An Argumentation Map Prototype to Support Decision-Making in Spatial Planning

Carsten Keßler[1], Claus Rinner[2], Martin Raubal[1]
[1] Institute for Geoinformatics (IfGI), University of Münster
Robert-Koch-Str. 26-28, 48149 Münster, Germany
carsten.kessler | raubal@uni-muenster.de, phone +49-251-83-39769, fax +49-251-83-39763
[2] Department of Geography, University of Toronto
100 St. George Street, Toronto ON M5S 3G3, Canada
rinner@geog.utoronto.ca, phone +1-416-978-6047, fax +1-416-946-3886

SUMMARY

Collaborative decision-making usually entails argumentation – the exchange of personal views on certain topics, in particular using logical reasoning. Argumentation is often structured into discussions with contributions by individual participants responding to each other. In spatial decision situations, most discussion contributions will contain geographic references. Argumentation Maps were developed to support geographically referenced discussions by cartographic visualization and query functionality. This concept makes geographic references in discussion contributions explicit and uses them for linking text messages to maps, and vice-versa. Based on an analysis of previous work on discussion and decision support in spatial planning, we propose a set of requirements and design guidelines for implementing Argumentation Maps. These guidelines are centred on two main issues: user friendliness and support of open standards. A prototype which implements interoperability specifications of the Open Geospatial Consortium demonstrates the usefulness and usability of Argumentation Maps for public participation in spatial planning.

KEYWORDS: *Argumentation Maps, geographically referenced discussions, collaborative decision-making, spatial planning*

INTRODUCTION

Decision-making in groups of stakeholders usually includes argumentation processes – the exchange of personal views on certain topics, in particular using logical reasoning. Argumentation is often structured into discussions, with contributions by individual participants responding to each other. In spatial decision situations, most discussion contributions will contain geographic references, for example to the participants' home, their neighbourhood, or a reference to an object (existing or planned) which is being debated.

The concept of Argumentation Maps was developed by Rinner (1999, 2001) to support such geographically referenced discussions by cartographic visualization and query functionality. Argumentation Maps make geographic references in discussion contributions explicit and use them for linking text messages to maps, and vice-versa. By linking discussion contributions and map references, a meaningful web of geographic and argumentative objects is created, allowing for combined geo-argumentative analyses.

Existing participatory Geographic Information Systems (GIS) fall short of supporting discussion processes in spatial planning, and discussion platforms and groupware tools lack options for geographically referencing contributions. To make full use of the conceptual power of Argumentation Maps, a Web-based application that integrates both a mapping component and a discussion tool has been developed. Different options for the linking of maps and discussion contributions were analysed.

In the following section, we review the original Argumentation Map concept and discuss related research approaches and applications. We then propose functional requirements and design guidelines for Argumentation Maps. Finally, we present a prototype implementation that uses open standards, in particular the Web Map Service (WMS) and Web Map Context (WMC) specifications of the Open Geospatial Consortium (OGC). We conclude the paper with a discussion and an outlook on future work.

ARGUMENTATION MAPS

Rinner (1999, 2001) introduces Argumentation Maps as an object-based model for geographically referenced discussions. The model treats argumentation elements and geographic reference objects as independent entities. From a user's point of view, it describes the relationships between a discussion and a map. Besides argumentation elements and geographic reference objects, the model includes user-defined *graphic* reference objects. Thus, the model distinguishes between reference objects which are part of the map and reference objects which have been created by the users, e.g. to mark an area. Figure 1 shows an overview of the three components of the model and the relationships between them.

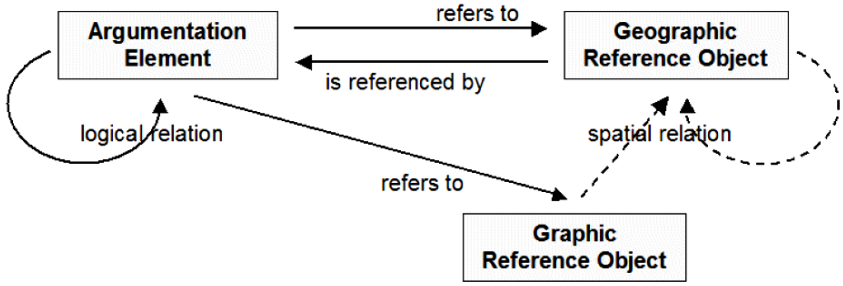

Figure 1: Overview of the Argumentation Map model (from Rinner, in press).

The modelling of three independent object classes allows for different kinds of relationships. In particular, *many-to-many* relationships are supported, that is, an argumentation element can reference several geographic objects, and a geographic object can be referenced by several argumentation elements. Moreover, as shown in Figure 1, the components may also have relationships to other components of the same class. Reference objects may have spatial relations to each other, and argumentation elements may have logical relations to each other; again, many-to-many relationships are supported.

The Argumentation Map concept is flexible and allows for functionality, which cannot be implemented with models that use coordinate pairs instead of reference objects for geographic referencing. For example, with coordinate-based approaches, it is not possible to identify whether two argumentation elements refer to the same real-world object. The Argumentation Map model provides the structure for effective analyses, e.g. when looking for the most controversial objects on a map. Argumentation elements can be accessed directly by selecting the corresponding reference objects on the map, and vice versa.

Geographically referenced discussions have been addressed by other authors, and tools have been developed for collaborative spatial planning, often referred to as public participation GIS (PPGIS). Kingston et al. (1999) present a PPGIS tool, which implements a digital version of the analogous "Planning for Real" method. This method has been used in public participation procedures, allowing citizens to write comments on small flags which are placed at the corresponding locations on a large-scale model. The digital version on the Web also enables citizens to comment on map objects, but

without structured discussion support. Moreover, one comment can only refer to one map object, and it is not possible to create graphic reference objects.

Hachmann (2004) implements a coordinate-based 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. Exchange of information is only supported between citizens and municipality offices, but not among citizens. However, other citizens' comments and the corresponding answers can be accessed without restrictions.

Voss et al. (2004) describe an integration of the Java-based thematic mapping tool CommonGIS and the Dito discussion forum. Their prototype implementation supports many-to-many relationships between geographic objects and annotations. As the prototype is made up of two separate applications, the data exchange has been implemented through server-side data pipes. The combination of these two powerful tools allows for flexible handling of geographically referenced discussions, but users need to familiarize themselves with the complex functions of both applications to benefit from this flexibility. For content providers, an integration into an existing spatial data infrastructure might entail problems, as no open standards are supported.

REQUIREMENTS AND DESIGN GUIDELINES

When used for decision-making in spatial planning, Argumentation Maps are setup by a provider such as a city's planning department, and used by participants in planning procedures. Participants could be laypersons or planning experts, depending on the nature of the planning process (participatory or not). The functional requirements and design guidelines established in the sequel are intended for lay and expert users as well as for information providers. They are derived either from the features of the Argumentation Map model or from technical constraints. Table 1 provides a summary of the specific requirements.

Requirement, referring to …	**Discussion component**	**Map component**
Integrated user interface	x	x
Structured discussion	x	
Common (Web) mapping functions		x
Integrated database, many-to-many relationships	x	x
Access control, security	x	
Customization by provider		x

Table 1: Summary of functional and technical requirements for discussion and map components of an Argumentation Map.

Generally, an Argumentation Map implementation should provide a *single user interface*, which integrates both the map and the discussion. This interface design allows users to access both components seamlessly, without having to switch between two separate applications. From a technical point of view, an integrated approach facilitates the dynamic linking of map features and discussion contributions, e.g. for interactive highlighting of discussion contributions and the corresponding reference objects on the map.

The discussion component of the implementation should provide a balance between *discussion structure* and *simplicity*. Structure is achieved by the definition of different types of discussion contributions and the possible response relations between them. Examples include a simple question-answer structure or the more powerful Issue Based Information Systems (IBIS; Kunz & Rittel 1970, Conklin & Begeman 1988) approach. Ideally, the discussion structure could be adapted to the skills of the intended audience.

The map component can be designed similar to Web mapping or GIS viewer applications as described by Peng and Tsou (2003), so that new users can quickly familiarise themselves with the tool. Beyond *basic mapping functions* such as zooming, panning and layer selection, it should allow users to *create geographic reference objects* for their contributions, or to *reference existing objects*.

The Argumentation Map model offers numerous options for combined geo-argumentative analyses. These analyses are not possible in an environment, which consists of a discussion with mere verbal descriptions of the contributions' geographic references. Hence, the model needs to be mapped completely to the data structure that stores the discussion and its reference objects, to take full advantage of the expressiveness of the model. The support of *many-to-many relationships* between discussion contributions and reference objects is important for functions such as conflict area analysis, which allows users to find those objects on the map that are the most disputed. As the discussion and the corresponding geographic reference objects are tightly linked, it is important to have full control over the storage of both. Discussion contributions or reference objects might be deleted or "lost" if they are not controlled by the same application, which would then lead to inconsistencies in the model.

Since Argumentation Maps support discussions with geographically distributed participants, implementations will typically follow a client/server architecture model, with the server storing discussion contributions and reference objects (usually in a database), and the clients reading from and writing to the database. For productive environments, e.g. in participatory planning scenarios, basic *security mechanisms* such as user identification and a secure setup of the database are required to impede a manipulation of the discussion. Argumentation Map implementations developed for a certain use case should be re-useable for other similar use cases. Hence, content providers should be offered an easy setup with custom spatial data. This can be achieved by using *open standards* in the implementation allowing for a seamless integration into existing spatial data infrastructures.

AN OPEN STANDARDS-BASED PROTOTYPE

The prototype implementation presented in this section has been developed for participatory planning scenarios, with a special focus on the use of standards to ensure interoperability. Usenet newsgroups were considered for the discussion component as they provide a standardized means for asynchronous, structured, and distributed discussions (Horton and Adams 1987). However, they do not meet the requirements for implementing the Argumentation Map model, since the linking of newsgroup postings to geographic reference objects is difficult to realize. Hence, the discussion component for the prototype was built from scratch and resembles a newsreader, but uses a server-side database for storage. The tree structure for discussions has been adopted from newsgroups, so that a new contribution may respond to an existing one. Beyond that, a simple labelling mechanism has been implemented to allow users to mark their contributions as *question*, *suggestion*, *pro*, *contra* or *neutral*. A contribution's type is indicated by the icon shown next to its title in the discussion tree. The contribution types have been used for simple kinds of statistics which give a quick overview of the predominant opinion towards an object on the map.

Some of the requirements for the prototype include client-side functionality which goes beyond the capabilities of pure HTML and JavaScript Web pages, e.g. the display of vector graphics or the interactive highlighting of discussion contributions and geographic reference objects. Hence, the discussion component was integrated into a client-side Java Applet, together with the map

component, as shown in Figure 2. The map component relies on the GeoTools Lite libraries (http://www.geotools.org/), an open source Java API for maps composed of ESRI Shapefiles. Moreover, this library can integrate image maps. This feature has been used to retrieve background maps from OGC-compliant Web Map Services (WMS) (OGC 2001a). The support for vector maps and image maps from WMS allows for a seamless integration into existing spatial data infrastructures. In addition, a map of the current state of a place, which is often already available on a WMS, can be overlaid with plan data from a GIS.

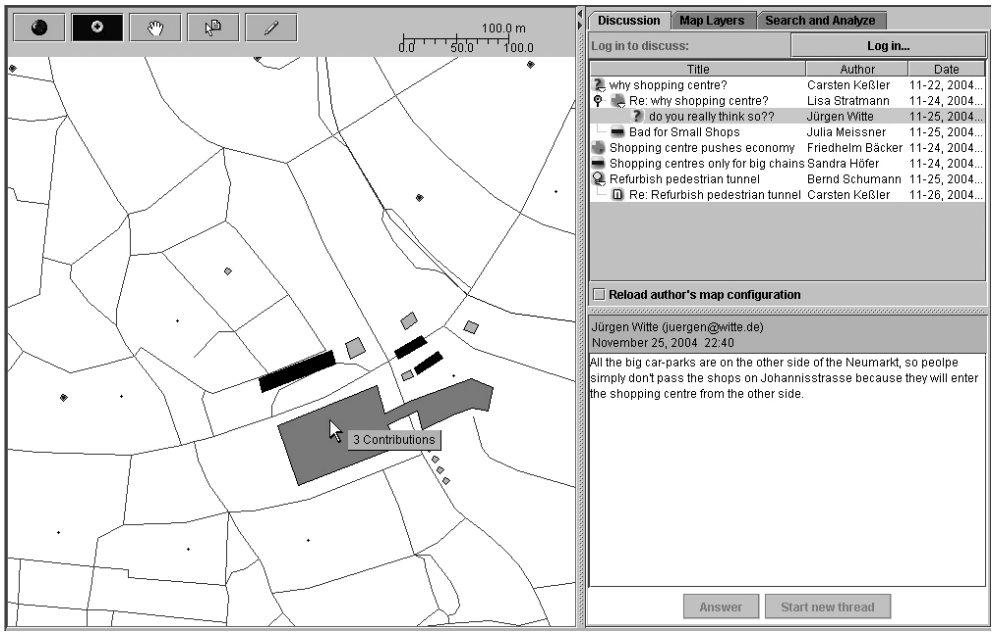

Figure 2: Screenshot of the prototype's user interface, combining the map and the discussion components.

A number of functions, which make use of both the discussion forum and the map, have been implemented in the Applet. The discussion can be explored interactively from the forum component as well as from the map component. The map provides a special tool that allows the user to select those discussion contributions, which refer to a map object. When clicking on this object on the map, all corresponding contributions are automatically highlighted in the forum. Moreover, map objects, which have been referenced, show the corresponding contribution's title in a tool tip when the user moves the mouse pointer over it. If two or more contributions refer to the same object, the number of referencing contributions is displayed in the tool tip instead of the title. In the forum component, the user can select contributions in the discussion tree to highlight all referenced objects on the map. When users create a new discussion contribution, they can select objects on the map as geographic reference objects for the new contribution. Reference objects can be map features loaded from the Shapefile or previously created reference objects from the backend database. In addition, new reference objects can be created[1]. The workflow for writing new contributions is flexible, leaving it to the user whether to write the text first and select reference objects later, or to proceed the other way around.

[1] In the current version of the prototype, only point objects can be created by the users as graphic references. Support for polygons and polylines is currently under development.

The search and analyze tools implemented in the prototype also take advantage of the explicit links between discussion contributions and geographic reference objects. Users can search the discussion contributions for keywords. The results can be limited to contributions that have geographic reference objects which are currently visible on the map. The above-mentioned statistics tool is updated automatically when the user moves the mouse pointer over a reference object on the map, as shown in Figure 3. Moreover, the conflict area identification tool can be used to shade all geographic reference objects according to the number of referencing contributions. Hence, the user can get a quick overview which objects on the map are the most discussed ones.

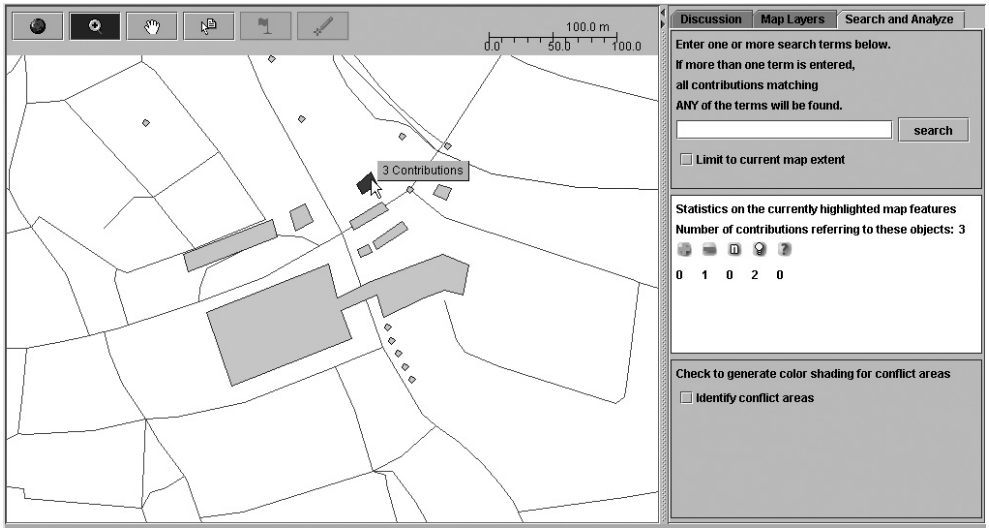

Figure 3: Prototype's *search and analyze* panel.

The server-side component of the prototype consists of a number of Java Servlets, which provide two basic functionalities: First, they allow the client to retrieve maps from WMS. For security reasons, Applets can only access Web servers from which they were loaded from. Therefore, the Servlets build a server-side proxy, which collects maps from distributed WMS, overlays them, and hands them over to the Argumentation Map Applet. This functionality allows the content provider to integrate maps from numerous WMS into the application. Second, the Servlets allow the Applet to access the backend database, to load the discussion contributions and their geographic reference objects, and to insert new datasets into the database. Figure 4 provides an overview of the prototype architecture.

Besides the Web Map Service standard, OGC Web Map Context (WMC) documents have also been used in the implementation (OGC 2003). They provide a standardized, XML-based means of storing map configurations. A WMC with a specific extent and layer selection is stored for every contribution. Therefore, readers can view the map in the way the contribution's author was viewing it. This feature is particularly useful to make sure that a reader can view all objects referenced by a contribution; otherwise, the contribution's text may be unclear.

The core functionality of "understanding" WMC documents can be used in future versions to allow users to upload a WMC created in another application. Moreover, the Servlets are designed in a way which enables users to add new WMS on the fly. Integration of these two features into the client side Applet would lead to an open platform for geographically referenced discussions, which can be run completely independent of any map data, as they can be loaded dynamically from any WMS.

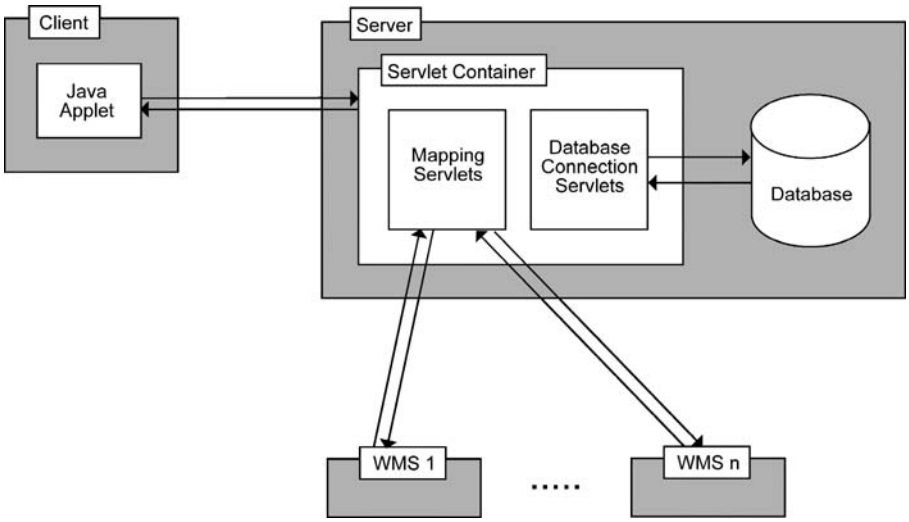

Figure 4: Prototype architecture.

DISCUSSION & CONCLUSION

We have presented an Argumentation Map prototype for geographically referenced discussions in a planning scenario, which implements the OGC Web Map Service and Web Map Context Documents specifications to facilitate integration into existing spatial data infrastructures. Besides WMS and WMC documents, no standards have been used. This is due to the lack of a standard for spatially referenced information outside GIS, and due to the fact that Newsgroups were deemed unsuitable for geographically referenced discussions. Hence, proprietary solutions had to be tailored both for the discussion forum and for the link between discussion contributions and geographic reference objects. The Open Geospatial Consortium is developing *XML for Image and Map Annotations* (XIMA) (OGC 2001b), which could be used for spatially referenced information outside GIS in the future. However, XIMA is not a standard yet and it describes relationships between annotations and map portions. Hence, it is not suitable for an object-based approach such as Argumentation Maps.

From a user's point of view, the prototype offers easy-to-use and self-explanatory functions for interactive exploration of a geographically referenced discussion. The workflow for participation in the discussion has been designed to be flexible enough to leave the sequence of operations to the user. The discussion can be searched for keywords, and the user can view descriptive statistics on the reference objects. The conflict area identification tool allows for a quick overview of the most disputed map objects.

Argumentation Maps have been presented as a concept for decision support in spatial planning. Argumentation Maps support the more qualitative aspects of decision-making in contrast to typical Spatial Decision Support Systems and can be labelled as Public Participation GIS tools. We are interested in further exploring the link between qualitative and quantitative decision-making based on current planning procedures. For example, the preference settings of quantitative decision rules could be subject to prior discussion among stakeholders. Or, conversely, Argumentation Maps could be used to support qualitative discussion of the results of preliminary decision analyses.

Future work on the prototype will concentrate on the integration of missing features and optimisation to accelerate start-up and response time. The benefits of an integration of additional

standards such as the OGC Web Feature Server (WFS) specification will be analysed. Support for WFS would provide a standardized way to access vector data. The tool will undergo a realistic usability test when those features have been implemented. It will be used for conflict area identification in a natural resources conflict scenario. A spatial planning case study for the City of Osnabrück, Germany, has been set up for demonstration purposes.

ACKNOWLEDGEMENTS

This research has been partially supported by the German Academic Exchange Service (DAAD) with a scholarship to C.K., who is now funded through the European Commission's MEDIS project (contract no. EVK1-CT-2001-00092), and by the Natural Sciences and Engineering Research Council of Canada (NSERC) with a grant to C.R.

BIBLIOGRAPHY

Conklin J. and Begeman M.L., 1988 gIBIS: A Hypertext Tool for Exploratory Policy Discussion, in Proceedings of the Conference on Computer-Supported Co-operative Work (CSCW'88), Portland, pp. 140-152

Hachmann R., 2004 Beteiligung für alle – Der interaktive Landschaftsplan Königslutter am Elm [Participation for everyone – The interactive landscape plan of Königslutter am Elm]. GeoBIT 10/2003: 11-13. Available online at http://www.laum.uni-hannover.de/iln/personen /hachmann/hachmann_03_2.pdf [last access: March 10th, 2005]

Horton M. and Adams R., 1987 Standard for Interchange of USENET Messages (RFC 1036). Technical report. Available online at http://www.faqs.org/ftp/rfc/pdf/rfc1036.txt.pdf [last access: March 10th, 2005]

Kingston R., Carver S., Evans A., and Turton I., 1999 A GIS for the public: Enhancing participation in local decision making. In GIS Research UK (GISRUK'99)

Kunz W. and Rittel H.W.J., 1970 Issues as elements of information systems, Technical Report 0131, Institut für Grundlagen der Planung, University of Stuttgart, Germany

OGC, 2001a Web Map Service Implementation Specification. Available online at http://www.opengis.org/docs/01-068r2.pdf [last access: March 10th, 2005]

OGC, 2001b XML for Image and Map Annotations (XIMA). Discussion Paper. Available online at http://www.opengis.org/docs/01-019.pdf [last access: March 10th, 2005]

OGC, 2003 Web Map Context Documents. Available online at http://www.opengis.org/docs/03-036r2.pdf [last access: March 10th, 2005]

Peng Z.-R. and Tsou M.-H., 2003 Internet GIS. John Wiley & Sons, Hoboken, NJ

Rinner C., 1999 Argumentation Maps – GIS-based Discussion Support for Online Planning. Ph.D. Dissertation University of Bonn, Germany. Published as GMD Research Series No. 22/1999, Sankt Augustin, Germany

Rinner C., 2001 Argumentation Maps – GIS-based Discussion Support for Online Planning. Environment and Planning B 28(6): 847-863

Rinner C., in press Computer Support for Discussions in Spatial Planning. In Campagna, M. (Ed.): GIS for Sustainable Development. Taylor & Francis

Voss A., Denisovich I., Gatalsky P., Gavouchidis K., Klotz A., Roeder S., and Voss H., 2004 Evolution of a Participatory GIS. Computers, Environment and Urban Systems 28(6): 635-651