USING SDI-BASED PUBLIC PARTICIPATION FOR CONFLICT RESOLUTION

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ABSTRACT

Web-based tools for public participation using maps, often referred to as public participation GIS (PPGIS), gain importance as the Internet becomes a commonly available source of information. E-government finds its way into town halls, and both citizens and municipalities begin to benefit from the low costs and the convenience of the web. Moreover, public participation has been fostered as a main concept for sustainable development by several international agreements throughout the past years, such as the European Commission's Directive 2003/35/EC (European Commission 2003) or the United Nations' Agenda 21 (United Nations 1992). Although PPGIS have been a hot research topic for almost a decade, we are still waiting for the breakthrough of applications in this field. This paper delineates the way from the existing, mostly monolithic and non-interoperable tools to service-oriented, reusable applications, using the development of the *Argumentation Map* prototype as an example. Generally, spatial data infrastructures (SDIs) should provide a suitable environment for the integration of PPGIS; we will discuss the suitability and sufficiency of currently used standards for this special SDI use case.

KEYWORDS: Public participation, Argumentation Maps, spatially referenced debates, SDI, collaborative decision making, e-government

INTRODUCTION

As more and more people have internet access, and public participation gains in importance through the promotion of sustainable development strategies, a number of PPGIS applications have been developed by different research groups (such as the Centre for Computational Geography, School of Geography at University of Leeds, UK; Fraunhofer AIS in St. Augustin, Germany; or the Department of Geography and Environmental Development, Ben-Gurion University of the Negev, Israel). The topic of PPGIS has been discussed in a wide range of publications, both from a technical and from a sociological perspective (see Sieber 2004 for an overview).

The tools falling under the generic term PPGIS make extensive use of geographic information. Hence, PPGIS represent typical beneficiaries of SDIs. Nevertheless, barely any research has been done on PPGIS in the context of SDIs. Some publications refer to PPGIS (or similar applications) which use background maps loaded from services compliant with the Open Geospatial Consortium's (OGC) Web Map Service (WMS) specification (such as Kolbe et al. 2003). Information on PPGIS with improved interoperability, e.g. by supporting more standards, cannot be found in the literature. However, some projects have been released as open source (Hachmann 2004).

This paper will sketch the possibilities to create the “missing link” between PPGIS and SDI. Previous work on PPGIS, and the development of the Argumentation Map prototype will be put in the context of standardisation and interoperability, analysing the sufficiency and fitness for use of existing standards for PPGIS. The development of future PPGIS tools and their integration into SDIs will be envisioned, using the Argumentation Map prototype as an example.

In the following, we will give an overview of some existing PPGIS applications with a focus on adaptability to other use cases and compliance with interoperability standards. We will then present our own PPGIS prototype (both from a user’s point of view and from a technical perspective), and delineate our experiences during its setup for the EU project MEDIS. Thereafter, we will discuss how public participation can benefit from an SDI (and vice-versa), once fully standards compliant PPGIS tools are available. Finally, we will outline the planned future development of the prototype and discuss the more general problem of standards-based map annotations. The paper finishes with conclusions and gives an outlook on future work.

PUBLIC PARTICIPATION GIS

In this section, we will present the current state of research in the field of PPGIS. Some representative examples will demonstrate the functionality and the level of interoperability that has been reached. The examples include a PPGIS “classic” (Virtual Slaithwaite), an up-to-date tool which is applied in an interactive landscape planning process, and a research prototype that integrates a professional discussion forum and a web-based Java GIS.

Kingston et al. (1999) present the “Virtual Slaithwaite” application, a tool which implements a digital version of the analogous “Planning for Real” method. This public participation method allows citizens to place small flags on a large-scale model. The flags contain comments such as concerns, ideas and suggestions. This method does not support a structured discussion, as it is not possible to respond to the comments on other flags. The web-based implementation allows users to comment on map objects. In the client-side Applet, one comment can only refer to one map object, and it is not possible to create new reference objects.

Hachmann (2004) implements a tool for interactive landscape planning. It presents a map of a landscape plan to the users and provides an easy-to-use interface to create graphic reference objects, which can be commented on. The tool is based solely on these objects created by the user, that is, it is not possible to refer to objects visible on the map, as in the Virtual Slaithwaite tool. This is due to the fact that Hachmann uses image maps, in contrast to the vector maps built from ESRI Shapefiles used by Kingston et al. Comments can only be exchanged between citizens and municipality offices, but not among citizens. However, all comments and the corresponding answers from the municipality are freely accessible. The source code of the software has been released as open source, and it is built from components to guarantee extensibility.

Voss et al. (2004) present a prototype, which integrates the Java-based thematic mapping tool CommonGIS (http://www.commongis.com/) and the Dito discussion forum (http://zeno8.ais.fraunhofer.de/zeno/). A key feature is the support of many-to-many relationships between contributions in Dito and geographic objects in CommonGIS. The data exchange between these two separate applications has been implemented through server-side data pipes. The combination of two powerful and highly specialized tools makes the work flow of geographically referenced discussions very flexible. However, new users, especially if they have no experience in GIS, need to familiarize themselves with the complex functions of both applications to benefit from this flexibility. From a content providers' point of view, an integration into an existing spatial data infrastructure might entail problems, due to the proprietary formats and protocols the prototype is based on.

These few examples give an impression of the current state of research of the technical aspects of PPGIS. Most of the existing PPGIS tools are hardly adaptable to different use cases because they were developed for one specific scenario. This stands in contrast to the standardisation efforts of organisations such as the OGC or the International Standards Organisation's Geographic Information / Geomatics Committee, which aim at interoperability between web services for geospatial data. For a standards-based PPGIS application, the exchange of the back-end spatial data and hence the use-case would be easily practicable, especially in an SDI-based data environment. Kolbe et al. (2003) present a prototype for collaborative planning of bike tours which allows users to comment on maps. It retrieves its maps from OGC Web Map Servers. Although this tool has not been developed for public participation, it demonstrates how standards-based applications can serve for the exchange of spatially related information, while being easily adaptable to different use-cases and allowing for a seamless integration into SDIs.

PROTOTYPE AND CASE STUDY

In the following, we will present the Argumentation Map prototype and the MEDIS project as a specific use case. We will report on our experiences during the setup of the tool for the project, with a special focus on data retrieval and integration. SDIs will be discussed within the scope of public participation, and we will demonstrate how Public Participation might act within SDIs in the future.

Argumentation Maps

Argumentation Maps (short: ArguMaps) have been introduced by Rinner (1999, 2001) as an object-based model for geographically referenced discussions. The model is based on argumentation elements (discussion contributions) and geographic reference objects, which are independent from each other. From a user's perspective, it relates a discussion and a map to each other. Besides the above-mentioned argumentation elements and geographic reference objects, the model includes *graphic* reference objects, which can be defined by the user. Hence, the model differentiates between reference objects the map already contains (*geographic* objects) and reference objects which have been added by the users, e.g. to mark an area (*graphic* objects). Figure 1 gives an overview of the three object types of the model and defines the possible relationships between them.

Introducing three independent types of objects allows for different kinds of relationships. In particular, the model supports *many-to-many* relationships: an argumentation element can reference several geographic objects, and a geographic object can be annotated by several argumentation elements. Moreover, the components may also have relationships to other components of the same class, as shown in Figure 1. Reference objects usually have spatial relations to each other (e.g. topological relations), and argumentation elements may have logical relations to each other (such as "A answers B" or "A quotes B and disagrees with C"); again, the model supports many-to-many relationships.

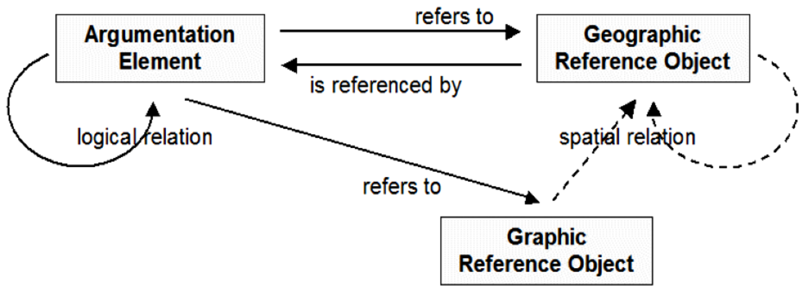

Figure 1: Overview of the Argumentation Map model (from Rinner (in press)).

The ArguMap model is flexible, as it is independent of a fixed discussion structure, and allows for functionality, which cannot be realized with coordinate-based approaches. For example, with tools that use coordinate pairs instead of reference objects, it is impossible to determine whether two discussion elements actually refer to the same real-world object. The model generates the structure for effective analyses, such as identifying the most controversial objects on a map. It allows for implementations which make discussion contributions directly accessible by choosing the according reference objects on the map - and vice versa.

Prototype Functionality

Keßler et al. (2005) present a prototype, which aims at compliance with existing standards, reusability and user-friendliness, implementing the ArguMap model. It combines a thread-based forum, comparable to Usenet newsgroups, with a map display. Users can select spatial objects on the map and add them as references to their discussion contributions. Figure 2 shows the prototype's user interface. The workflow for the exploration of the discussion is kept flexible, leaving it up to the user to either browse through the discussion and see which reference objects are highlighted on the map, or to look for objects of interest on the map and read the referencing discussion contributions. Both ways are kept simple: when the user clicks on a contribution in the discussion tree, all referenced objects on the map are highlighted. The other way around, a click on an object on the map automatically highlights all referencing contributions in the discussion.

As usability, especially for non-experts, has been a focus in the development of the prototype, writing new geographically referenced discussion contributions is also kept simple: the user interface for writing new contributions (either to respond to existing contributions or to start a discussion thread on a new topic) resembles writing an e-mail with a title and a text body, as shown in figure 3. Additionally, the user can add geographic reference objects to the contribution by simply clicking them on the map. The selected reference objects are highlighted on the map, so that the user gets an overview of the selected objects. If no objects are available at the according location, the user may also add graphic reference objects, which is limited to point objects in the current version. Finally, the user can label her contribution as *neutral*, *pro*, *contra*, *question* or *suggestion*. These labels are indicated through icons in the discussion tree, so that readers can get a quick overview of the main position of a contribution, or of the main positions towards a suggestion, for example.

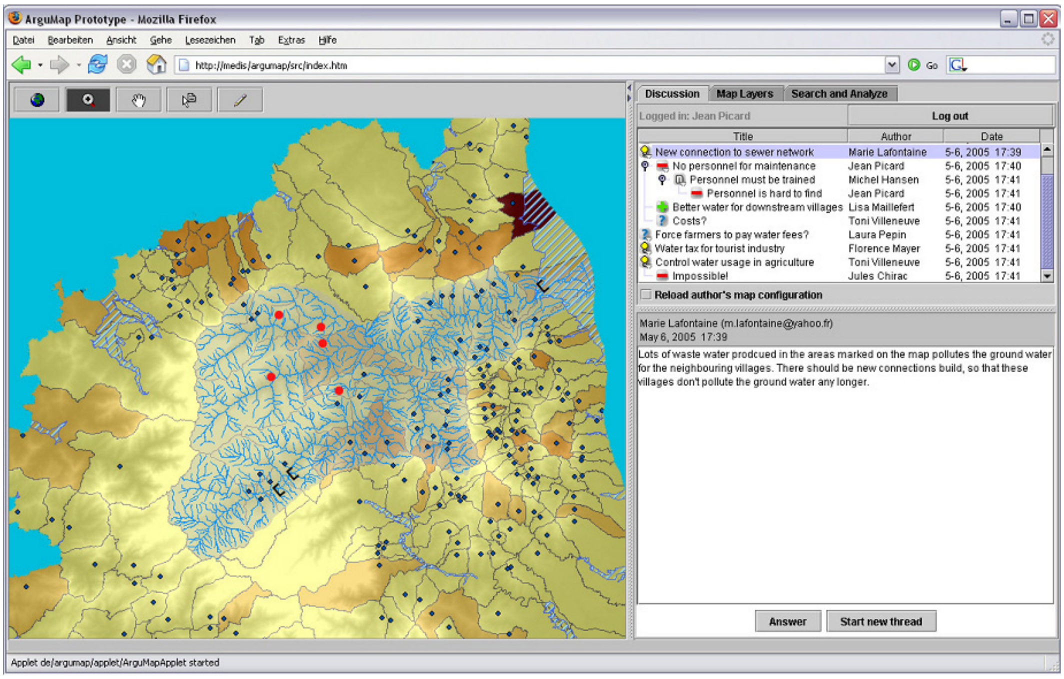

Figure 2: User interface of the ArguMap prototype.

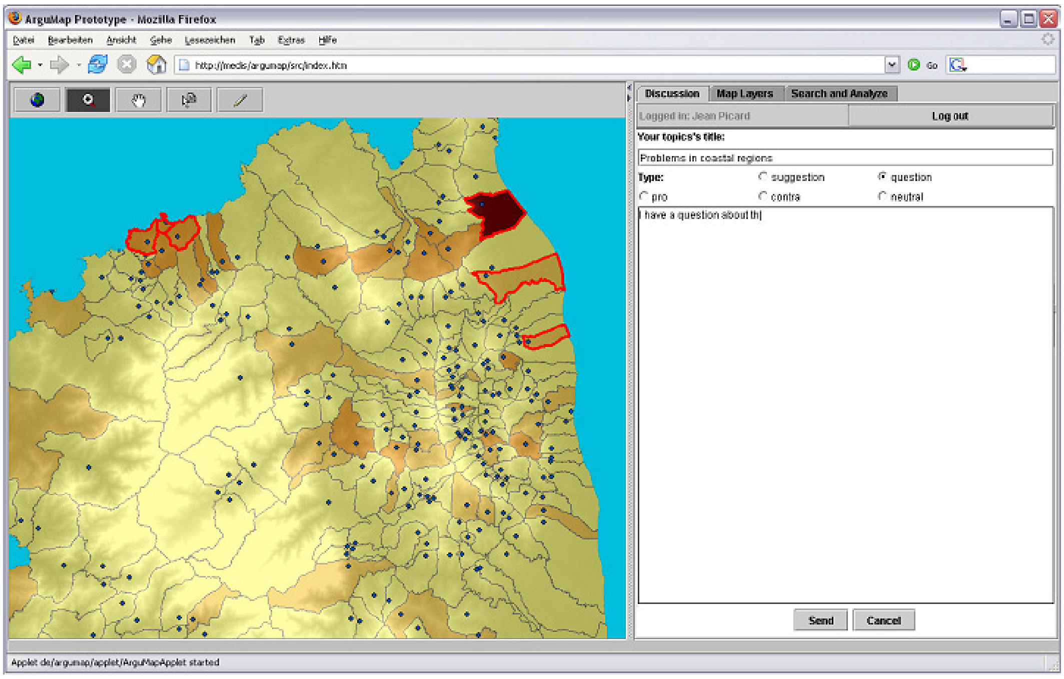

Figure 3: User interface view when writing new discussion contributions with geographic reference objects.

Beyond the basic functionalities of exploring the geographically referenced discussion and contributing to it, the prototype provides some basic analysis functions, which are shown in figure 4. Users can search the discussion for keywords of interest. The search can be limited to contributions, which refer to objects in the currently visible map extent. A counter gives an overview of the main position towards an object on the map by displaying the number of contributions and their labels. The tool for conflict area identification adds a new, colour-shaded layer to the map. This layer covers all referenced objects on the map and paints them from green (for the objects with the fewest referencing contributions) to dark red (for the objects with the highest number of referencing contributions). Thus, the reader can easily identify the objects that are the most discussed ones, and which represent potential areas of conflicts.

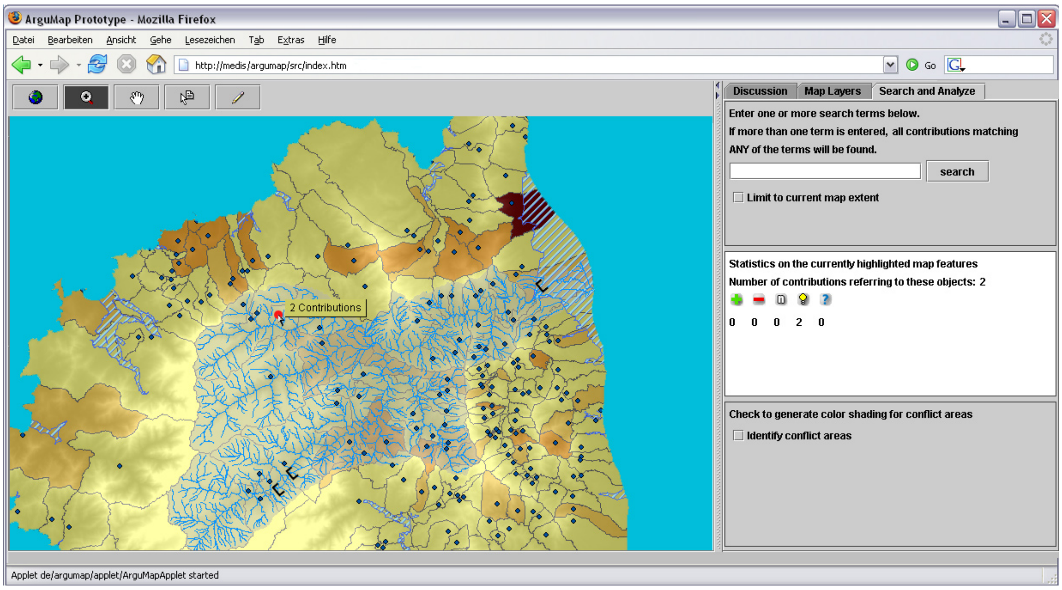

Figure 4: Analysis functions of the prototype.

Prototype Architecture

Technically, the ArguMap prototype is made up of a Java Applet on the client side and a number of Java Servlets on the server side. Discussion contributions and reference objects are written to a server-side database. The prototype's map component is built upon the GeoTools Lite libraries (http://www.geotools.org/Geotools+1.0+Lite+Project). It allows for the combination of raster maps retrieved from map servers compliant with the OGC Web Map Service specification, with vector maps built from ESRI Shapefiles. This combination enables content providers to overlay the current state of an area (oftentimes available from one or more WMS) with plan data from a GIS. Figure 5 gives an overview of the prototype architecture.

The Servlets running on the server can be divided into two groups: one group of the Servlets is responsible for the communication with the database, that is reading discussion contributions, registered users and (geo)graphic references from the database, and writing new objects to the database (contributions, reference objects, and users). The second group of Servlets forms an OGC compliant WMS client, which collects maps from a number of WMS, overlays them, and hands them over to the client side Applet. Beyond that, these Servlets also manage OGC compliant Web

Map Context (WMC) files. These XML-based files store map configurations, put together from any number of WMS, with the selected layers and map extent. A new WMC file is stored for every contribution and can be reloaded by the readers of the discussion by checking the according check box in the user interface (as shown in figure 2, below the discussion tree). This functionality makes sure that the user has everything in view that the author of a discussion contribution refers to; otherwise, it might be possible that a reference object is outside the currently selected map extent, or that a layer which is important for the understanding of a contribution has been switched off.

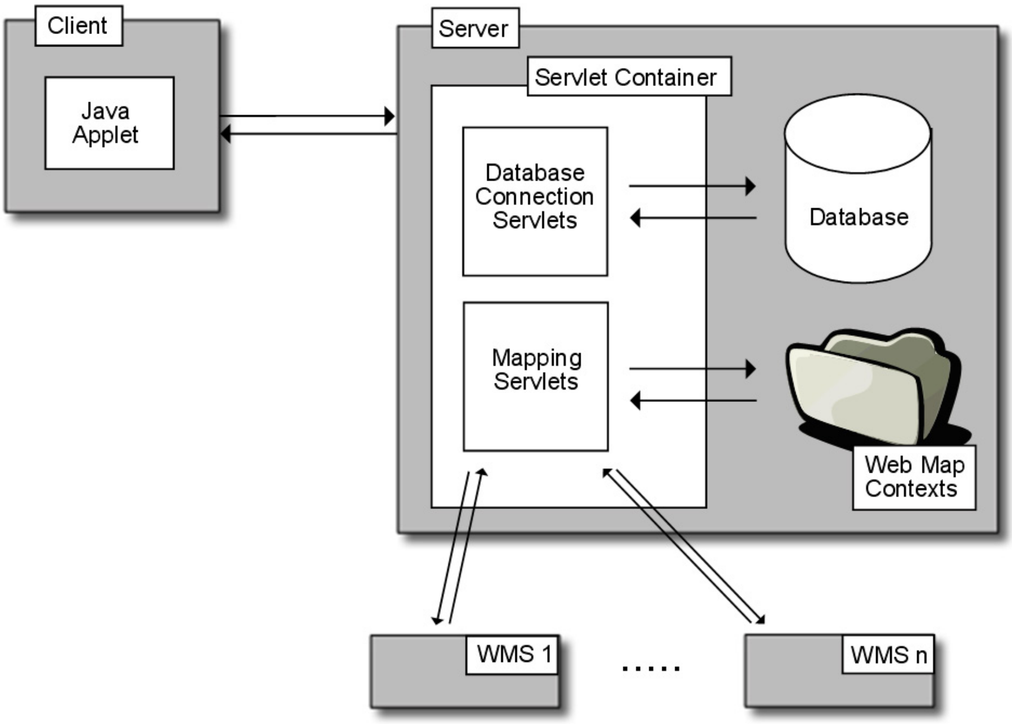

Figure 5: Architecture overview of the current version of the ArguMap prototype.

Case Study

The development of the Argumentation Map prototype has been continued within the MEDIS project (http://www.uni-muenster.de/Umweltforschung/medis). This EU funded project aims at developing recommendations for a sustainable water management on Mediterranean islands in light of water scarcity problems, increasing tourist numbers and agricultural challenges. Within the project, stakeholder involvement is one important method for gaining knowledge about existing problems on the one hand and for creating widely accepted recommendations on the other. The lack of water on the Mediterranean islands leads to conflicts among the citizens, especially those with high water consumption, such as for agriculture or in the tourism industry. Moreover, mismanagement and unfair treatment of different groups of consumers (through different pricing models for private and industrial consumers, for instance) add to the conflict potential caused by the natural water shortage. In this scenario, there are two potential usages for the prototype. On the one hand, the prototype's analysis tools can be used to identify potential conflict areas, identifying the areas with the highest number of discussion contributions. On the other hand, the prototype allows for a collaborative elaboration of conflict solutions. Stakeholders can propose and debate new ways of fair water sharing while directly referring to objects on the map.

The outcome of the discussion, which is usually rather a web of discussion contributions and spatial reference objects, than a consensus, can be used as input for a spatial decision support system. Moreover, it gives municipalities and governmental institutions an idea of the citizens' concerns and problems, and concepts for resolutions might be sketched. Beyond that, affected people are given a comfortable, easy-to-use platform to express their difficulties and ideas.

Public Participation in SDIs

The setup of the prototype as described above requires a proper, user-friendly implementation, because most of the users are lay-persons concerning GIS. Beyond that, data retrieval and integration is a crucial point. Within the scope of the MEDIS project, the usefulness of the prototype is closely related to the quality of the data presented in the map component. Data for the different islands are mostly available as parts of datasets which cover a whole country, the whole of Europe, or even the whole world. Hence, the data are mostly not detailed enough, because the actual areas of interest are comparatively small. In addition, many providers of free spatial data do not permit users to publish their data in services on the Web, therefore a lot of the data which are actually at hand can not be used due to license restrictions. Data for the sample catchments on the islands either have to be collected by the project partners on site, or they have to be integrated from commonly available sources such as the free services from the geography network (http://www.geographynetwork.com/).

For applications such as the ArguMap prototype in the MEDIS scenario, an SDI which offers a data catalogue with detailed information on data availability, granularity, license models and pricing can simplify and accelerate the setup of an application for different use cases. Organisations that want to provide a PPGIS tool on the web do not necessarily have to host any data themselves. Respectively, special data required for an application can be shared within the infrastructure (Williamson et al. 2003, p.18). Such a catalogue becomes even more useful when the scenario area goes beyond national borders, and the content provider has to look for adequate data on different national levels. As the standards developed for geospatial data and services form the technical foundation of SDIs, a better reusability of PPGIS tools compliant with these standards can be achieved. A fast and standardized way of accessing spatial data as provided by an SDI could accelerate project accomplishment and hence help to save time and money.

Beyond the benefits of an SDI for public participation outlined above, integrated PPGIS tools can also help to enhance data quality within the SDI. Users of these tools might detect errors in the spatial data. The tool provides them with an interface to mark these errors and comment on them, to describe an error and possibly even the correction. Future PPGIS tools might integrate ways which allow for sending such detected errors directly to the person or organisation responsible for the data. The contact information can be retrieved from the capabilities documents, in the case of OGC compliant services, or from other metadata. This kind of data reviewing can be integrated into the SDI's quality management (Doucette and Paresi, 2000). The online data viewer "TIM-Online" (http://www.tim-online.nrw.de) of the regional SDI of Northrhine-Westphalia in Germany already provides its users with comparable functionality (Sandmann, 2005). Current research deals with the question how this update process can be automated, while making sure that the data entered into the spatial data storage (usually a database) are correct. Sayda (2005) presents an approach which follows the principle that the more users report a specific update to the data storage, the more feasible it is. This work flow that has been developed for Location Based Services (LBS) with mobile clients such as PDAs or mobile phones initiating updates, can also be transferred to stationary clients.

TOWARDS A STANDARDS-COMPLIANT, REUSABLE PPGIS TOOL

After presenting some existing PPGIS applications and presenting the ArguMap prototype, we will now sketch the future development of this prototype. The main aim will be to make it fully standards compliant. Proprietary interfaces or formats should be avoided whenever possible.

Future Development of the Prototype

The architecture of the current version of the ArguMap prototype, as shown in figure 5, still has a number of drawbacks concerning full compatibility with standards used in SDIs. Hence, the future development will focus on replacing proprietary workarounds by standardized solutions. On the server side, the prototype needs to be equipped with the ability to communicate with the most important OGC services. Especially the retrieval of vector data encoded as Geographic Markup Language (GML) from Web Feature Services (WFS) will be a focus of the development. The integration of WFS will make the use of ESRI Shapefiles dispensable. This entails that the client needs the ability to render and display GML. To achieve this functionality, the exchange of the underlying application programming interface (API) will be necessary. Beyond that, the GeoTools Lite API, which is used in the current version of the client, is not supported by the development team any longer. Using the follow-up called GeoTools 2 should be considered as a replacement; however, other APIs such as OpenMap (http://openmap.bbn.com) have be taken into account, too.

Considering the development of the client, the main aim will be to make the prototype more open to different clients. The current architecture implies a tight coupling of the client and server modules. All functions available through the Servlets are harmonized with the client's Applet. The future architecture should consist of a server core, which provides only the basic functionalities of ArguMaps. This core should be easily extensible, so that two things can be realized: on the one hand, this would provide a basic framework which allows for the use of very different kinds of clients, ranging from very simple, pure HTML clients, to full standalone applications or extensions of GIS. These clients are very different in terms of realizable functionality. For example, a Java Applet can contain more complex functionality than an HTML web page. Hence, the server core would have to be extended with functions that are specially adapted to a certain kind of client and provide the functionality that cannot be implemented in the client itself. On the other hand, this concept would also allow for extending the server with new functionality, e.g. for the management of different user levels (such as administrators, moderators and regular participants).

If the steps outlined in the two sections above can be realized, the interoperability, re-usability and extensibility of the ArguMap prototype could be heavily enhanced. However, the geo-referenced discussions written to the database would still be "locked" inside the tool, and could not be reused in any other application, as they are stored in a proprietary way. This is mainly due to the lack of a standard for map annotations.

How to Annotate Maps

Standards in the geo-spatial domain cover a wide range of services and data, ranging from simple raster and vector maps, coverages and sensor networks to geoprocessing services and metadata (see Kresse and Fadaie (2004) or the OGC reference model (OGC 2003) for an overview). Surprisingly, there is no existing standard for the handling of map annotations, that is for relating different kinds of information such as texts, images or any other kind of multimedia to locations on a map. Geo-referenced digital “Post-it notes” are very useful for a whole number of applications, such as personalized travel guides or automatically generated travel diaries (Andrae and Winter, 2005), geo-referenced photo albums, or maps showing the images taken by the web cams distributed over a city; basically, they can be applied whenever personalized information needs to be added to a digital map. Hence, a number of proprietary solutions have been implemented for this kind of problem.

Google maps (http://maps.google.com) is one of the latest developments in this field. It provides users with a JavaScript API which allows them to add additional data to Google maps, indicated through arbitrary icons. These additional data are not added to the backend data, but they are added to the map within the client browser. Yahoo maps (http://maps.yahoo.com) provides similar functionality. The GeoURL service (http://geourl.org) addresses a very specific topic. It allows users to geo-reference their website by adding a special metadata-tag containing their location. Once a website has been added to the GeoURL database, users can search the database for websites in their neighbourhood. Map Bureau’s pointMapper (http://www.mapbureau.com) is an application written in Macromedia Flash which allows users to add points or lines to maps. The background maps can be either raster maps (JPEG images) or special vector maps in Flash format. The points and lines are added through JavaScript functions, or by loading special resource description framework (RDF) files, and they can be linked to any other source of information on the web – text, images, videos, etc.

The few examples sketched above give an impression of the different areas of use for map annotations. At the same time, they show the different technical options for the implementation of this functionality. However, non of these solutions is compliant with interoperability standards. One attempt to develop a standard which integrates seamlessly with OGC services was *XML for Image and Map Annotations* (*XIMA*) (OGC 2001a). This OGC discussion paper presents a draft specification that uses standardized XML files to annotate maps. It draws on GML and it is meant to be used for the defence and intelligence community, but also for city planning, participatory government and tourism. XIMA allows for the annotation of maps with text as well as so-called *rich* contents such as images, video sequences, or Scalable Vector Graphics (SVG). With XIMA documents, users can mark points, lines, polygons or any other kind of GML feature on an image. An XML file that complies with this specification contains an *Annotation List*, which is made up of a number of *Annotations*. Each of these Annotations has one or more *Annotates* objects that contain a map that is annotated. Thus, one Annotation can refer to a number of maps. Moreover, it can contain a number of GML elements that specify the points, lines or areas this annotation refers to. Beyond that, an Annotation has a *Content* object, which usually holds the comment as text, but can also hold the above mentioned rich content. In the case of rich content, links are used to refer to the actual files. A number of properties objects like title, author or date round off the Annotation object. Figure 6 shows the complete document tree for XIMA documents.

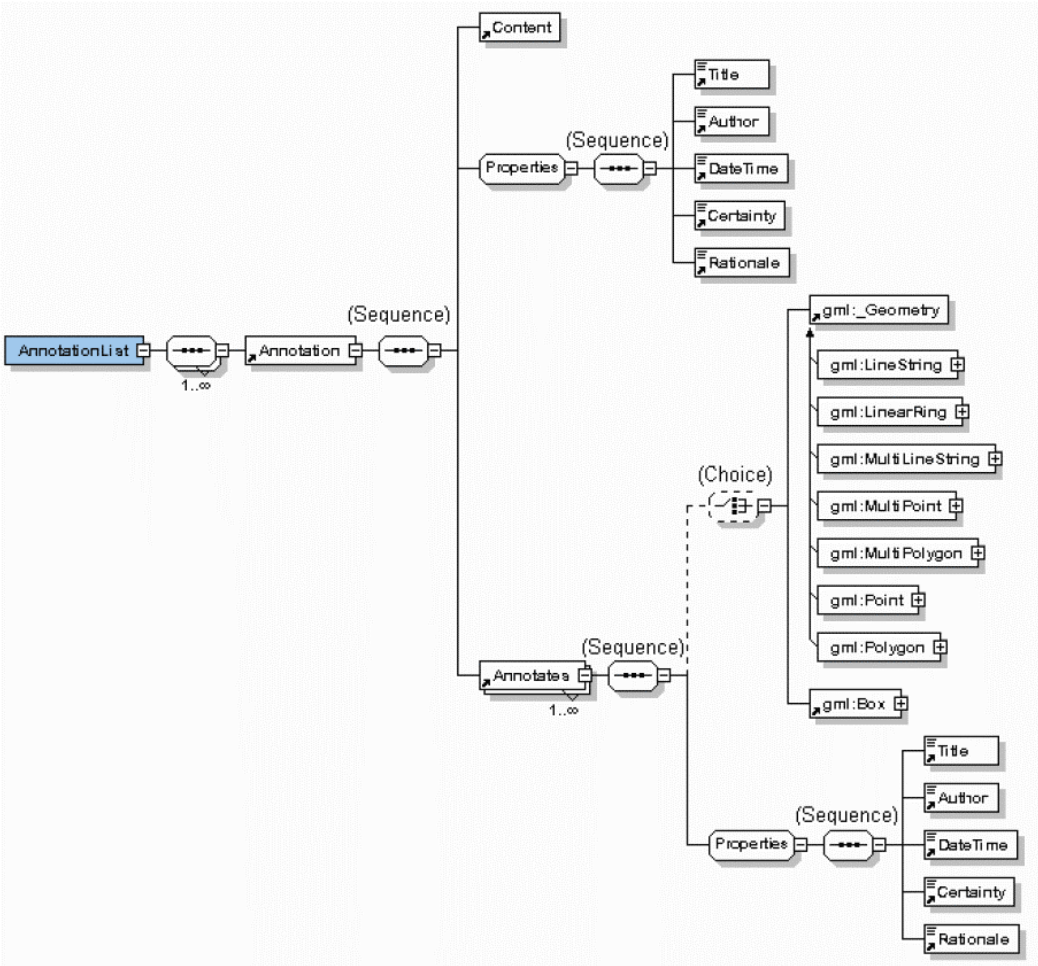

Figure 6: XIMA document tree (from OGC 2001a).

Unfortunately, the development of XIMA has not been pursued any further. The discussion paper *Location Organizer Folder* (*LOF*) (OGC 2001b) presents another GML-based approach for relating additional information to maps, but with a different intention. LOF are meant to be used by analysts as a geo-referenced data storage, which can be valuable in fields like disaster analysis. However, although there were some initial attempts for a standard in this field, which certainly emerged from the need for a solution that integrates with OGC services, there is no such standard yet. Without a standard, it will not be possible to build applications which can exchange geo-referenced information, and developers will be forced to build proprietary, isolated solutions, as in the ArguMap prototype.

Transferring the elucidations on interoperability and standards-based map annotations to the ArguMap prototype leads to an extended architecture, as described in the previous section. Figure 7 shows the envisioned architecture of a fully standards-compliant future version of the prototype. It supports all important standards for retrieving spatial data from web services. Moreover, the link between client and server has been loosened, allowing different clients to use the server core. The clients interact with interfaces implemented in client-specific server extensions and provide functionality that allows the users to give feedback on data quality. Finally, the proprietary solution of storing discussion contributions and geographic reference objects in a database has been replaced by standards-based map annotations (possibly XIMA documents, depending on the future developments in this field).

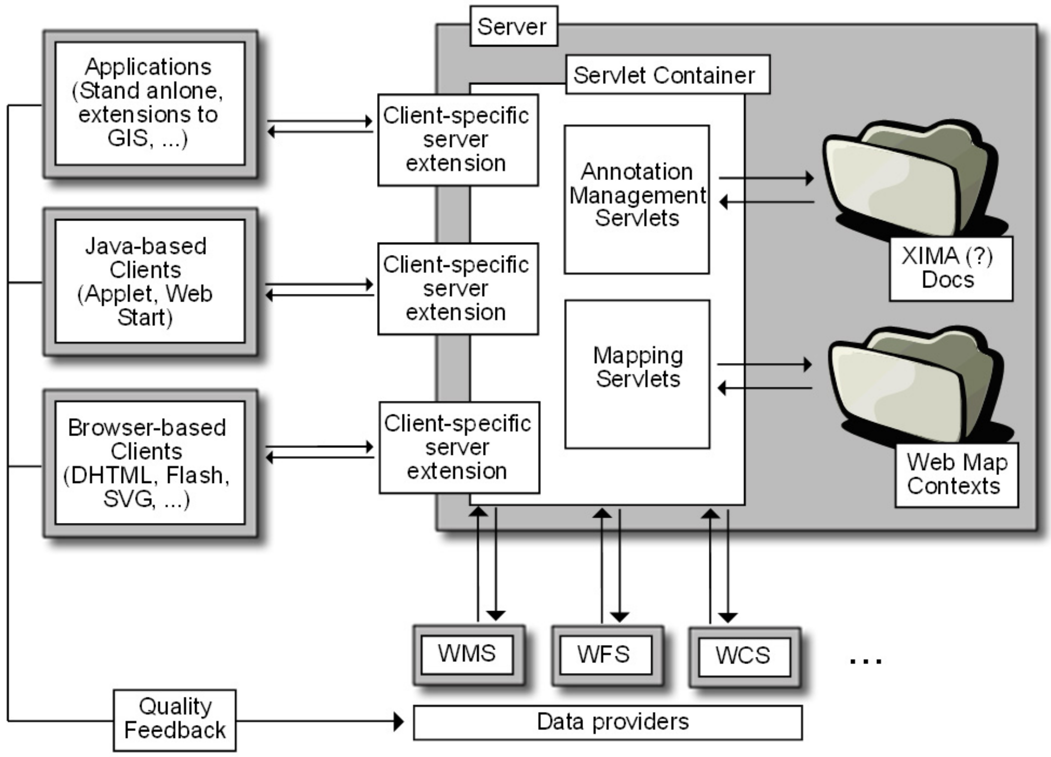

Figure 7: Draft architecture for a fully standards-compliant future version of the ArguMap prototype.

CONCLUSIONS AND FUTURE WORK

We have presented our work within the MEDIS project, using a web-based application for public participation. Argumentation Maps have been reviewed as the methodological foundation of the prototype, and discussed in detail both from a user's and from a developer's perspective. Benefits for the public and for providers of spatial data emerging from the application of public participation tools within an SDI have been elucidated. Finally, the problem of geo-referencing information outside a GIS has been discussed, with a focus on integration with SDI standards.

Conclusions

SDIs provide a suitable environment for the integration of PPGIS applications. Public Participation tools, which are fully compliant with the standards used in the SDI, can capitalize on the variety of available data, and data collected for special use cases can be made available within the SDI. However, most PPGIS tools still use proprietary protocols and are thus difficult to integrate into SDIs. Moreover, the lack of a standard for geo-referencing information which is compliant with current SDI service standards hamper the evolution of fully standards-compliant PPGIS, forcing developers to tailor proprietary workarounds.

Future Work

The development of a standard for geo-referencing information is a topic that should be urgently addressed by the GI research community. XIMA could serve as a foundation for the new specification, which would have to prove its usefulness and fitness for a broad range of applications in test beds and real world scenarios. Once there is such a standard, development of interoperable applications using it could begin, including PPGIS.

Concerning the development of the prototype, one of the next steps will be to make it an open source project, to ensure that the development does not stop when the MEDIS project is finished. Moreover, this will hopefully lead to an active development group, which pushes the evolution of the prototype forward. From an organisational point of view, the integration into the open source initiative 52° North (http://www.52north.org/) is one option, as this initiative has a vital community involved in the development of open source software for the geospatial domain.

As the prototype is supposed to be as user friendly as possible, regular usability tests will be part of the development process in the future. The first version of the prototype is currently undergoing such tests at the University of Toronto, which have already brought some helpful hints on the improvement of the prototype's architecture. Moreover, these tests are supposed to validate the usefulness of the ArguMap model itself, independent of the implementation.

ACKNOWLEDGEMENTS

This research is funded through the European Commission's MEDIS project (contract no. EVK1-CT-2001-00092). The initial version of the Argumentation Map prototype has been developed by the first author during a stay at the University of Toronto, which was partially supported by the German Academic Exchange Service (DAAD).

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