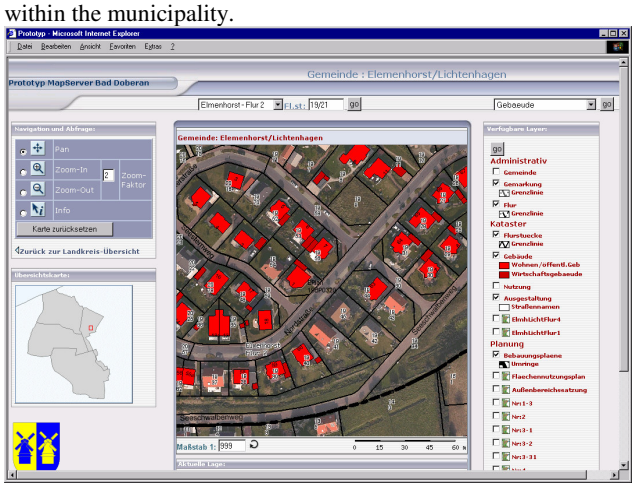

Figure 3: Protected human interface prototype on municipality level

5. SUMMARY AND CONCLUSION

Due to the general availability the Internet technology increasingly gains in importance also for the official administrations. The employment of Internet technology represents here a more profitable solution. The Internet is based on the client-server architecture. This offers the possibility that the data remain and can be administered and maintained, where they are produced due to the competence, the responsibility, the technical knowledge, and the infrastructure. Additionally also the programs can remain on the server, so that the user of the data does not have to worry any longer about complex hardware and software. The user accesses data only via the WWW-browser. The information are ready for use. By such an approach a lot of time can be gained related to training of programs, maintenance of data and costs of hardware and software. In contrast to this stands the responsibility, which the data provider has to guarantee. Taking over the role of a service provider he has to deliver and publish the data in a easy-to-use form and based on the requirements the users on county or municipality level define.

By using Open Source solutions the opportunities for participation at developments of others exist. The solutions often fit better to the needs of the users, because users may themself be developers of system components. Apart from the smaller capital outlays the high stability and security as well as the large flexibility of the Open Source code plays an important role. Therefore Open Source solutions find also increasing acceptance and a rising spreading degree. From the users viewpoint no serious distinctions are given here compared to commercial products. It looks somewhat different on the side of the provider of an Internet-GIS service such as a cadastral office on the county or municipality level. Here it is to be clearly presupposed that technically experienced staff exists, that does not only guarantees the systems availability in the given manner, but also develops and expands the system further. With the appropriate understanding of the role of a geo chief information manager and a service provider the land registration offices become able to deliver full geo service packages from one hand.

6. REFERENCES

Bill, R., 1999a. Grundlagen der Geo-Informationssysteme. Band 1. Hardware, Software und Daten. Wichmann Verlag, Heidelberg.

Bill, R., 1999b. Grundlagen der Geo-Informationssysteme. Band 2. Analysen, Anwendungen und neue Entwicklungen. Wichmann Verlag, Heidelberg.

Piepel, C., 2002. Basiswissen Geodienste im Internet: Technologie und OGC Standards, in: 7. Münchener Fortbildungsseminar Geoinformationssysteme, 6.-8. März 2002, Runder Tisch GIS e.V.

Herrmann, C., Asche, H., 2001. Web Mapping. Wichmann Verlag, Heidelberg.

Strobl, J., Blaschke, T., Griebsebner, G. 2002. Tagungsband AGIT 2002, Wichmann Verlag, Heidelberg.

GI-Produkte: www.geoinformatik.uni-rostock.de/produkte.asp → GI-Systeme → Internet-GIS

GI-Links:www.geoinformatik.uni-rostock.de/links.asp → Internet systems

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