

# **Design and Implementation of Argumentation Maps**

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## **Abstract**

A tool for spatially related discussions which is easily adaptable to different use cases can be utilized in numerous fields of application. This thesis presents a prototype implementation serving for asynchronous, distributed, spatially related discussions which is based on the argumentation map model introduced by Rinner (1999). Different approaches are examined for the implementation, both from a conceptual and from a technical point of view. An analysis of existing systems for the exchange of spatially referenced information shows different techniques for the linking of information outside GIS to geographic objects. The design of the prototype is focused on the use of open geospatial standards to ensure a seamless integration into existing spatial data infrastructures. The prototype is demonstrated with a scenario from public participation in spatial planning.

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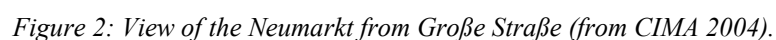
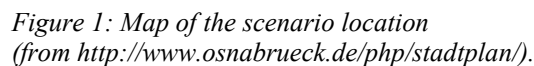
# 1 Introduction

The first chapter gives an introduction to the thesis. The first section presents a scenario which is referenced in the course of the thesis. The second section explains the motivation for this work. The third section defines its scope and the intended audience. The fourth section contains the hypothesis, followed by a brief overview of the structure of the following chapters.

## 1.1 Scenario

Imagine the following case: A city wants to redesign a place in the centre of the city that serves as a central bus stop. The place itself and the surrounding architecture do not look nice and thus spoil the image of the city. A woman and her husband are very interested in this topic since she owns a shop near the place and he passes it every day changing the bus line on his way to work. Thus, both of them have a lot of ideas how to improve this place. Unfortunately, they are on holiday when the public meetings take place that are held to discuss the different options how to redesign the place and to collect ideas from the citizens. Since they cannot attend the meetings, they log on to the city's website from the Internet café at their hotel. The website hosts a system that allows them to view the different options the planners have designed, discuss them in a forum with other citizens and sketch their own design on the map. They can also view other citizens' sketches and comment on them, thus giving input to the planning process without attending the meetings. Actually, she even prefers the online system to a public meeting because she feels uncomfortable speaking in front of a large group of people. When they check the municipality's website a few days later, they see that other people have commented on their drafts and they start discussing the pros and cons with them.

This scenario will be used throughout the thesis. The place that is to be redesigned is called "Neumarkt" (see figure 1 for overview map) and is located in the city of Osnabrück which is placed in the north-west of Germany and has about 160.000 inhabitants. The redesign of the Neumarkt has been a topic of public discussion for several years. The fact that the place is not only spoiling the city's image but that it also comprises a major road (as shown in figure 2) with 4 lanes and 30.000 cars and 1.500 buses passing each day (CIMA 2004) complicates the development of a new plan for the place. Moreover, the wide street separates two shopping areas from each other (Große





## 1.2 Motivation

### 1.2.1 Public Participation – A Fundamental Part of Democracy

Public participation in planning processes is a key-issue in a democratic society (Laurini 2004) and fundamental to legitimate the decisions made in these processes (Simão and Densham 2004). This basic assumption also applies to *spatial* planning. Future changes to the citizens' environment have to be discussed in advance to give stakeholders the opportunity to bring in concerns, criticism, annotations and suggestions. The aim is to find a consensus that fits the needs of the community and, if possible, does not disadvantage individuals. If such a common agreement can be found, the project will be accepted by the public as a democratic decision. In a transparent planning process, anyone involved can retrace the premises of the final decision (Rinner 1999).

Moreover, the planning process itself can be improved by integrating local knowledge the planners might lack, as well as different perspectives on the project (Simão and Densham 2004). Citizens engaged in the planning process are often times lay-persons, so they have a view on the project that will certainly differ from the professional view of the planners. This can help the planners to focus on aspects of the projects they have not taken into account before. Thus, planning processes gain a new direction concerning the flow of information – it is no longer just the planners informing the public, but also the other way around. In addition, the participants contribute to the “heterogeneity and diversity of knowledge and values which strengthens the whole decision making process, by bringing together more people who are willing to be actively involved [...] resulting in a greater ownership of the final programme, policy or plan” (Healey 1997).

But the involvement of stakeholders is not only important for the stakeholders and to improve the planning process – it is also essential for the project's responsible body, which may be private or state-run. Planning and executing a large-scale project always means being responsible for problems that arise during the realisation and afterwards. Conflicts and obstructions caused by stakeholders trying to stop the plan can be minimised if affected people and organisations are comprised in the planning process at earlier phases (Edelenbos 1999). Since such conflicts might even be brought to trial, which can be very time-consuming and expensive, responsible bodies want to avoid interferences at such a late stage of a project by communicating with stakeholders in advance. Therefore, public participation is also important for those financing a project

since it can guarantee maintaining of schedules – finally, it helps the responsible body to save time and money.

### **1.2.2 International Agreements on Public Participation**

The benefits of public participation described above have caused international organisations to promote the involvement of citizens and stakeholders. The Agenda 21 (United Nations 1992), which emerged from the United Nations earth summit 1992 in Rio de Janeiro, considers public participation to be a central method to achieve sustainable development. The Agenda 21 consists of a set of 27 principles that shall help the states that signed the Rio Declaration on Environment and Development to develop national sustainable development strategies. These principles include that “each individual shall have [...] the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available” (Principle 10).

On the European level, the European Commission fosters public participation. Directives like 2003/35/EC, which states that “Effective public participation in the taking of decisions enables the public to express, and the decision-maker to take account of, opinions and concerns which may be relevant to those decisions, thereby increasing the accountability and transparency of the decision making process and contributing to public awareness of environmental issues and support for the decisions taken” (European Commission 2003), include compulsory rules that have to be implemented by the EU member states by certain dates. The European Commission also promotes the use of new technologies for transparent public participation processes (Voss et al. 2004).

### **1.2.3 The Participatory Process – An Ideal Scenario**

In an ideal case, public participation should be open to anyone who is likely to be affected by a plan or who might help to improve a plan. Besides that, it is crucial to judge all contributions to the debate equally, independent of the person who expressed them. There must be no chance for individuals to emphasise their opinions in a way that discriminates against others' right to participate. Anyone should have the right to point out his opinion, and anyone should also be able to inform himself about the current state of the debate. To enable consensus-finding after an argumentation, all contributions have to be stored and organised in some way to make sure that the agreement takes all of them into account. The final decision must be founded properly and made in a transparent

fashion that allows for its retracement later on. Concerning spatial planning, the participants should be able to link their contributions to the points or objects of concern, e.g. with the help of a map, to avoid misunderstanding of their arguments that may result from mere descriptions.

#### 1.2.4 Drawbacks of Traditional Procedures

Compared to the ideal case of a public participation process outlined above, the traditional ways of involving citizens in planning show some discrepancies. There are basically two ways of how public participation is (in most cases) organized today: either by public meetings in which the citizens can express and discuss their concerns and arguments, or by putting the plan in a public place like the city hall for a certain period of time where anyone can have a look at it and then hand in criticism in writing.

Both approaches have certain disadvantages. In a public meeting, it is very hard to realise that everyone has the same right to speak. Even if there is a professional mediator who makes sure that everyone gets the chance to make his comments, there is a significant advantage for those who are used to speak in front of large groups. According to Sutherland et al. (2003), there is the risk that in such meetings, rhetoric has a bigger influence on the final decision than facts have. Moreover, quite a lot of people would feel uncomfortable speaking in front of a group of strangers, which will keep them from joining the discussion, although they might have an important or helpful contribution. Another drawback is that not everyone can attend these meetings due to the fact that some people will have to work, or be impeded in another way. This contradicts the principle that anyone should be able to participate. In meetings with debates on spatial topics, arguments can barely be linked to the locations they refer to. One method to realise this idea is *Planning For Real*, which relies on a 3D-model of the area that is the topic of the discussion. The participants can write their contributions on little flags and place them on the model, at the associated position (Carver et al. 1999). Though this approach offers a fair treatment of all participants, it has certain drawbacks, too: on the one hand, the flags placed on the model are quite small, so the participants can only give short comments, consisting of keywords and short phrases. This model does not support longer arguments and elucidations. Moreover, the number of contributions is also limited by the size of the model. Thus, *Planning For Real* can only be applied when the number of participants is relatively small. Another problem is that, in contrast to a verbal

discussion in a meeting, a debate with questions, answers, comments and arguments is not supported – there is no way of answering other people's “flags”.

At first glance, the second method (publishing the plan at the city hall) seems to have some advantages compared to public meetings. But this approach has other disadvantages. Though verbal skills do not have an influence any longer, and though more people will be able to take part as the debate is not limited to one single meeting, it demands quite an effort from a citizen to come to the city hall, ask an official for access to the plan, write down his arguments and then sign and submit his letter. Most people would rather just let the planners do their work unless they dread to be heavily affected by a plan - although they might have some good ideas or annotations. Especially young people might be deterred by this old-fashioned, inconvenient procedure.

### **1.2.5 Web-based Participation**

While traditional ways of public participation cannot meet the requirements of the “perfect” participatory process for the reasons outlined above, web-based systems have the potential to overcome these difficulties. Laurini (2004) proposes the use of the Internet “as a medium for exchanging information, ideas, maps between all actors”. On the web, limited office hours do not exist, and web-based discussions can easily be designed in an asynchronous fashion, so that there is no need for the participants to (virtually or in person) meet at a designated time. Thus, citizens can join the process whenever it is suitable for them. In addition to the “24-7” availability, a web-based system has the benefit that it offers a way of participation that is more convenient and relaxed than the conventional procedures. People who want to participate in the planning process do not have to go to a certain place any longer - they can just log in to the municipality's web site, take their time to analyse the data on the planned project, and make their contributions to the discussion. The relatively anonymous environment of an online forum is ideal to make sure that no-one is kept from participating because of the fear to speak in front of a large group (Kingston et al. 1999), and it also takes away the power of rhetoric. Hence, contributions can be judged more fairly.

A web-based system would also offer much better ways to analyse the plan and discuss about it. A digital map, together with some geographic information system (GIS) functions like zooming, panning, switching layers on and off, and querying functions, would allow the visitor to retrieve information on the project and then join the discussion.

Contributions could be augmented with all types of hypermedia, for example images, sounds, movie sequences or three dimensional models. In contrast to the analogue Planning For Real method, the number of virtual “flags” that can be put on the map is almost unlimited. Discussion contributions can refer to each other, and the whole discussion is stored for evaluation – which is a much more effective way to analyse the results of the discussion for the planners. Spatially related discussion contributions offer powerful means of analysis, e.g. for conflict area identification, which allows planners to easily see which parts of the plan cause concern among citizens. If the infrastructure for map contents in the municipality relies upon open standards, it is very easy to publish plans on the web, which allows the municipality to improve its service for the citizens with very low effort and low costs.

Though properly designed web-based public participation systems have a remarkable number of advantages, these benefits can only be exhausted if certain prerequisites are fulfilled. Everyone must have access to the web-page which hosts the system, so that it might be necessary to install a public access station at the city hall, for example, so that those people who do not have Internet access at home can join in. This is especially important to make sure that low-income households with no access to the web have the same chance to participate than higher income households that can afford Internet access (Peng 2001). Since the number of households with Internet access is still rising<sup>1</sup>, it can be assumed that it is just a question of time until this will be an every-day tool like the telephone. In view of the fact that there are still a lot of people – especially elder people – who are not familiar with the use of the web, a web-based system alone would exclude parts of the public, too. Thus, these systems should be regarded as a complement to the traditional procedures rather than a replacement.

During the past years, several research projects dealt with the development of online map-based systems for public participation in spatial planning processes. While some of the projects (such as the *Virtual Slaithwaite* project - see review in chapter 4) could show that such systems can increase, improve and simplify public participation, the overall outcome was that a lot of research in several fields needs to be done until web-based public participation tools reach a state at which they can be used (Kingston et al. 1999).

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<sup>1</sup> According to the annual report 2003 of the German “Regulierungsbehörde für Post und Telekommunikation”, a governmental authority in charge of the regulation of the privatisation in the logistics and communications sectors, 58% of the people elder than 14 were using the Internet in Germany in 2003, compared to 50% in 2002.

This thesis, and the prototype implementation that goes with it, will contribute to the development of stable web-based public participation tools for spatial discussions.

### 1.3 Scope and Intended Audience

The aim of this thesis is the development of a prototype implementation to show that maps on the Internet with GIS functions connected to a discussion forum can improve public participation. The prototype is intended to support map-related, distributed, asynchronous debates, which means that the attendants of the discussion are neither meeting at one place (which would be a “same place” or “physical presence” debate) nor discussing at the same time (which would be synchronous). According to table 1, which clarifies the distinction of the different kinds of information exchange introduced by Ellis et al. (1991) with some examples, the prototype implementation belongs to the *AT* category.

	<i><b>Spatial</b></i> <i>Physical presence</i> <i>(same place)</i>	<i>Telepresence</i> <i>(different place / distributed)</i>
<i><b>Temporal</b></i>		
<i>Synchronous</i> <i>(same time )</i>	<b>SP</b> : Public meeting, panel discussion, press conference	<b>ST</b> : Phone call, video conference, Internet relay chat (IRC)
<i>Asynchronous</i> <i>(different time)</i>	<b>AP</b> : Bulletin board, hospital charts, refrigerator notes	<b>AT</b> : (E-)Mail, Internet forums, Usenet newsgroups

Table 1: Classification of information exchange according to time and space. Adopted from Ellis et al. (1991).

The research on computer systems for public participation covers other fields which will not be considered in this work. Spatial decision support systems (SDSS) are only considered insofar as the discussion supported by the tool developed in the course of this work might be part of an SDSS, but the tool will not offer any functionality that supports decision-making itself (see section 2.1 for definitions of the term SDSS). Besides that, it must be stated that the tool is going to cover only the public participation part of a planning process. It is not thought to automate the whole planning process. Other aspects such as the social and political impacts of e-government (as examined in Sieber (2004))

or juridical issues will not be covered either. Usability tests are not the focus of this work. The tool which is developed in this work should be useful for anyone involved in the planning process. It facilitates participation for citizens and stakeholders and gives the planners an opportunity to retrieve, store and organise local knowledge. It must be stated that it is not going to be an expert tool, but rather the opposite – it should be usable by as many people as possible, especially lay-persons. Decision support researchers might use it as a foundation for new decision support systems or as an extension for existing ones. Although this thesis focuses on the use of the tool for public planning, it should be able to serve in various other cases which require an instrument that supports spatially related, asynchronous, distributed debates. Such use-cases could be collaborative route planning (e.g. for leisure activities such as hiking or bike tours (Kolbe et al. 2003) as part of a tourist information system, web-based discussions on environmental issues, or a planning tool for event agencies in charge of organising the allocation of stands on fairs – to name just a few examples.

## **1.4 Hypothesis**

It is possible to implement a web-based public participation system, that integrates the use of a map and a discussion forum to enable spatially related discussions. The system offers basic GIS functions such as panning, zooming, layer selection or querying on the map side and a structured discussion on the argumentation side. Moreover, the system offers combined spatial / argumentative queries, e.g. “show all contributions that refer to object x that were posted this week”. It relies upon open standards to enable the integration into existing spatial data infrastructures.

## **1.5 Structure of Thesis**

The next chapter will define important terms used throughout the thesis, and introduce the most important concepts of argumentation theory. This will be followed by a subsection on the question how arguments and spatial objects or locations can be linked conceptually. Chapter 3 will deal with the technical prerequisites for the development of the prototype. An analysis of existing applications in this field of research will be given in chapter 4 to depict the functions of the different tools and to examine the support of discussion structures, the user interface and technical aspects. Chapter 5 will give a

detailed description of the functionality a web-based public participation system must have to enhance the participatory process as depicted above. These requirements, together with the results of the analysis of existing applications, will lead to the design of the prototype implementation presented in chapter 6. The final chapter will review this thesis and especially the prototype and evaluate which parts of the requirements are met by the prototype and explain why some of the requirements could not be met. Beyond that, open questions and future improvements of the prototype application will be discussed.



## 2 Theoretical Background

This chapter describes the theoretical background of spatially related discussions. The first section defines basic terms used in the course of this thesis. The second section introduces theoretical concepts for human argumentation, as well as computer systems for discussion support, which are partly based on the theoretical concepts. Both the concepts and the computer systems represent classes of concepts or tools; the sections do not give a complete overview. The shown examples are sufficient for an evaluation regarding the use in a system as described in the hypothesis because they resemble other concepts or systems in their main ideas and functionalities. The third section deals with the question how to model geographic references for discussion contributions on a conceptual level. Section four completes this chapter with a conclusion.

### 2.1 Terminology

#### 2.1.1 Argumentation

In the course of this work, the term *argumentation* (or *discussion*) is used for any kind of communication between people (the *participants*) exchanging their views of a certain topic. Van Eemeren and Grootendorst (1996) state that “argumentation is a speech act complex aimed at resolving a difference of opinion” (p. 9). Thus, in contrast to other definitions<sup>2</sup>, argumentation is not limited to a methodical progress of logical reasoning (Tweed 1998), but does also include personal feelings, opinions and preferences that cannot be explained logically. Any kind of statement in a discussion is called *contribution*, whereas contributions that give logical reasons for the statements they make are called *arguments* (e.g. “Install a traffic light at the intersection to make it more secure for the large groups of school kids crossing it every day” would be an argument, in contrast to “The school should be painted green”, which lacks logical backing).

#### 2.1.2 PPGIS, Computer Systems for Public Participation

Although there are several different definitions of *Geographic Information Systems* (*GIS*), most of them are similar to the one given by Worboys and Duckham (2004), who describe GIS as “a computer-based information system tailored to store, process and

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<sup>2</sup> Some definitions (e.g. in formal logic) differ completely from my definition, whereas other definitions sound similar, but state that an argumentation always comprises the outcome developed in the course of the discussion.

manipulate geospatial data” (p. 1). The term *Public Participation GIS (PPGIS)* was used by some authors to describe systems for public participation that use maps for user communication (e.g. Gudes et al. 2004). As GIS offer far more advanced functions, it does not seem appropriate to call these systems GIS. Laurini (2004) proposes the use of the term *Computer Systems for Public Participation* instead. This term is used in this thesis since the reviewed systems as well as the prototype presented are far from a conventional GIS in terms of functionality, e.g. spatial data analysis or spatial data editing.

### **2.1.3 (Spatial) Decision Support Systems**

From the numerous different definitions which describe the characteristics of *Decision Support Systems (DSS)*, one can extract that the term DSS generally describes systems that assist the user in analysing data and support him in making a decision (Densham 1991). DSS are applied to *semi-structured* problems, which cannot be solved based on pure hard facts, but which require the user to set his preferences as a second input to the system. The term *Spatial Decision Support Systems (SDSS)* refers to DSS which were developed for spatial decision making problems. Some of the systems in the field covered by this work have also been labelled SDSS (Simão and Densham 2004), as they offer functions which assist users in defining preferences for decisions. The terms PPGIS and SDSS are closely related in the literature and not always clearly defined.

## **2.2 Modelling Human Argumentation**

### **2.2.1 Argumentation Theory**

Diverse approaches have been developed to structure human argumentation, with different aims in mind. Some were designed to help the participants find a compromise, while others primarily aimed at avoiding repetition of arguments and preventing the discussion to go “off-topic”. Both types have in common that they try to structure the discussion and introduce different types of contributions for this purpose. Tweed (1998) states that the two most popular approaches in this field are *Issue-Based Information Systems (IBIS)* and *Toulmin-Based Logic (TBL)*. Both will be outlined below as examples of schemes for structuring human argumentation.

### 2.2.1.1 Issue-Based Information Systems (IBIS)

IBIS was introduced by Kunz and Rittel (1970) as a method to support political decision processes with a special focus on so-called “wicked” problems, which means that the problems are complex and that a solution is therefore hard to find. The method was successfully applied to tasks as different as architectural design and planning at the World Health Organisation (Conklin and Begeman 1988). The discussion in IBIS consists of three basic elements: *Issues*, *Positions* and *Arguments*. Issues depict the beginning of a discussion, stating the question that is to be discussed or the aim that is to be achieved. Positions are different options for how an Issue can be achieved or answered. Arguments can either support or object to Positions. Besides these basic relations, Issues can specialize or generalize, replace, question or suggest other Issues in the course of a discussion. Issues can question Positions and Arguments, Positions and Arguments can suggest Issues, and Positions can respond to Issues. Figure 3 provides an overview of the relationships between IBIS elements. Besides the relationships shown in figure 3, Issues can be grouped to *Topics* in order to manage complex discussions (Tweed 1998).

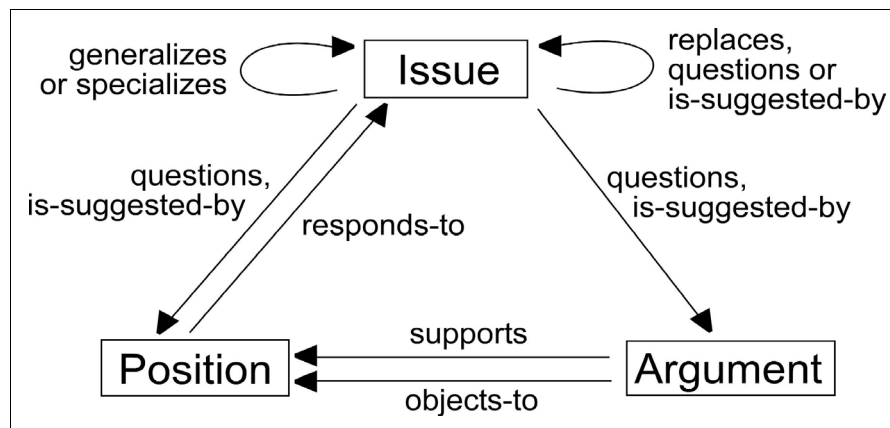


Figure 3: Relationships between IBIS elements after Conklin and Begeman (1988).

As mentioned above, IBIS discussions always start with an Issue. This Issue is the root of a tree that is developed in the course of the discussion. Positions and possibly sub-Issues are added to the starting Issue as its children, which in turn have Arguments (for Positions) or Positions (for Issues) as their children. There is no rule when adding nodes to the tree should be stopped. Usually, the discussion tree keeps evolving until all aspects of the discussion have been added. Hence, IBIS does not provide any scheme for how

coming to a final decision, nor does it indicate when a consensus has been found; its purpose is rather to enable the participants to point out their own arguments, and understand those brought up by others. Arguments are related to each other to get a structured overview of the whole discussion.

### 2.2.1.2 Toulmin-Based Logic (TBL)

TBL was introduced by Toulmin (1958). The model is also based on three types of contributions, called *Claims*, *Data* (also called *Grounds*) and *Warrants* in this case (Gottsegen 1998). In contrast to those in IBIS, these building blocks are more flexible. Data can be any kind of assertions, and their function is to back Claims. Warrants are supposed to show that the inference of a Claim from the backing Data is reasonable. The flexibility of the model lies in the fact that any of the three types can be attacked or supported by other Data or Claims, which might in turn need backing, and so forth. See figures 4 and 5 for an overview of the possible relationships between TBL elements.

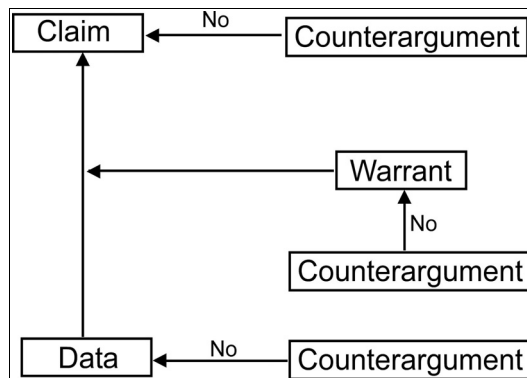


Figure 4: Relationships between TBL elements after Gottsegen (1998).

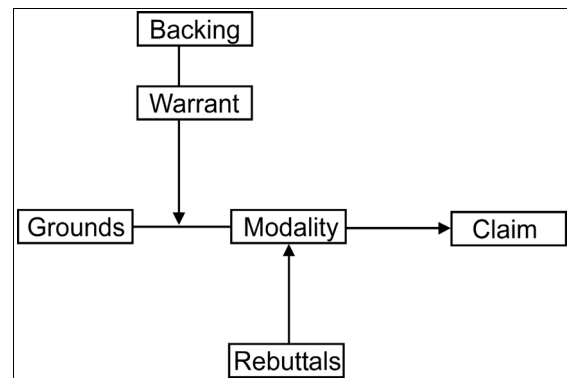


Figure 5: Additional TBL elements according to Tweed (1998).

Tweed (1998) states that additional elements are part of TBL discussions: *Modalities* indicate the degree of certainty of a claim, *Rebuttals* are possible limitations of a claim that might lead to its invalidity, and *Backings* are evidences authorising Warrants (see Figure 3). However, these additional types can be seen as special versions of the more general types. Backings are a special type of Data elements, and Rebuttals and Modalities can be considered Claims themselves, needing backing by Data and Warrants to justify them.

In contrast to IBIS, TBL strives for a data-based discussion, relying on “hard facts”, rather than on opinions. According to Gottsegen (1998), the two approaches cannot be compared to each other because IBIS is meant to picture an overview of the discussion, whereas TBL's purpose is to describe the structure of discussion in detail.

### **2.2.2 Computer Support for Argumentation Processes**

This section will introduce different types of computer systems that support argumentation processes, ranging from discussion forums on web pages to specialised tools for collaborative decision making (CDM). Some systems were developed for research purposes, while others are commercial products or open source software. It is not intended to give a complete overview of *all* applications available in this field; the tools described in this chapter rather represent different types of tools. The description of the tools will focus on:

- the underlying discussion schemes,
- the environment they were developed for (e.g. meetings, distributed discussions, etc.),
- the field of application they were developed for (if applicable), e.g. design rationale or collaborative planning
- the skills they require from the users, and
- other prerequisites.

See chapter 3 for the technical view on the tools presented in this section.

#### **2.2.2.1 Usenet Newsgroups**

The Usenet<sup>3</sup> is one of the oldest applications of the Internet, serving as a tool for telepresent, asynchronous discussions between people who share an interest in some topic. It consists of *newsgroups*, each of which covers a certain topic. The newsgroups are organised hierarchically (see figure 6) and open to anyone who has access to a news server, which is usually offered by Internet providers. Newsreaders enable the user to connect to a news server and subscribe to the groups he is interested in. Most e-mail applications also serve as newsreaders (e.g. Microsoft Outlook / Outlook Express, Netscape / Mozilla, Opera etc.), so that the software needed to join newsgroups is in most cases already installed on the computer. Each newsgroup consists of a number of *threads* – discussions on a certain “sub-topic” of the general topic of the group. A thread is made up by a number of contributions – called *postings* in the Usenet, which have a body and a

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3 The word “Usenet” originally derives from “Unix User Network”.

title, similar to e-mails. Figure 7 shows a screen shot from the comp.lang.java.databases group. It shows the tree structure used in the threads, following the rule that every new posting is a child of the posting it replies to. Beyond the fact that threads are structured as trees, there are no specific rules for the contents of a posting. In most cases, a posting that starts a new thread asks a question or raises a statement the author wants to discuss. The other postings in the thread might try to answer that question, sketch different opinions or ask counter questions. As mentioned above, the Usenet is free to anyone, which means that anyone can join a group by subscribing to it and read its threads, as well as create postings himself by answering an existing thread or starting a new one. Thus, there is no mechanism to keep people out, apart from the possibility of setting up a private news server. Moreover, there are no means of verifying a participant's identity. Concerning usability, users who are familiar with the use of an e-mail application will not have any difficulties in using the Usenet, since both techniques are very similar and writing a posting is almost the same as writing an e-mail. Beyond that, users who have joined a newsgroup once will not have any problems joining any other group since all newsgroups work in the same way.

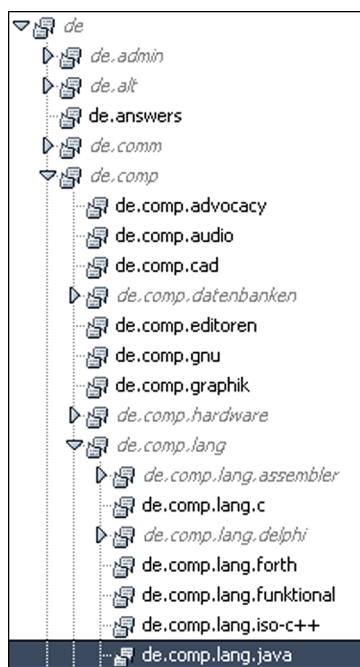


Figure 6: Hierarchical structure of Usenet newsgroups.

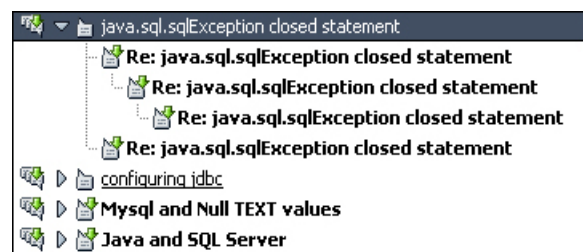


Figure 7: Tree structure of newsgroup threads.

### 2.2.2.2 Internet Forums

Besides the Usenet, Internet forums (also called *discussion boards*) are another popular tool for web-based, telepresent, asynchronous discussions. As there are so many different implementations of this kind of tool, this subsection gives only an overview of the functions most of them offer.

Internet forums are dynamic web pages that can be viewed with any standard web browser, which means that there are no special software prerequisites for the user. They usually require the user to register before joining the discussion, although some allow *guests* (unregistered users) to view the discussion. It is hard to make a general statement about the structure of a discussion board. In general – similar to Usenet newsgroups – their purpose is to serve for discussions among people who share a common interest, e.g. a forum for the geoinformatics students at the university of Münster (<http://geofs.uni-muenster.de/phpBB/>). In most cases, there are sub-categories set up within the forum that give a loose structure to the postings (for the geoinformatics forum, those might be “general announcements”, “open source software”, “computer science”, “events” etc.). Figure 8 shows a screen shot of a the start page of a forum, listing its categories. Within these sub-categories, *topics* deal with certain questions and list the *posts* that deal with it. In contrast to Usenet newsgroups, the discussions in Internet forums usually develop linearly, which means that each new contribution is simply attached to the end of the topic's list. Thus, discussion boards are in most cases less structured than newsgroups, but they have other advantages. Most forums allow users to add images to their message and format them using HTML. Users can create profile pages giving detailed information about themselves, containing links to personal web sites, instant messenger numbers, birth dates and so forth. Many popular forums offer complex search functions and statistics on the users' activities. In contrast to the Usenet, discussion boards are flexible, as they can be customized to whatever purpose they are set up. They allow the web master who runs the forum on his website to determine whether the forum is open to everyone or private, giving access only to those persons the web master created an account for. They even allow the web master to add his own functions to the forum.

The complex functions of a discussion board entail that forums might not be as easy to use as the Usenet. Usually, the user needs to register with every forum he wants to join. Moreover, every new forum will require the user to take some time and get an overview of how it works, although most forums resemble each other.

Community

[FAQ](#)
[Search](#)
[Memberlist](#)
[Usergroups](#)
[Register](#)
[Profile](#)
[Log in to check your private messages](#)
[Log in](#)

The time now is Sat Aug 21, 2004 8:07 am  
[phpBB.com Forum Index](#) [View unanswered posts](#)

Forum	Topics	Posts	Last Post
<b>General</b>			
<b>Announcements</b> Read me first before posting anywhere! Moderator: <a href="#">Moderator Team</a>	103	139	Thu Aug 12, 2004 6:07 pm <a href="#">ffeingol</a> →
<b>phpBB</b>			
<b>phpBB Support</b> Get help with installation and running phpBB 2.0.x here. Please <b>do not</b> post bug reports, feature requests or MOD-related questions here. Moderators: <a href="#">Development Team</a> , <a href="#">Moderator Team</a> , <a href="#">Support Team</a>	118313	557568	Sat Aug 21, 2004 8:05 am <a href="#">Knuckles10</a> →
<b>i18n / Convertors</b> Want a language pack or convertor? Have feedback on either of these? Are you a developer of one of these? Here is the place to post. Read the announcements here first! Moderators: <a href="#">Development Team</a> , <a href="#">Moderator Team</a>	1898	11058	Sat Aug 21, 2004 6:33 am <a href="#">DJBenson</a> →
<b>phpBB Styles</b>			
<b>Styles Announcements &amp; Releases</b> Announcements for new styles that can be downloaded and installed for your forums Moderators: <a href="#">Moderator Team</a> , <a href="#">Styles Team</a>	214	2135	Sat Aug 21, 2004 7:30 am <a href="#">steak32</a> →
<b>Styles Development &amp; Discussion</b> Got a question on how to do something style/theme related? Post it here. Moderators: <a href="#">Moderator Team</a> , <a href="#">Styles Team</a>	12121	68858	Sat Aug 21, 2004 6:31 am <a href="#">CyberAlien</a> →
<b>Non-phpBB specific</b>			
<b>General Discussion</b> Post <b>non-phpBB</b> related topics here. Post if you have a point or worthwhile comment, don't post just to increase your post count! Moderator: <a href="#">Moderator Team</a>	13382	141351	Sat Aug 21, 2004 8:07 am <a href="#">soxie</a> →
<b>Test Me</b> Do <b>ALL</b> testing here! Moderator: <a href="#">Moderator Team</a>	8	23	Sat Aug 21, 2004 6:46 am <a href="#">ridgeback</a> →

Mark all forums read All times are GMT - 8 Hours

Who is Online

Our users have posted a total of **1144905** articles  
 We have **136665** registered users  
 The newest registered user is [CyberMartyr](#)  
  
 In total there are **166** users online :: 22 Registered, 4 Hidden and 140 Guests [ [Administrator](#) ] [ [Moderator](#) ]  
 Most users ever online was **620** on Wed Oct 22, 2003 10:31 am  
 Registered Users: [apcl](#), [asinshesq](#), [batty](#), [beery](#), [cherokee red](#), [Cristina](#), [dmob](#), [erfai](#), [feather inju](#), [fuldfk](#), [hsialin](#), [islab](#), [Kinetix](#), [Knuckles10](#), [mannythehamster](#), [poopie pants](#), [primedomain](#), [soxie](#), [TehBooster](#), [Tenson](#), [vagabond](#), [Vic D'Elfant](#)  
 This data is based on users active over the past five minutes

Log in

Username:  Password:  Log me on automatically each visit ☐

New posts

No new posts

Forum is locked

Figure 8: Screen shot of a forum (adopted from <http://www.phpbb.com/phpBB/>).

### 2.2.2.3 gIBIS

Conklin & Begeman (1988) present gIBIS, “an application-specific hypertext system designed to facilitate the capture of early design deliberations” (p. 303). It was developed for meetings of small teams and introduced a graphical display of the discussion structure (in contrast to lists of arguments). As its name indicates, gIBIS (*graphical* IBIS) is based on issue-based information systems (see section 2.2.1.1). The authors introduced a fourth node type called *Other*, which can be used for any kind of node that does not fit any of the Issue / Position / Argument node types, e.g. external documents. Nodes of type *Other* can be linked to any kind of node by a link of type *Other*.



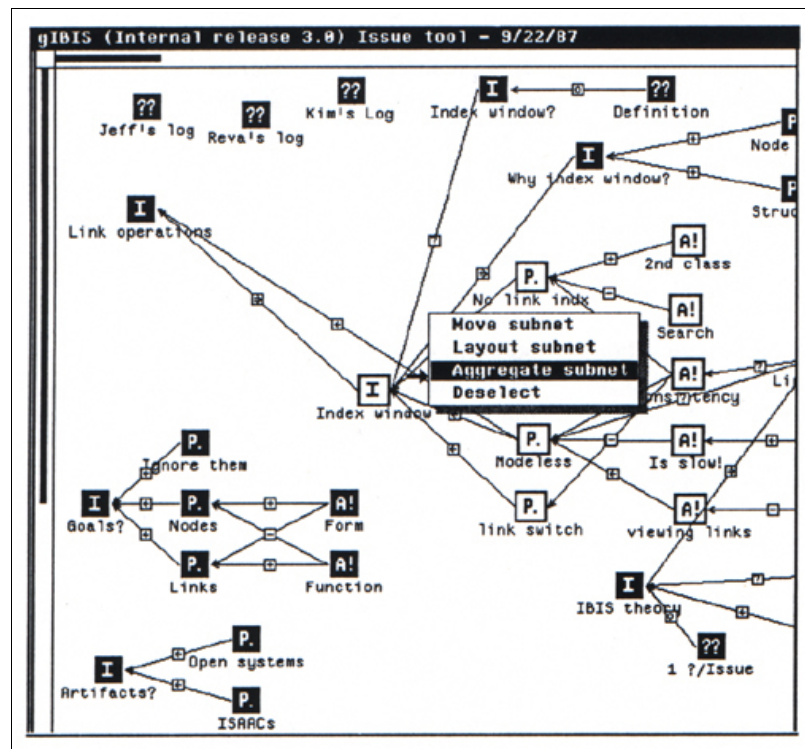


Figure 9: Screen shot of the left part of the gIBIS interface, showing the discussion tree. Adopted from Buckingham Shum (2003).

The application displays the IBIS structure on the left side, as shown in figure 9, and the nodes' contents on the right side. The structure is displayed in different colours that can be customised by the user (not visible in the black and white screen shot). Context-sensitive menus that appear when the user selects a node in the tree show all legal operations on this node, e.g. adding appropriate follow-up nodes, moving, editing or deleting the node, or creating links to existing nodes. Besides the functions that manipulate the IBIS structure, the system offers a query interface to select nodes that fit certain criteria. When the user submits the query form, all nodes that comply with his query are highlighted in the structure. As gIBIS was developed for Sun workstations, it must be considered a tool for professionals, though it would not have made sense to develop such a tool for everyday use by lay persons in 1988, when hardly anyone had a computer at home.

As gIBIS was only running on Sun Workstations, its architects developed the successor called QuestMap for Microsoft Windows Operating Systems. Today's equivalent is

Compendium<sup>4</sup> (see figure 10). Both offer basically the same functionality as gIBIS did, but with improved usability and enhanced integration of external documents. Moreover, they can be used over the network, with each user having the program installed on his machine and communicating through the application instead of meeting in person. Personal meetings require a dedicated facilitator who is in charge of adding the contributions to the system. QuestMap and Compendium also shift the intended usage from collective sense-making to creating so-called *group memory* that captures informal knowledge in meetings for storage. The group memory should contain all informal knowledge that has been relevant for a group's decisions so that it can be retraced at a later date (when the group members might have forgotten about the discussion). Thus, repeated discussions on the same topics can be avoided (Conklin 1996).

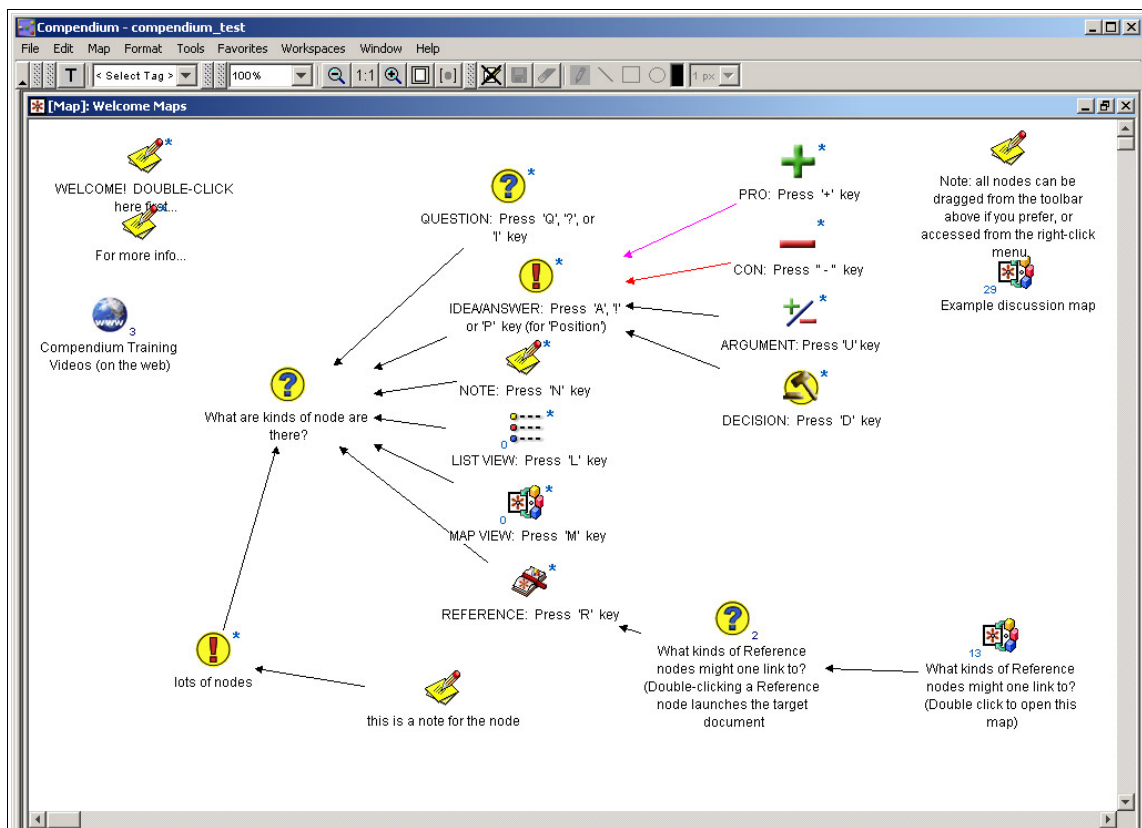


Figure 10: Screen shot of a Compendium window.

As gIBIS and its successors offer more powerful discussion tools, they are more complex and require the users to learn to use them before they can benefit from them. Conklin & Begeman (1988) report that “there was quite a bit of learning and experimenting going on

<sup>4</sup> Compendium is an open-source software implemented in Java and can be obtained at <http://www.compendiuminstitute.org/>.

while users constructed their networks” (p. 321). For the use in meetings (the originally intended environment for these tools), the methods require a facilitator who is in charge of operating the system and recording the attendants' thoughts and ideas. Concerning hardware, a video projector or a similar device is required, so that the discussants can view the current state of the debate. If the systems are used in a network, every participant works directly with the system, so that there is no facilitator needed; however, in this case, every participant must know how to use the system.

#### 2.2.2.4 Dito

*Dito* is a powerful tool for web-based discussions developed at Fraunhofer AIS, Sankt Augustin, Germany. It is based on the elder *Zeno* system and still uses its core, adding a user-friendly graphical interface (shown in figure 11) to hide the “rather technical handling”<sup>5</sup> of the system from the users (Böring 2003). Compared to the other approaches presented above, one could state that *Dito* is in the middle between the easy-to-use, loosely structured newsgroups and forums on the one side, and powerful, complex tools like *gIBIS* on the other side. *Dito* resembles other Internet forums, but offers functions that make it powerful enough for professional use. Discussions can be structured by folders and threads, contributions can be linked to each other without restrictions, attachments and hyper links to remote resources such as web sites can be added to contributions, and contributions can be labelled, for example, as pro or contra. *Dito* offers a built-in logged chat module, different user roles in a discussion, and mediation support. These are not all functions *Dito* provides, but they show that *Dito* is much more powerful than an ordinary Internet discussion board.

As mentioned above, contributions in *Dito* can be linked to each other, regardless of the domains or threads they belong to. Thus, the underlying discussion scheme goes far beyond the one used in newsgroups or discussion boards. The argumentation model in earlier versions of *Zeno* was based on a formal variant of *IBIS* (Gordon and Karacapilidis 1997); later versions offer the above-mentioned labelling mechanism for contributions that allows users to use *IBIS*, *TBL* or any other type of structure for their discussions; in most cases, the structure will develop with the discussion (Märker 2003).

As *Dito* is very versatile and comes with numerous functions, users will have to take some time to learn to use it, to take full advantage of the system. The size of the user

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5 Translated from the German user manual: Böring (2003), p. 6.

manual (59 pages) indicates the number of functions the tool offers. However, there are no special prerequisites to use the system other than a web browser and Internet access.

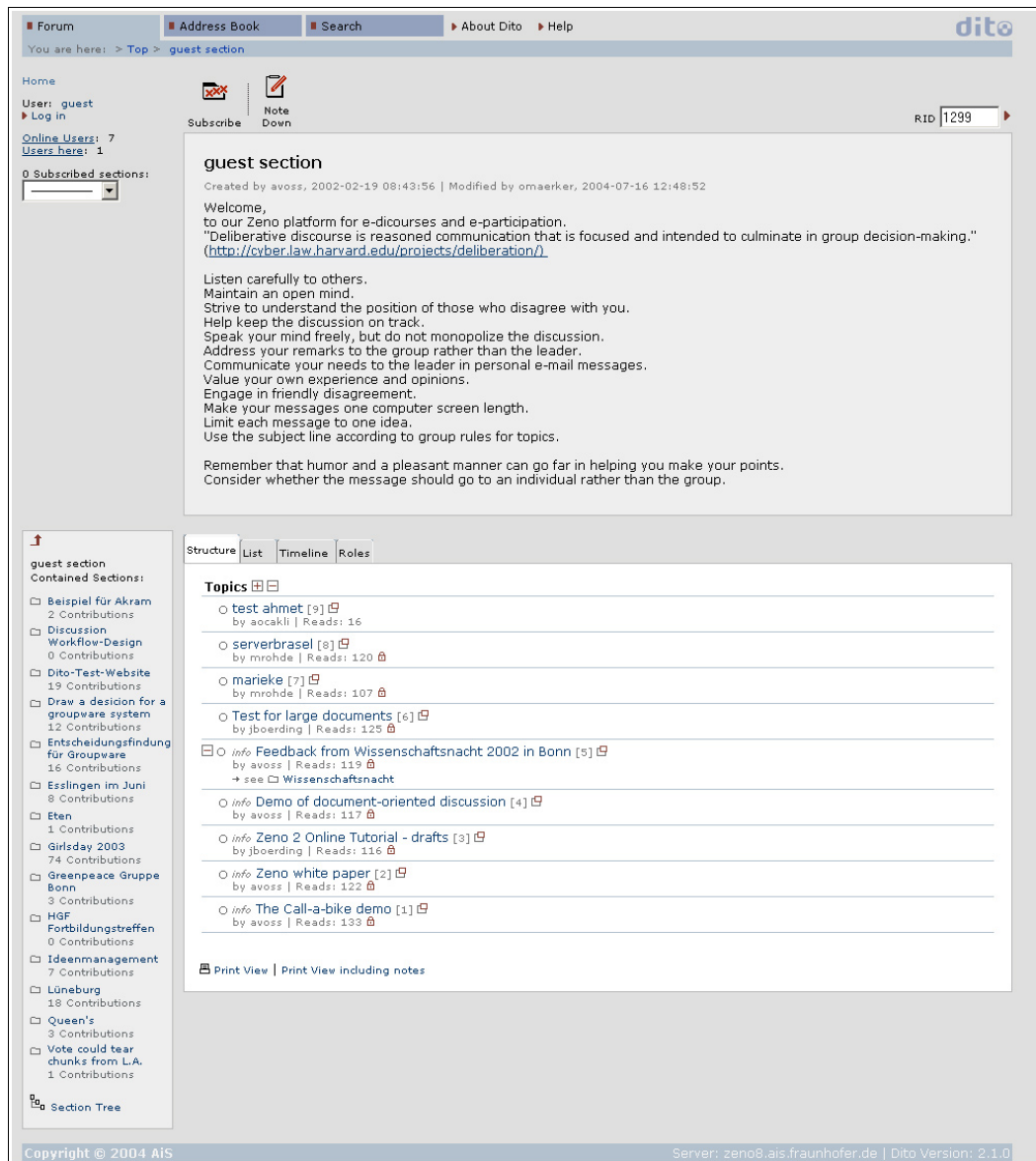


Figure 11: Screen shot of a Dito forum (from <http://zeno8.ais.fraunhofer.de/zeno/forum>)

## 2.3 Linking Discussion Contributions to Map Locations

The question how to conceptually link discussion contributions to map locations is crucial for the design of a tool for spatially related debates. Voss et al. (2004) state that annotations are relations between map locations (*references*) and discussion contributions (*comments*), whereas references and comments are objects. Moreover, the model should support many-to-many relations, so that one comment can annotate several (0...n) references, and one reference can be annotated by several (0...m) comments<sup>6</sup> (Voss et al. 2004). Figure 12 shows these relationships between comments and references in terms of a Unified Modelling Language (UML) class diagram.

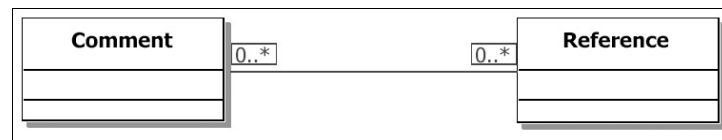


Figure 12: Annotation relationship between comments (discussion contribution) and references (map objects) according to Voss et al. (2004).

Rinner (in press) presents a theoretical framework for spatially related discussion called *Argumentation Maps (Argumaps)*, updating Rinner (1999). His work focuses on the “relation between map elements and the argument structure of an asynchronous discussion forum” (Rinner 1999, p. 7). His model (see Figure 13 for overview) is independent from an implementation. Like the model presented by Voss et al. (2004), this framework is object-oriented in assuming that spatially referenced arguments always refer to spatial objects, as opposed to a pair of coordinates<sup>7</sup>. This characteristic is independent of the GIS data model used for the implementation despite the fact that vector graphics contain representations of real-world objects that are directly identifiable, in contrast to raster graphics. Compared to the model presented above, the Argumap model introduces a third element - graphic reference objects that can be added to the map by the user. These graphic reference objects can be any type of shape the user draws on the map to spatially reference his argumentation element. Moreover, Rinner (in press)

<sup>6</sup> Map objects with 0 comments make only sense if they were already existing on the map and were not added to the map for discussion purposes; references that were added just for discussion purposes (like small dots or flags) should have at least one comment that annotates them – otherwise, they would be useless.

<sup>7</sup> The pairs of coordinates defining a map object's spatial extent is one of its characteristics, among other attributes. Hence, spatial objects are not independent of coordinates, but they comprise more information than just the underlying coordinates.

defines relationships not only between *different* kinds of objects, but also between objects of the *same* kind: Every argumentation element may have logical relations to other argumentation elements (e.g. it may respond to another element)<sup>8</sup>, and every geographic object may have (implicit) spatial relations to other geographic elements (such as neighbourhood relations, relations like “A is west of B”, etc.).

The essence of both models outlined above is that it is not sufficient to handle an argumentation element's spatial reference as one of its attributes next to its author, date and so forth. It makes even less sense to design discussion contributions as attributes of spatial objects (imagine a map object representing a house, with attributes like number of floors, living space, etc., and a comment like “the ceiling in the living room needs to be painted” as another attribute). Geographic data and discussion elements must not be mixed up, as they are both entities of their own, and the data model must represent this fact in a way that is flexible enough to handle many-to-many relationships as described above.

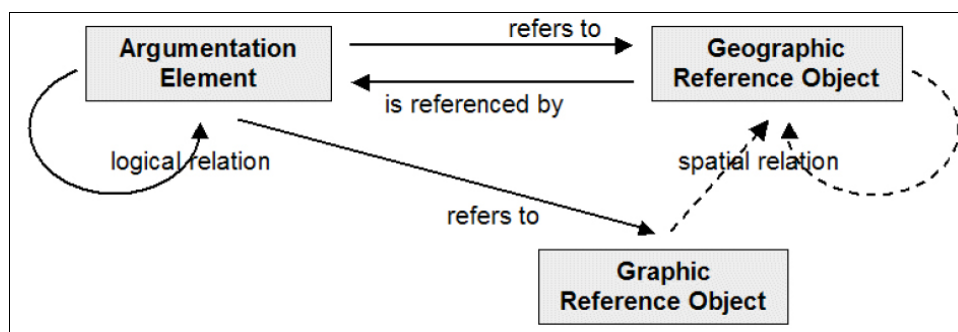


Figure 13: Relationships between argumentation map elements (from Rinner (in press)).

## 2.4 Conclusion

This chapter presented IBIS and Toulmin logic as two popular argumentation models that have been successfully applied in various projects. Both of them require the users first to familiarize themselves with their rules before they can take advantage of the structure they provide. A number of software tools for computer supported discussions was presented, ranging from simple, easy-to-use tools like Usenet newsgroups and Internet

<sup>8</sup> Generally, almost every element in a debate will have a logical relation to other elements. Only very few elements (new questions or statements that do not refer to other elements) would not have any logical relation to any other element; but this is only true as long as there are no new discussion elements referring to them.

forums, to advanced implementations of the argumentation models. Concerning the software tools, it can be assumed that the more powerful a tool's discussion structure is, the longer it will take for a new user to familiarize with it. Professional solutions like gIBIS (resp. QuestMap / Compendium) or even the easier-to-use Dito are hard to use without an introduction (or a study of the manual in the case of Dito). Thus, these tools cannot be taken into account for an environment that should be usable intuitively, especially for non-professionals – although they would provide a very good foundation for the analysis of the discussions afterwards.

The last section showed that it is not sufficient to take either a map and attach the discussion to it, with the contributions as attributes of the map elements. Nor is it appropriate to handle map elements as parts of discussion contributions. Both components must be regarded and designed separately and then be linked so that flexible, spatially related discussions can develop, with the option to have many-to-many relations between discussion contributions and geographic reference objects.

## 3 Technological Background

There are various options for implementing the mapping part and the discussion part of an argumentation map, as reported in chapter 2. This chapter describes these options from a technical point of view, since these prerequisites – in addition to the conceptual characteristics – have an influence on the choice of the best suitable option for the prototype. The descriptions give an overview of the technologies, but are limited to the features influencing the choice of the best option for the prototype. Thus, this chapter does not only present the different technologies, but it also discusses them in the context of the prototype application, both from a user's and from a system provider's point of view.

The first section discusses web mapping technologies. The second section presents implementation options for web based asynchronous discussions. The third section deals with the question how to link map and discussion technically. The last section draws a conclusion of this chapter.

### 3.1 Online Mapping Technologies

#### 3.1.1 General Considerations

Web-based systems fall in the category of client-server architectures. Client-server architectures are made up of three basic elements: *presentation*, *business logic* and *data*. The presentation element provides the user interface to the system, whereas the business logic deals with the actual computation. The data element holds all information inside the system, e.g. for a web shop, all offered goods with prices and descriptions. The data are usually stored in a database. The partition into server and client goes somewhere between these three elements, as depicted in figure 14. The variety of systems ranges from *thin client* systems, where the data, logic, and parts of the presentation are placed on the server side (figure 14a), to *thick client* systems that leave only (parts of) the data on the server side (figure 14b) (Peng and Tsou 2003). The transition from thin to thick clients is smooth.



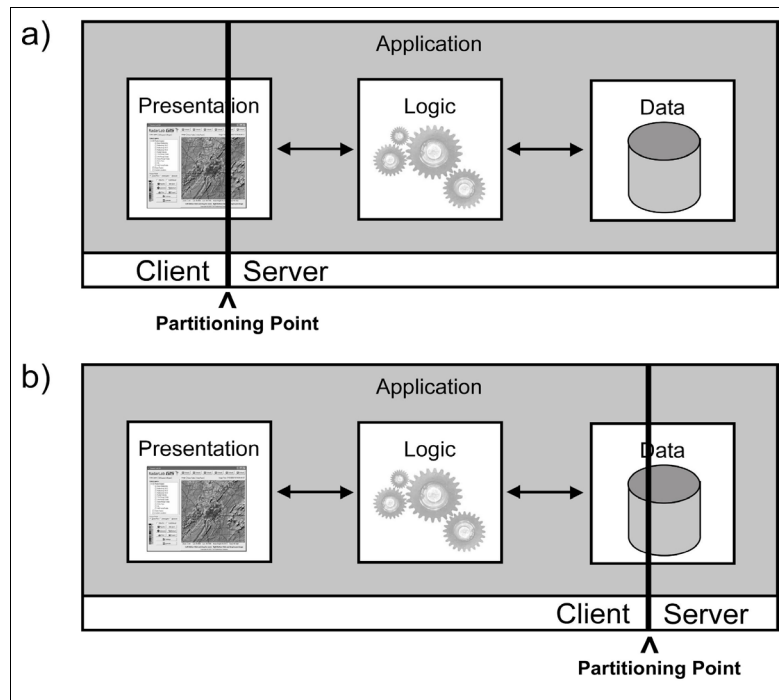


Figure 14: The partitioning point differentiates between thin client (a) and thick client (b) or any position in between.

A general question that arises when developing a system that allows users to view maps over the web (as for other distributed systems) is how thick the client should be. As the system should be accessible for everyone through the web, a “thicker” client means longer start-up times for the user, since more code must be transferred from the web server. This is not the case if the client consists of an application or browser plug-in the user needs to install to use the system. In this case, the user would download it once and install it on his computer. Thus, frequent users would avoid to download the client every time they use the system, although the system uses a thick client. But the use of a client-side application or plug-in has some important disadvantages. Users might not want to install the application or plug-in for security reasons, as it gets full access to the system once it has been installed. On most systems, administrative rights are required to install software, so that users who do not have sufficient rights (in office or university networks, for example) will not be able to install the plug-in or client application. Another drawback is that all users must download new versions when the system is updated. If the application provides a thin client that consists of HTML pages and / or a Java Applet (see section 3.1.3 for a description of Applets), it is downloaded each time a user wants to use the tool, so that new updates will be available for all users instantly. For the developers, the use of a thicker client consisting of an application or plug-in means that they have to

provide a version for every operating system, since they are delivered as byte-code, in contrast to platform-independent web-pages or Applets. For these reasons, browser plug-ins and client-side applications will not be considered any further for the implementation of the prototype.

### 3.1.2 Proprietary Commercial Map Servers

Various GIS software vendors sell map server solutions that allow the user to publish data on the web that were produced or modified in a desktop GIS. Examples are ESRI ArcIMS (Internet Map Server), GeoMedia WebMap or MapInfo MapXtreme. These map server environments usually integrate the set-up of the server-side application and the web site that interacts with the server. The client is in most cases a *dynamic* HTML (*DHTML*<sup>9</sup>) page that provides numerous functions such as panning, zooming, layer selection, querying, buffering or measuring distances. Besides these thin clients, Java clients, Browser plug-ins or client applications are available as thick clients for some map servers (ESRI 2002, Peng and Tsou 2003). Application manager tools assist the content provider in setting up the client page and the server application. They allow him to select the functions he wants to add to the page, adapt the layout and determine how the data on the server-side should be handled, e.g. how layers should be displayed (symbols, colours, etc.) or at which scales a certain layer should be displayed. The integrated development of server-side and client-side components is a convenient method of publishing maps on the web, but as a drawback these client-server systems use proprietary calls from the clients to the server. Therefore, it is not possible to exchange the map server software used by a client. However, most of the commercial map servers can be set up in a way that allows them to respond to Open Geospatial Consortium (OGC) Web Map Server (WMS) compliant calls (see section 3.1.4 for details on OGC WMS), so that they can also be used by OGC WMS specification compliant clients to retrieve maps. Apart from the technical factors, providers must take into account that commercial map server environments entail high license costs.

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9 The combination of HTML, Cascading Style Sheets (CSS) and JavaScript for manipulation of the Document Object Model (DOM) is often referred to as DHTML (Niederst 1999). CSS are used to define a web page's layout, separating content (which is in the HTML files) from layout. JavaScript allows web programmers to access a web site's elements (organized in the DOM) and change them dynamically, which is used for dynamic menus, for example. Although the names resemble each other, JavaScript must not be confused with the Java programming language.

### 3.1.3 Java Applets

Java Applets are Java programs that are embedded into web pages. Thus, they provide a powerful client-side technology that can be used to develop (more or less) thick clients. An Applet is loaded when the user loads the HTML page that integrates it by a special tag. The only prerequisite is that the browser must have a Java plug-in installed that runs the Applet, which is the default set-up for some web browsers (such as Mozilla / Netscape or Opera), whereas others require to download it separately (Microsoft Internet Explorer), which is free of charge. As Java is a complete object-oriented programming language, Applets can be used to augment web pages with functions that cannot be realized with HTML and JavaScript. Displaying file types not supported by web browsers or complex graphic functions like painting are examples for functions that go beyond the possibilities of DHTML. Although Java Applets can use the full functionality of the Java programming language, there are some constraints that limit their capabilities. Due to security constraints, Applets are running in a so-called *Sand Box*, which means that they are isolated from the file system of the executing machine. They are not allowed to access any files on the client computer, and they can establish network connections to no other web server than the one they were loaded from. Thus, some functions offered by simple web pages cannot be implemented in Java Applets, e.g. loading images from third-party web servers.

In the context of web-based GIS functions, Applets are often used to display specific GIS file formats for vector data in web pages. Examples are the DXF format, which is also used for computer aided design (CAD), or ESRI's shapefile format. Each shapefile consists of a set of files that store the geometry, location and attributes of geographic features, and one shapefile contains the data of one feature class (e.g. all streets in the city of Osnabrück). A map is usually made up of a set of shapefiles, containing different feature classes like streets, sights, buildings etc. Applets that display one or more vector-based files have some advantages compared to a thin client loading maps from a commercial web server. Apart from the fact that they allow for a greater variety of functions, they can be considered to be more user friendly, since the user does not have to wait for the server to respond after panning or zooming the map, for example, since all functions are running on the client machine. However, loading the page will take longer than loading a thin client HTML web page, since the amount of data that must be

transferred to the client is larger, and it always takes some seconds until the browser has launched the Java plug-in.

Examples of open-source libraries that facilitate the development of Applet with GIS functionality are OpenMap (<http://openmap.bbn.com/>), ROSA (<http://www.maptools.org/rosa/index.phtml>) or GeoTools-Lite<sup>10</sup>. A brief examination of the main features of these libraries showed that GeoTools-Lite is the most suitable one for the development of the prototype. It is a Java application programming interface (API) that enables Java developers to use shapefiles in their Applets and applications, without having to implement reading and displaying shapefiles from scratch. GeoTools-Lite offers a multitude of functions for GIS-related programs, including functions like zooming and panning maps, switching layers on and off, highlighting map features, adding previously defined tool bars to maps, or adding tool tips to map features. Tool tips can be used to display additional information on a feature when the user moves the mouse pointer over it, e.g. the name of a street. Thus, the basic framework for a developer who wants to add mapping functionality to his Applet is available for free.

Concerning the prototype implementation, a Java Applet seems to be the most suitable solution for the implementation, as the requirements of the prototype include some functionality that is not realizable with a DHTML page. Other technologies such as Macromedia Flash, offering a powerful scripting language called ActionScript, and relying on a prevalent browser plug in, would offer basically the same functionality for the users, but they require a cost-intensive authoring environment for the development. In contrast to that, Java is free of charge, and free integrated development environments (IDEs) such as Eclipse<sup>11</sup> allow for a low-cost development. In addition, the Java language is platform independent, as mentioned in section 3.1.1, so that the prototype implementation will run on every platform with a Java Runtime Environment (JRE).

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<sup>10</sup> GeoTools is an open source project managed by the University of Leeds. GeoTools-Lite and the newer version GeoTools 2, which has been designed for application development, can be obtained at the project's website: <http://www.geotools.org>.

<sup>11</sup> Eclipse can be downloaded from <http://www.eclipse.org>.

### 3.1.4 OGC Web Map Servers

The *Open Geospatial Consortium (OGC)*<sup>12</sup> is an organisation that develops standards for geo-spatial services. It consists of a number of members including GIS companies, research institutes and administrative organisations. Its mission is “to deliver spatial interface specifications that are openly available for global use” (OGC 2004). One of the specifications introduced by the OGC is the *Web Map Service (WMS)* Implementation Specification (OGC 2001a), which defines a standard for services that offer geographic maps on the web. The specification relies upon the hyper text transfer protocol (HTTP), the standard protocol for the transfer of web pages (and other web content) from web servers to web browsers on client machines. Services that implement the WMS specification are self-descriptive, which is achieved through extensible mark-up language (XML) documents. These XML documents contain information on the geographic extent covered by the maps on the server, the map layers offered by the server and other capabilities of the server such as supported image output formats. This information on the server's capabilities can be used by the clients to build requests that call maps from the server. These requests are also standardised by the specification and contain parameters such as the geographic coordinates of the map, the map layers, and the output size and format. The server responds to such a request either with an image containing the map as described by the request, or with an error message in the form of an XML document. The latter case will happen when the request is incorrect or incomplete, or when the server encounters an internal error while creating the requested map.

The WMS Implementation Specification is widely used. Different open source applications such as the *UMN MapServer* or *deegree*<sup>13</sup> implement the specification, as well as some commercial map servers such as ESRI's ArcIMS. Intelligent clients that are capable of reading the information in the capabilities documents allow the users to add new WMSs on the fly – all they need is the uniform resource locator (URL) that is associated with the server they want to add. Beyond that, WMSs can be cascading, which means that one WMS can retrieve maps from other WMSs (which might in turn use other WMSs, and so forth) and overlay their maps with its own content to produce the output map. XML-based documents called *Web Map Context Documents* (WMC docs) have

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<sup>12</sup> The OGC's website can be found at <http://www.opengis.org>.

<sup>13</sup> The UMN Map Server can be obtained at <http://mapserver.gis.umn.edu/>; deegree can be obtained at <http://deegree.sourceforge.net/>.

been specified by the OGC to introduce a standardized way to store map configurations, so that they can be reconstructed at a later point in time (OGC 2003a) (section 3.3.4 will describe WMC documents in detail). There are numerous municipalities that use open source WMS implementations today because of its low purchase costs and the improved interoperability compared to proprietary software solutions, which also simplifies the set-up of spatial data infrastructures.

Equipping the prototype for this thesis with the ability to communicate with OGC WMS would facilitate its integration into existing spatial data infrastructures that rely on the WMS specification. As mentioned above, Applets cannot connect to remote servers other than the one they were loaded from. Thus, the integration of WMS maps would require a server-side proxy that loads the maps from one or more WMS and hands them over to the Applet. Moreover, the user would experience short offsets between the instant update of shapefile based layers (if there are any) and the update of the WMS map, as it must be reloaded over the web. In contrast to that, the shapefile is loaded into the Applet on start up, and zoom and pan operations on shapefile based layers can be calculated inside the client. However, the prototype should support WMS integration, as this is the most important standard for the exchange of maps over the web. Content providers could integrate maps from numerous WMS sources into the application with little effort, offering their users a greater variety of data to take into account when forming an opinion.

## **3.2 Online Discussions**

### **3.2.1 General Considerations**

The definition of the contributions making up the discussion is a general consideration for the development of an online discussion system. These discussion contributions can be regarded as digital versions of the contributions defined in section 2.1.1. Contributions are clearly defined entities, comprising information such as title, message and possibly attachments. Every contribution can be distinguished from any other contributions in the discussion. A contribution is written by an author who can be identified (e.g. by his e-mail address), and it is associated with the point in time when it was created. Moreover, a contribution may have logical relations to other contributions. Its creation time and its

logical relations to other contributions allow for the assignment of a clearly defined position in the course of the discussion.

### 3.2.2 Usenet Newsgroups

With Usenet newsgroups, users send postings to groups, as described in section 2.2.2.1. Technically, this means that they send the posting to the news server they log on to, which in turn propagates the posting through the web to every news server it is connected to. This procedure is repeated, using a flooding algorithm, until all servers that list this particular group have received a copy of the posting (Horton and Adams 1987). These servers *mirror* the group, providing their users with the latest postings. News servers offer their users a number of selected groups, which may either be mirrored from other servers or be run locally (the group “`www.geo.geoinformatik`” is a local group on the news server of the University of Münster, for example). Local groups may, in turn, be mirrored by other news servers. Every newsgroup posting on a Usenet server has a unique identifier that allows the newsreaders to identify postings. Since some newsgroups are very popular and receive many postings every day, the servers cannot store all postings permanently, but delete old postings after a certain period of time, which can be determined by the group's administrator (typically 15 to 30 days).

Newsgroups offer a number of benefits for the use in the prototype. First of all, newsgroups offer structured discussions, they are easy-to-use and do not require special software. Secondly, the infrastructure for discussions is already existing. Finally, there is no database or other kind of storage needed, so one could just select an existing newsgroup and use it for the spatially related discussions.

Despite these advantages, there are some problems with using newsgroups for the discussion part of the prototype. A user interface that consists of a browser window, showing the map, and a newsreader showing the discussion cannot be considered user-friendly. This configuration forces the user to switch between two windows permanently. Moreover, it is not possible to implement query tools that allow combined spatial-argumentative queries with this set up, because this feature would have to be implemented in the newsreader, which would be a third party product in this case. On the other hand, an integrated newsreader inside the Applet would make the client very thick and cause long start-up times, let alone the laborious implementation. Beyond that, a crucial question is where to store the spatial reference of a contribution.

There are two options:

1. The spatial references could be attached to the postings. This option could be implemented with a number of attachments or in-line documents, e.g. a WMC document for the map server configuration and a geographic mark-up language (GML<sup>14</sup>) file containing the spatial references the user added to his posting. But this solution would increase the file size for each of these posting drastically, causing much traffic as the message is propagated between the news servers and finally to the readers<sup>15</sup>. Moreover, the news server that hosts the group will delete the postings after a certain period of time. Analyses of the data might fail because a part of the discussion might have been deleted.

A private news server would solve these problems, but raise other issues. The server needs to be administrated, which causes additional costs. The server's administrator must make sure that everyone who wants to join the discussion has an account (user name and password) for the server, which becomes very laborious when a large number of people wants to join in. Mirroring the group on other news servers for this purpose would raise the above-mentioned traffic issue again.

2. The spatial references could be stored in a database that has a record for every posting with some geographic reference points, and the map extent and layers the author was viewing when he wrote the posting. This solution would keep the newsgroups “clean” of blown-up messages, but would cause messages in the groups that make no sense without their spatial reference. Thus, readers of the group who read the spatially referenced postings with their standard newsreader cannot make any sense of them without the mapping component of the argumentation map. Moreover, this solution would split up the information, storing the contributions in newsgroups whereas the spatial references would reside in the database. As this solution requires a database anyway, one could store the discussion contributions in the database just as well (which, of course, would mean that the discussion is not based on newsgroups).

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14 GML is an XML-based OGC standard “for the modeling, transport, and storage of geographic information” (OGC 2003b).

15 Postings that cause much traffic will certainly raise rebukes by other users, because attachments or large in-line contents are not accepted in most newsgroups .



Newsgroups offer a structured discussion, and they are easy-to-use, but they cannot be considered as the ideal solution for the prototype. A split user interface consisting of a newsreader and a web browser cannot be considered user friendly, and integrating a newsreader into the Applet can be assumed to be very laborious and would cause a very thick client. Some details in the implementation of the Usenet also raise technical problems, especially concerning persistent storage.

### **3.2.3 Online Forums**

Forums are dynamically generated HTML pages, as mentioned in section 2.2.2.2, which means that the page that is transferred to the browser is not a static file on the server, but rather the output of a program running on the server that is executed each time it is called. Typical languages for this type of server-side scripts are PHP<sup>16</sup> or ASP<sup>17</sup> which many forums use. The actual contents of the forum – its contributions, and the member data – are usually stored in a database on the server. The scripts read the contents of the database to produce HTML pages that are sent to the client browser.

A possible implementation of the argumentation map prototype could extend an existing forum. This would require a re-design of the back end database so that it can store the spatial references. Beyond that, the HTML user interface would have to be re-designed so that it integrates the map. As the map will require a Java Applet for the reasons outlined above, all links in the HTML forum would have to be augmented with JavaScript functions which call methods on the Applet, e.g. to highlight the references of the contribution the user is currently viewing. Opening a contribution by clicking one of its references on the map would require to call JavaScript functions from the Applet. In general, this is also possible, but depends on the displaying browser's security settings.

For the argumentation map to work as intended, the user must have JavaScript activated, a Java plug-in installed and the security settings set to enable JavaScript/Applet communication. Thus, on the client side, the chance that one of these prerequisites is not met is higher than for a solution that consists just of an Applet. Beyond that, using an existing forum means that large amounts of foreign code must be adopted. Keeping in mind that a forum usually does not offer a structured discussion, adopting an existing

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<sup>16</sup> PHP is a popular scripting language that is mostly used for server-side augmentation of HTML pages with dynamic code that is executed before the server sends out the resulting HTML page. For further details, check <http://www.php.net>.

<sup>17</sup> Active Server Pages (ASP) are Microsoft's solution for server-side scripts. Like PHP, they are often used to generate web pages from the content of a database.

forum cannot be seen as the ideal solution for the prototype, both from the user's and from the developer's point of view.

### **3.3 Creating the Link**

Section 2.3 dealt with the question how to link discussion contributions to geographic references from a conceptual point of view. Technically, there are several ways of implementing this feature, which partly depend on the chosen techniques for the map and for the discussion. Some of the methods presented in this section derive from existing applications which are presented in chapter 4. It is important to keep in mind that the implementation should represent the conceptual many-to-many relationship between discussion contributions and geographic references, with identifiable objects on both sides.

#### **3.3.1 Description of Map Annotations with URLs**

One method to augment maps with additional content is the use of URLs. Section 3.1.4 described how URLs are used to describe a requested map for a WMS, with the parameters containing information on the requested map's layers, extent, spatial reference system and so forth. Kolbe et al. (2003) present a system that uses the query part of the URL to encode comments and other content, e.g. images. A special client is required to decode this information and place the comments on the map at the corresponding location (for a detailed description of the system, see section 4.3.3). As all information that is required to generate the map is encoded in the URL, the underlying geodata remain unchanged.

This technique is an option that would allow for the augmentation of newsgroup or discussion board postings with links to a map client. This client would restore the map from the URL parameters as it was created by the posting's author. Although the implementation presented by Kolbe et al. (2003) uses coordinates as spatial references for the comments, it would be possible to adapt the URLs and the client to achieve object-based map references. This object-based paradigm as proposed by Rinner (in press) (see section 2.1) would allow for map objects with multiple comments, and a number of map objects could be assigned to one comment. Thus, many-to-many relationships would become possible.

The fact that the map is always created from only one URL at a time is the main

drawback of this technique. This means that it is not possible to get an overview of all comments that have been made to this map. Moreover, this technique only supports showing the map that belongs to a discussion contribution, with all the comments made by the author. But it does not support calling discussion contributions from the map, e.g. by selecting a map object.

### 3.3.2 XML for Image and Map Annotations (XIMA)

The OGC discussion paper “XML for Image and Map Annotations (XIMA)” (OGC 2001b) presents a draft specification that uses standardized XML files to annotate maps that draws on GML which is meant to be used for the defense and intelligence community, but also for tourism, city planning and participatory government. It allows for the annotation of maps with text as well as so-called *rich* contents like images, video sequences, or Scalable Vector Graphics (SVG)<sup>18</sup>. 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 15 shows the complete document tree for XIMA documents.

Compared to the use of URLs as described in the previous section, XIMA documents have the advantage that they are built upon open standards such as on XML and GML<sup>19</sup> (although XIMA itself is not a standard yet). Moreover, a client which uses XIMA documents could show the annotations from more than one document at a time, which is not possible with URLs. The disadvantage is that they are also based on coordinates, not on map objects. It is not possible to identify that two annotations refer to the same objects, as they might use slightly different coordinates, although they want to refer to

<sup>18</sup> SVG is “a modularized language for describing two-dimensional vector and mixed vector/raster graphics in XML” (Ferraiolo and Jackson 2003).

<sup>19</sup> URLs are standardized, too, but there is no standardized way of using them to describe relationships between map objects and discussion contributions, or other kinds of annotations.

exactly the same area on the map, for example. Another example for this problem is the fact that an annotation can refer to multiple maps or images, and may specify a different GML element for every map or image. Hence, it is not possible to identify whether the annotation refers to two different objects, or to the same objects shown on two different maps. This is due to the fact that XIMA documents describe relationships between annotations and map portions, instead of spatial objects. In contrast to that, the argumentation map model presented in section 2.3 supports identifiable spatial objects. Thus, two contributions which refer to the same area on a map will refer to the same, clearly identifiable object. Beyond that, the OGC does not seem to follow up the development of this standard, as this discussion paper was published in early 2001, and there are no consequent documents on the OGC website yet (November 2004).

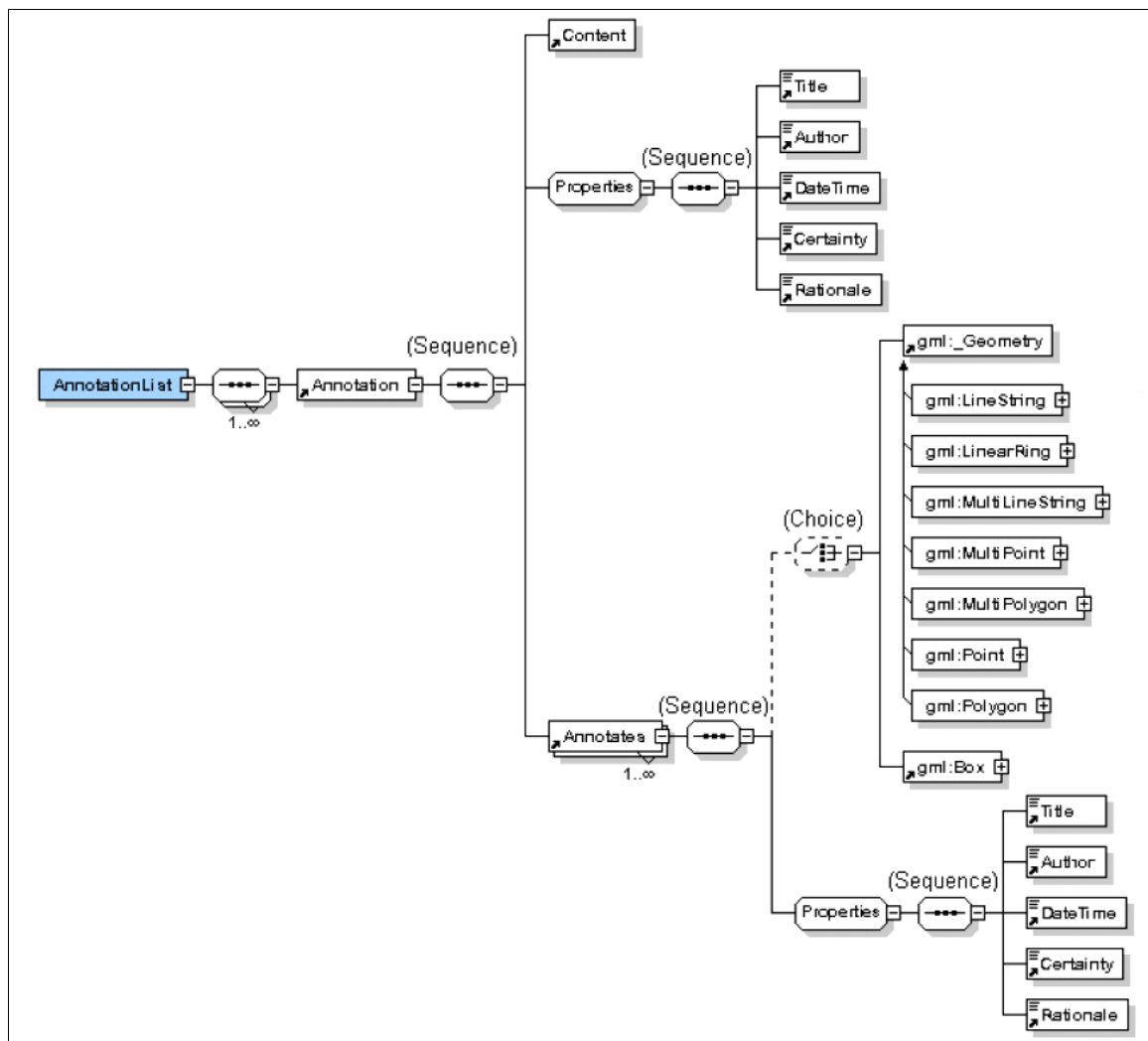


Figure 15: XIMA document tree, from OGC (2001b).

### 3.3.3 Database

Forums usually store their contributions in a database on the server, as described in section 3.2.3. A straight-forward solution for the persistent storage of the links between discussion contributions and map objects is to place them inside the database, too. This solution also enables the direct mapping of many-to-many relationships to the data structure, as well as the use of spatial objects rather than just pairs of coordinates. These objects can be points, lines or polygons. Figure 16 shows a database diagram for the references between contributions and point reference objects.

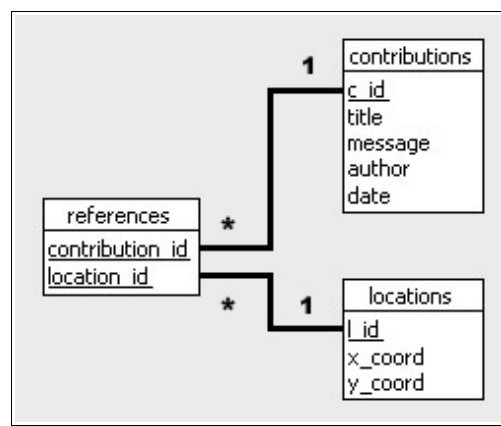


Figure 16: Database schema for discussion contributions with spatial reference objects and support for many-to-many relationships.

This schema has to be extended to support other kinds of spatial reference objects, but it is sufficient to show how many-to-many relationships are mapped to a database. The database consists of three tables: one table for the discussion contributions, one for the map locations and one for the references between records of the other two tables. The *contributions* table holds all information for discussion contributions like title, message, author and date. The *locations* table simply holds a pair of coordinates for a point. The contributions' and locations' IDs are used to store references between any pair of datasets in these two tables in the *references* table. By paging this information out to a third table, it is possible to have many-to-many relationships. For example, a new contribution can refer to two locations. This would cause one entry in the contributions table (e.g. with ID 251) and two entries in the locations table (e.g. with IDs 33 and 34) - given the case that the user just added the reference points and that they were not existing before. Moreover, this would cause two new entries in the references table (both with contribution\_id 251,

one of them with `location_id` 33, and one of them with `location_id` 34). Thus, the references table holds the information that contribution 251 refers to the spatial reference objects 33 and 34. If another discussant wants to refer to the point with ID 34, then this point is *not* added to the locations table again. Instead, a new contribution is added to the contributions table, e.g. with ID 252, and a new reference (`contribution_id`: 252, `location_id`: 34) is added to the references table. Hence, the object-based paradigm is mapped to the database, and duplicate spatial objects are avoided.

### 3.3.4 Storing Map Configurations

When a user reads a discussion contribution and views its reference objects on the map, it might be helpful to restore the map as it was when the contribution was written. The author might have been viewing certain layers and a specific map extent when he wrote the contribution. His text might refer to the contents of a layer the reader has switched off, or some of the references he placed on the map are out of view for the reader. For these cases, it is desirable to have the option to load a stored map configuration. The OGC developed a standard called *Web Map Context (WMC)* documents (OGC 2003a) for this purpose. These XML-based documents allow for the storage of the description of a map that was retrieved from an OGC WMS. They can be used to restore the map at a later time.

A WMC document consists basically of two parts: The *General* part and the *Layer List*. The former holds general information such as the map's extent, the image size, the spatial reference system, an abstract and contact information, while the latter holds a list of *Layer* elements. A Layer element describes one layer of the map with the server which offers this layer, the spatial reference system, the used image format, style, and some additional information like abstract, name and title. A third, optional element called *Extension* enables developers to add application-specific information to WMC documents. An example service which uses WMC documents is the “Viewer Client Generator 2.1.1.” of the Canadian Geospatial Data Infrastructure (<http://cgdi-dev.geoconnections.org/prototypes/owsview/>). Users of this website can include layers from different WMSs into the client and zoom to their area of interest. This configuration can be stored in a WMC document, which can be downloaded to the users machine. If he wants to continue work with this configuration later, he can upload the WMC document again, and the client restores the map as it was when the WMC document was stored.

WMC documents offer a standardized way to store maps that have been retrieved from one or more OGC WMS. For services which offer functionality that is not covered by WMS, the Extension element can serve as a container for additional information. For example, Applets or applications which use GIS vector formats in addition to WMS would require to store which of the non-WMS layers were switched on or off.

### **3.4 Conclusion**

This chapter described the technical view on the different options both for the mapping and the discussion part of the prototype. As the mapping part will contain a number of features that cannot be implemented with pure DHTML, and as other options such as client-side applications, browser plug-ins or the use of Macromedia Flash have other disadvantages, mapping will be implemented in a Java Applet. To meet the requirements of interoperability, the Applet will allow for integration of maps from OGC WMS. This will require a server-side proxy which calls the maps and hands them over to the Applet, as it cannot access remote WMSs directly because of the Sand Box principle. For the discussion part, neither using newsgroups nor extending an existing discussion board can be regarded as the ideal solution. The considerations in this chapter lead to the conclusion that integrating a custom-built forum into the Applet is the best solution for the prototype as it offers an integrated user interface and a powerful and flexible environment for the development. Section 3.3.3 explains how a server-side database can be used to map the object-based argumentation map model presented in section 2.3 to the back end data.

## 4 Analysis of Existing Systems for the Exchange of Spatially Referenced Information

This chapter reviews and analyses a number of tools that support the exchange of spatially referenced information. The first section points out which aspects are in the focus of the analysis. The second section presents a number of applications from the field of web-based computer systems for public participation. The third section sums up relevant aspects of related tools from other fields. The fourth section analyses the results and relates them to this thesis. This includes discussing their advantages and disadvantages, and looking for functions which can be adopted for the prototype. This chapter does not intend to give a complete overview on public participation GIS on the web, but it focuses on tools that allow users to augment maps with additional information.

### 4.1 Focus of the Analysis

The analysis of the systems examined in this chapter will focus on the following aspects (where applicable):

- **Intended use**

For which purpose was the tool developed? Who are the intended users (professionals or non-professionals)?

- **Map**

Does the tool use vector-based or raster-based maps? Is there a map server involved? If so, which software was used?

- **Discussion**

Does the tool offer any support for the exchange of information between users? Is there a structured discussion?

- **Connection between map and discussion**

How are the annotations linked to the map? How is this presented to the user, which map symbols are used? How are annotations stored?

- **Interoperability**

Can it be integrated into existing spatial data infrastructures? Which standards does it use? Is the implementation easily adoptable to other use cases?



- **Analysis functions**

Which analysis functions does the tool offer, both for users and for content providers?

- **User interface**

On which technique is the user interface based (DHTML, Java Applet, Macromedia Flash or Application)? Does it require an introduction or is it easily usable?

- **Case studies**

Were there any case studies using the tool? What were the results?

As the tools in section 4.3 have all been developed for different purposes, it is hard to criteria for their analysis. Generally, they will be surveyed against the background of the development of the prototype, and will provide suggestions for functions to be implemented in the prototype.

## **4.2 Web-based Computer Systems for Public Participation**

### **4.2.1 Virtual Slaithwaite**

The *Virtual Slaithwaite* project was initiated in 1998 as part of the Virtual Society program which was funded by the British government. The main intention was “the use of online geographical information systems to allow public interaction with geographical features” (Carver et al. 1999). Thus, it was developed explicitly for non-professionals. The online system showed a digital version of the “Planning for Real” method. As described in section 1.2.4, this method was used to collect citizens' ideas and comments on the development of the village. A large scale model of the village was built, and the citizens had the opportunity to write their ideas on flags and place them at the corresponding location on the model. The flags had different colours which represented different classes of problems such as health or crime (Evans et al. 1999).

The digital version on the web (<http://www.ccg.leeds.ac.uk/slaithwaite/>) was developed by the *On-Line Digital Democracy Group* at Geography School, University of Leeds, UK. It offers a vector-based map of the village with functions to zoom and pan, as shown in figure 17. When the user moves the mouse pointer over an object on the map, a short text with the street name or other information on the feature appears to facilitate orientation on the map. This is the only method of analysis the tool offers. The left hand

side of the window shows a short introduction to the system and a text box for the users' messages. The user can select an object on the map by clicking it. The corresponding text (e.g. street name or information such as "residential building") appears on top of the input text box, so that the user can see that his comment is associated with the object. Users can only select one map object per comment, so that comments with multiple spatial references are not supported. Moreover, it is not possible to create new reference objects, e.g. for empty areas. In contrast to the "analogous" Planning for Real, there is no option to categorize the comments. During the consultation period, the application did not allow users to view others' comments to avoid comments on other people's ideas. After the consultation period, everyone could read all comments on the map. In the present version of the system, it is not possible to view others' comments. Thus, a discussion between the citizens was not possible and not desired, as the viewing of other citizens' comments had been disabled during the case study. Hence, there is no discussion structure.

Technically, Virtual Slaithwaite relies upon the GeoTools libraries mentioned in section 3.1.3 and is thus an Applet displaying ESRI shapefiles. There is no map server involved. The comments sent to the Web server are processed by server-side Perl scripts and then passed into the analogous Planning for Real process. There is no clear statement in the literature on this project concerning the storage of comments, but they seem to be stored both with a pair of coordinates and with a text describing the selected map feature. This can be concluded from the screen shots in Evans et al. (1999) which show yellow dots on the maps, indicating users' comments.

Carver et al. (1999) present the results of the Virtual Slaithwaite case study. Besides some general criticism of the method which points at the general problems of public participation, the feedback to the actual online system was very positive. Most people appreciated the option to have an online tool for public participation, and many people even see the potential of extending the system with more information, e.g. multimedia. There were no comments on problems when using the system, so the user interface can be assumed to be easy to use.

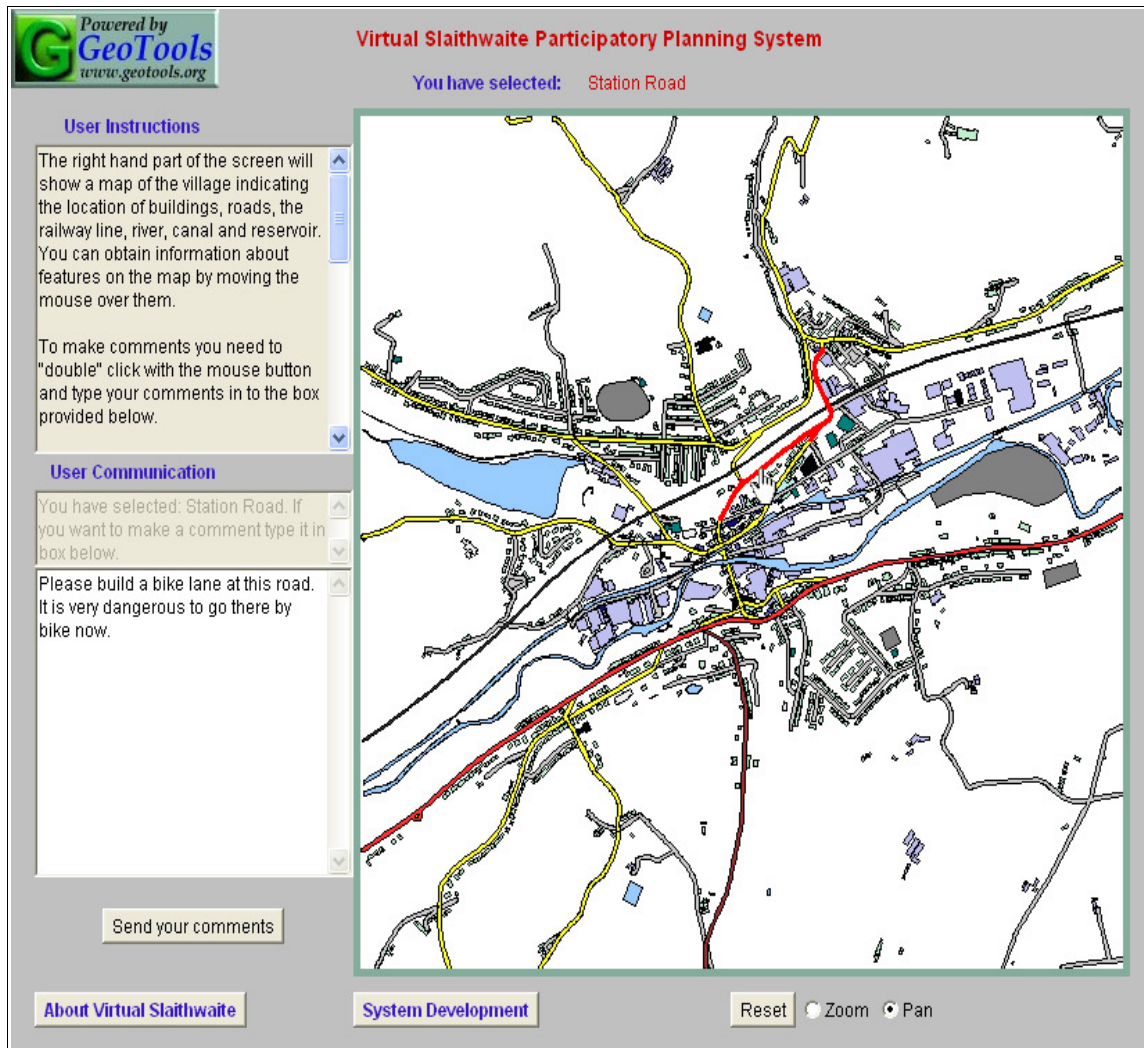


Figure 17: Screen shot from the current version of the Virtual Slaithwaite system (<http://www.ccg.leeds.ac.uk/slaithwaite/ppgis.html>). As it does not support reading other people's comments any longer, there are no dots on the map indicating other's annotations.

#### 4.2.2 Orange County Interactive Mapping

The *Orange County Interactive Mapping* tool can be found at the City of Orlando's web site at [http://www.cityoforlando.net/public\\_works/esd/gis/interactive\\_mapping.htm](http://www.cityoforlando.net/public_works/esd/gis/interactive_mapping.htm) (Steinmann et al. 2004). It offers numerous data for Orange county in Florida, USA. Its main intention is to provide a facility for citizens to view data on their county and to send in comments so that the municipality gets an idea of the citizens' concerns. Moreover, the tool is used to enhance the available data, as citizens are encouraged to report any mistakes they find in the data. As the system was developed for the citizens in the county, it was developed for non-professionals.

Besides the standard GIS functions (zooming, panning, layer selection), a number of enhanced tools are provided, which are contained in a “toolbox”, as shown in figure 18. These tools are arranged in three groups: The tools in the first group allow users to identify map features, measure distances or areas, and zoom to a specified region of the map. The tools in the second group enable users to augment the map with points, lines, rectangles, polygons, text, coordinates or a grid. Moreover, existing map features can be labelled with any information from their attributes. The third group of tools offers a query builder to find map features that match certain criteria, and a tool which shows a list with all features in one layer, with an option to zoom to every one of them. Beyond that, there are tools to store and load a session, in case a user wants to continue his work at a later time. The most important tool in this group is the e-mail tool which allows users to send an image or PDF file by e-mail. This function enables users to send the comments and sketches they have added to the map to staff at the county administration, or to friends or colleagues. Unfortunately, there is no indication where to send these maps for criticism or ideas, so that citizens would have to search the website for the appropriate e-mail addresses. Besides the e-mail tool, there are no means to exchange information on the map, so that there is no discussion support.

A number of links on top of the map allow users to view the current layer selection, a legend or an overview map. A gazetteer service offers the search for street addresses, intersections or points of interest. It is possible to create a customized PDF file of the map for printing purposes. A link to a FTP server provided by the council enables users to download the original data that are used to generate the maps. The option to select map features by layer, attribute or bounding box, together with the other analysis functions mentioned above, give users some powerful tools to explore the map's contents.

Technically, the website is made up of an ESRI ArcIMS with HTML viewer. Storing and loading sessions is realized through special XML files that are downloaded to the client computer. They have a proprietary format specified by Geocortex, the company which set up the service (<http://www.geocortex.net/>). It is not clear how the comments and sketches added to the map are stored, but it can be assumed that they are attached to coordinates. As there is no option to send them directly, but only embedded into an image or PDF file, there is no chance for spatial analyses which would allow the content providers to find all comments for the most discussed areas in the county, for example. As there is no literature on this system, it can be assumed that there have been no case studies so far.

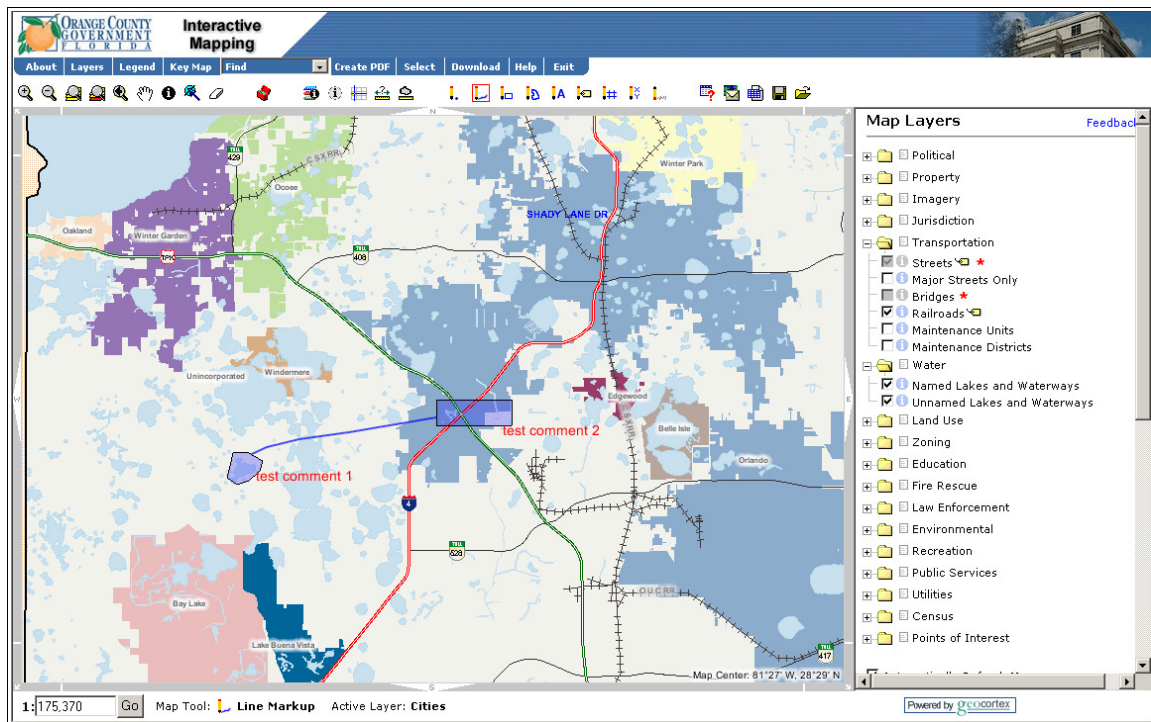


Figure 18: Screen shot of the Orange County Interactive Mapping website (<http://ocgis1.ocfl.net/imf/imf.jsp?site=orangecFL>).

### 4.2.3 Interactive Landscape Plan Königslutter am Elm

The *Interactive Landscape Plan Königslutter am Elm* (<http://thuja.land.uni-hannover.de/>) is a portal which provides the public with information on the landscape plan for the area Königslutter am Elm in Lower Saxony, Germany. It has been developed to complement traditional forms of public participation (Tiedke and Warren-Kretzschmar 2003) and has been designed for non-professionals.

Besides extensive textual information, the interactive map shown in figure 19 is the core of the website. It provides a simple user interface offering layer selection, zooming and panning. The layers show aerial photos, topographic maps and information on soil, climate, etc. One extra layer holds comments from public participation. This layer shows red squares which indicate the map area the corresponding comment refers to. By activating the “select comments” tool, the user can open a list of comments by clicking inside one of the squares. By selecting one of the comments, a static map opens which shows the map extent the comment's author was viewing. This map can also contain sketches (explained below). Moreover, the comment and some more information such as date, map extent coordinates and active layers are shown. If the comment has already

been handled at the municipality, an officer's answer is shown as well.

If a citizen wants to comment on the landscape plan, he has register to with the system. The viewing functions described above are enabled without logging in, but an active participation requires an account, which can be created easily on the website. After logging in, registered users can click a button to start the module for commenting on maps. The following web page shows a small screen shot of the map and offers buttons to edit, delete, print or send the comment. The edit button starts an Applet which provides tools to sketch points, lines, polygons and free hand drawings in different colours on the map. The added graphics are numbered automatically, so that they can be referenced easily in the text of the comment, which should be entered in the box next to the map, as shown in figure 20. Clicking the overview button takes the user back to the previous page, where he can send his map to the municipality. Although this description may sound complicated, the user interface is well-structured and easy to use.

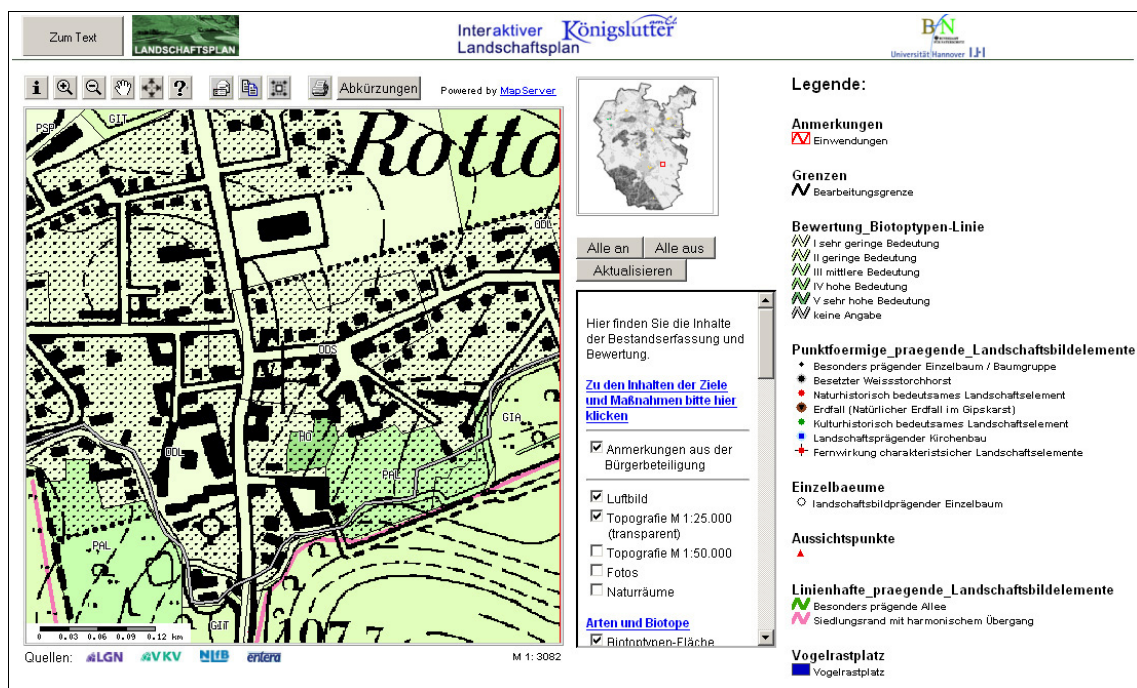


Figure 19: Screen shot of the interactive map (<http://thuja.land.uni-hannover.de/entera/mapserv.phtml>).

Technically, the system is based on a number of open source software modules. The website is generated from PHP scripts, and a content management system (CMS) has been developed to administrate textual contents. A UMN MapServer (see section 3.1.4)



is used to generate the map images. The comments are stored in a MySQL database, which can be accessed from a special query module which has been developed for the officers at the municipality. The project's initiators are planning to release the code of the system as open source, so that other municipalities can reuse it (Hachmann 2003).

The users' comments seem to be linked to the coordinates of the map area the comment refers to, whereas the users' sketches seem to be stored as images. As the sketched elements can be numbered, they can be referenced in the text, but this does not allow for spatial analyses, as the sketches are only stored as images, and not as spatial objects. However, the coordinates of the map extent the comments refer to would allow for certain analyses.

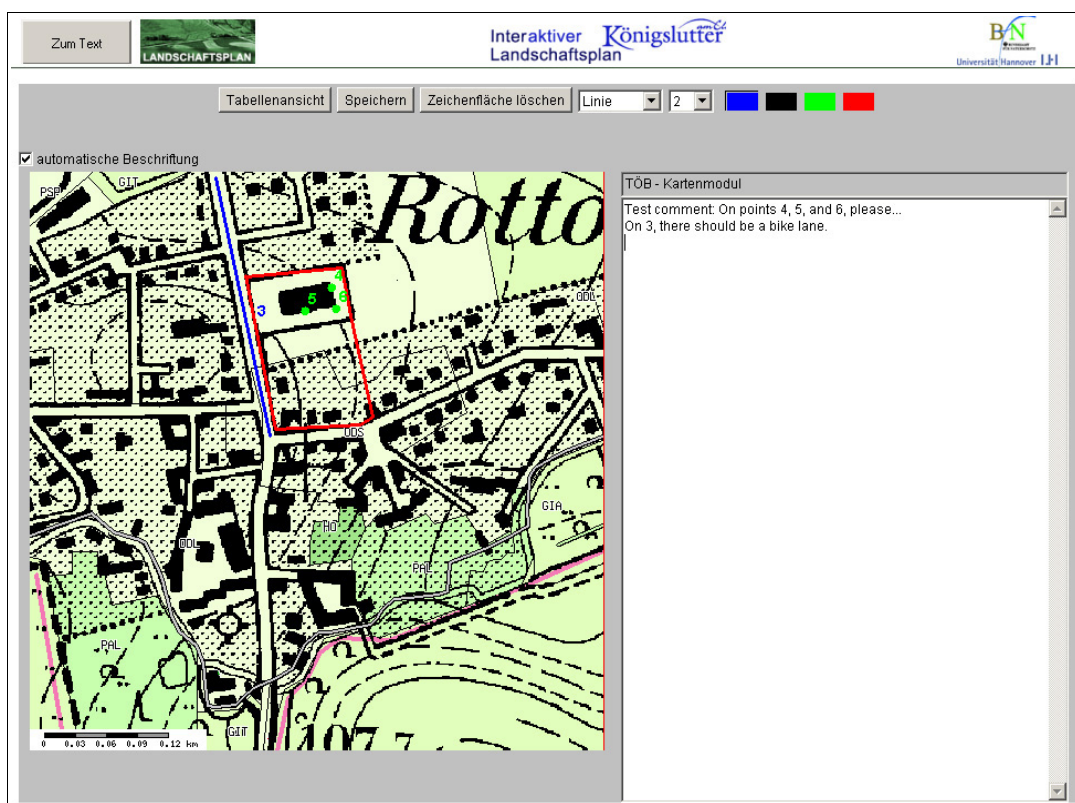


Figure 20: Screen shot of the module which allows users to add comments to the landscape plan (<http://thuja.land.uni-hannover.de/entera/mapserv.phtml>)

Although the existing structure of the web page would easily allow for an integrated discussion, this has not been realized by the authors. A user can view other users' comments and read the answers written by the municipality officers, but he cannot write answers himself. Hence, there is a flow of information between the citizens and the municipality, but there are no means of communication among citizens.

#### 4.2.4 Spatial Discourse

The Spatial Discourse prototype is developed at the Fraunhofer Institute for Autonomous Intelligent Systems in Sankt Augustin, Germany. It was developed for participatory spatial planning and decision making (Voss et al. 2004). The prototype was tested in a number of experiments in which groups were to solve spatial decision problems. The prototype is based on two components: The web-based discussion tool Dito (see the description in section 2.2.2.4 for information on the discussion structure) is used for the discussion part, and *CommonGIS* is used for the mapping part. CommonGIS (<http://www.commongis.com/>) is a GIS which focuses on interactive data exploration and spatial decision support methods. It is written in Java and can be run both as a standalone tool and as an Applet, loaded over the web. In the latter case, all data are transferred to the client machine, so that there is no map server involved. Both components are complex and powerful applications which rely upon proprietary implementations, so that they are not easily integratable into existing procedures.

The experiments mentioned above were carried out in different stages of the development of the prototype. In the first experiment, which was about finding suitable locations for testing skiing robots, Dito and CommonGIS were used as standalone tools. A first integrated version was used in the second experiment, which was about selecting locations for a new bike rental service. The third experiment was about locating UMTS transmitters in a German town, using an enhanced version of the prototype<sup>20</sup>. Beyond the versions of the prototype used in the experiments, Voss et al. (2004) present the design for the next integrated version, which is currently being developed. It will support many-to-many relationships between contributions and reference objects, as well as many-to-many relationships between maps and contexts. The latter allows for the use of the same maps for different discussions. Moreover, sophisticated kinds of analysis will be implemented, e.g. displaying different kinds of contributions with different map symbols, or temporal analyses. Creating contributions and reference objects will be flexible, so that it is possible to create either of them first and then assign the corresponding other part. Beyond that, users will be able to add annotations to existing reference objects. The only restriction will be that all of the referenced objects have to be on a special annotation layer, so that it is not possible to refer to objects on other map layers.

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<sup>20</sup> For details on the different stages of development of the Spatial Discourse prototype and on the experiments, see Voss et al. (2004).



The communication between the two tools, which are of very different nature, is the main challenge in the development of the prototype. As CommonGIS is based on an Applet, and Dito is based on HTML pages, both cannot communicate directly. Instead, data is exchanged through the server which hosts both applications. It is necessary that both reside on the same server because the CommonGIS Applet cannot access other servers because of the sand box principle (see section 3.1.3). It is not possible that the server refreshes either the map or the forum if the user makes changes in one part that cause changes in the other part, e.g. opening a contribution in Dito by clicking a reference object in CommonGIS. This is due to the use of the HTTP protocol, which does not support pushing information from the server to the client. Instead, both applications have to poll the server regularly for changes. This is realised through data pipes, which are created for every user who logs in to the server, similar to sessions.

Concerning the link between the map and the forum, the Spatial Discourse prototype uses a special table in the Dito database to store the mapping between discussion contributions and map objects. This table stores the URL to the CommonGIS Applet, the unique identifier of the reference object, and the annotation's author and creation date. These data are passed to the CommonGIS Applet to fill the annotation layer. Discussion contributions in Dito can be opened from CommonGIS by clicking an object in the annotation layer. This causes the server side data pipe to change so that Dito will be showing the according contribution after the next polling of the data pipe.

Although the authors claim that the application is easy to use, the options and numerous functions of the prototype indicate that users will need some time to find out how Dito works (see section 2.2.2.4). Moreover, CommonGIS offers far more functions than a usual web mapping application, which might be confusing for users who are not familiar with GIS. Although there have been several small case studies, there is no information in the literature on the users' comments on the system, apart from the information that the users have made many suggestions on how to improve the system (Voss et al. 2002).

#### **4.2.5 Spatial Understanding and Decision Support System**

Jankowski and Stasik (1997a) present a prototype for collaboratively solving spatial decision making problems. Their Spatial Understanding and Decision Support System (SUDSS) prototype was developed for asynchronous, telepresent (see section 1.3) scenarios. It provides the participants with tools to create and analyse problem solution

scenarios and to communicate over the web. It was designed especially for persons with no experience in GIS or spatial decision support methods, with an approach to be usable even by persons with little computer experience. Thus, the application consists of a simple top-level user interface, as shown in figure 21. Each button is tied to one of the system's modules. The top row buttons are associated with functions for collaborative work, such as expressing opinions (*Communicate*) or changing the task's constraints (*Request*), which opens a dialogue that allows the user to request additional time to solve a task (the users are given a certain period of time for each task to ensure efficient work). The middle row buttons provide functionality to work on the project and create solution alternatives (*Explore*), *Evaluate* other participants' alternatives (see figure 22 for a screen shot), and *Vote* on the different alternatives. The explore window provides the user with commentary tools to annotate maps and draw sketches. The lower row buttons provide *Help* and *Tips* of the day and *Close* the system.

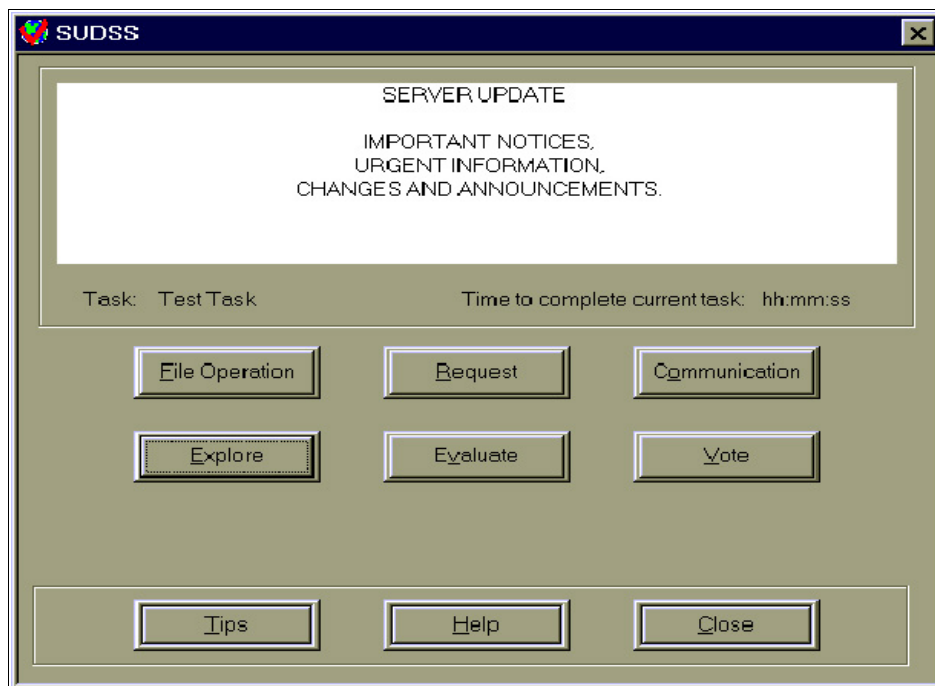


Figure 21: Screen shot of the SUDSS top level user interface (Jankowski and Stasik 1997a).

Technically, the system is based on a client server architecture, with a standalone application written for Windows operating systems on the client side. This choice has been made to be independent of web browsers and the HTTP protocol they use, to make

use of the full potential of the web with direct access to the underlying TCP/IP protocol. All data that are needed for the current task are transferred from the database on the server to the client on start up, to allow users to work independent from an Internet connection. The module for spatial analysis, which can be started by clicking the Explore button, is based on ESRI's MapObjects. Among other functions, it can be used for the pairwise comparison of different options for the solution of the given problem.

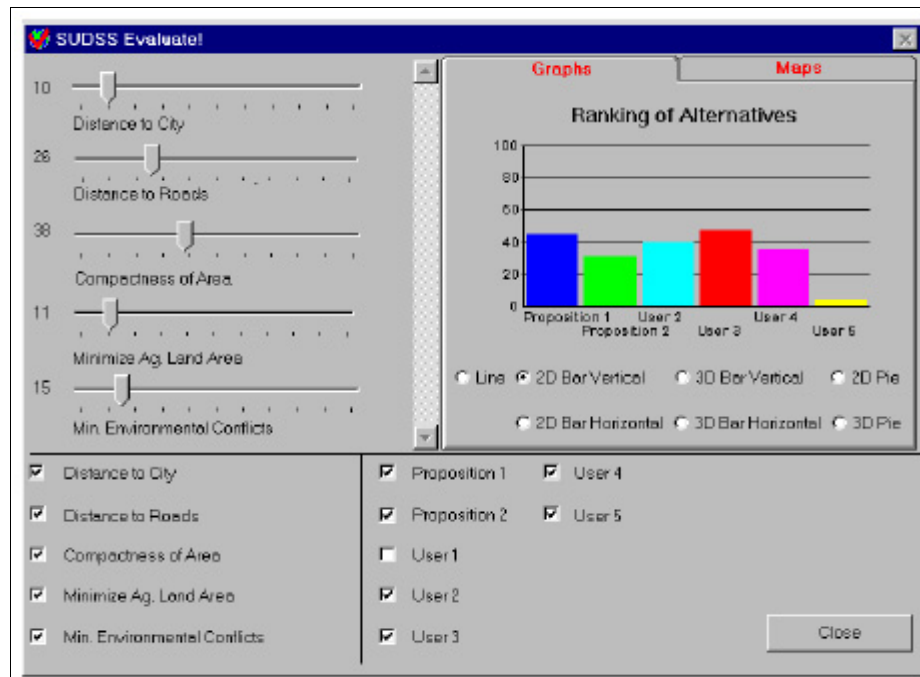


Figure 22: Screen shot of the SUDSS evaluate window from Laurini (2001).

The SUDSS prototype was tested with a group of 50 students at University of Idaho (Jankowski and Stasik 1997b). They were divided into small groups which had to go through the four steps of the experiment: data acquisition, proposal preparation, proposal rating, and voting for the alternatives. The students were given a fixed period of time for every step. Unfortunately, the results of this user test have not been documented.

## 4.3 Related Tools from Other Fields

### 4.3.1 MoMoSat

*Mobile Maps over Satellite (MoMoSat)* is a mobile, map-based system for information management in groups (Schmidt 2004). It has been designed for use in rural scenarios like mine field clearing or development aid. MoMoSat allows mobile users to augment maps with so-called *GeoNotes*, containers for digital data such as text, images or movie sequences, which are attached to map locations. Moreover, MoMoSat offers groupware functions for the synchronous and asynchronous communication among the people in a working team. As the people working in these environments are usually professionals, the tool has been designed for trained personnel.

The MoMoSat system consists of three hardware components: The primary data store, which provides maps and stores GeoNotes; a base station, which can be installed in a car or tent; and the mobile clients, which can be laptops, PDAs or tablet PCs. The base station acts as the agent between the mobile clients and the primary data store. It communicates with the primary data store via satellite connection, and with the mobile clients via Wireless Local Area Network (WLAN). All communication among the components can be encrypted. The mobile clients are equipped with Global Positioning System (GPS) devices, which allows them to locate themselves and request the corresponding maps from the base station automatically.

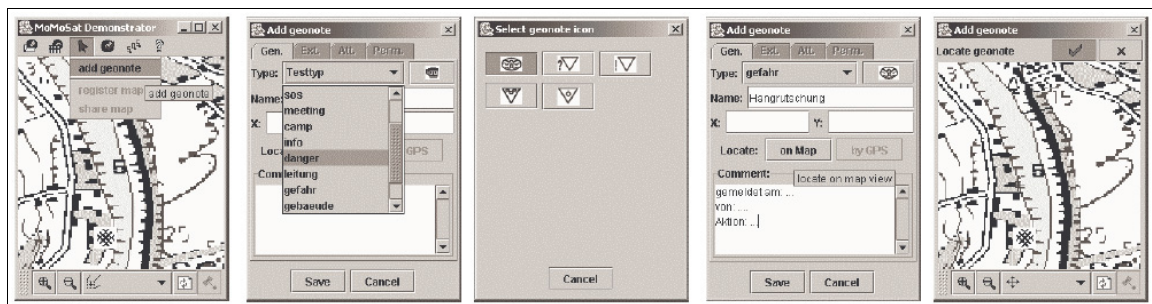


Figure 23: Work flow on a mobile MoMoSat client creating a GeoNote (Schmidt 2004).

The Maps are delivered to the clients by OGC compliant web map servers. The GeoNotes are written to the database through an OGC Simple Feature interface (OGC 2002), so that a new GML point object is created for every annotation. The management of GeoNotes is realised as a Java web service, using a SOAP/XML interface. The user management,

which is also implemented as a web service, allows for the creation of separate workspaces, so that every user can be added to a number of workspaces, which provide the maps for special projects. Thus, it is possible to run several projects on the same server. The client for PDAs is written in Java. Figure 23 shows how GeoNotes are created on a mobile client.

### 4.3.2 Map Bureau pointMapper

Map Bureau (<http://www.mapbureau.com/>) offers a new technique to augment maps on web pages with additional information, and to relate external information to map locations. The client consists of a web page with an embedded Macromedia Flash application which displays either vector maps or JPEG image maps. The application also provides basic navigation tools like panning and zooming. Moreover, it provides an application programming interface (API) which allows for the manipulation of the map with JavaScript functions. The API consists of a number of functions to load an external map, zoom to a location, add points to the map, highlight one of these points and define callback functions which are triggered when the user clicks one of the points.

Adding points can be realized in two ways: Either by defining an array in JavaScript, which is passed to the application, or by loading an external *Resource Description Framework (RDF)* file into the application. RDF files are special XML files for the representation of metadata on the web, as recommended by the World Wide Web Consortium (W3C)<sup>21</sup>. The possibility to encode spatial references in RDF files facilitates pointMapper users with the possibility to relate all kinds of web contents to map locations in a standardized way. An application of RDF are newsfeeds. With pointMapper, it is possible to relate every article in a newsfeed to a map location.

Contents on a web page can be spatially referenced by links which call functions of the API when they are clicked. This could cause highlighting of a point on the map, zooming to a special area or loading a new map. The callback functions mentioned above can be used to define what happens when the user clicks one of the points on the map. This feature can be used to display any web content related to the map point the user clicked.

The latest version of pointMapper does not support identification of map features, and annotations can only have the form of points which are bound to pairs of coordinates.

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21 The W3C is an international organization which develops standards for the World Wide Web to ensure interoperability. The website can be found at <http://www.w3.org/>; information on RDF can be found at <http://www.w3.org/RDF/>.

Moreover, it is not possible to highlight more than one point on the map at a time. Nevertheless, the idea of encoding geographic references in standardized RDF files offers great opportunities, especially for the development of semantic web content.

### **4.3.3 Ruhrtal à la Karte**

The website Ruhrtal à la Karte (<http://www.ruhrtal.de/>) provides information for tourists who want to hike or cycle in the the Ruhr valley in Germany (Kolbe et al. 2003). The page provides a map of the area with simple zooming and panning functions. Beyond that, it offers a tool which allows for the augmentation of the map with personal information. This can be used to plan bike or hiking tours among groups which communicate over the web. If this tool is activated, a click on the map opens a pop-up window, in which the user can enter a text and the URL of an image. This information is added to the map at the appropriate location. Another tool allows the user to add personal bike or hiking routes to the map by selecting start, end and intermediate points. After adding some annotations, images and / or routes, the user can send an e-mail containing a link which holds all information that is required to restore the map with all additions the user made. When the recipient clicks the link, the map is re-generated from the information encoded in the URL, and he can modify the annotations or add his own comments, which can be encoded in a new URL (which can be sent again, e.g. to answer the original e-mail).

Technically, all information which is required to reproduce a map with routes, annotations and images is encoded in the query part of the URL. Figure 24 shows the map generated from the link below. The DHTML client uses the parameters to overlay the map with the annotation texts and images, and small flag symbols for the routes. These additional map elements are placed on a separate CSS layer above the actual map image, which is retrieved from an ArcIMS map server. Every annotation is represented by a fragment in the query part of the URL, which stores the coordinates of the annotation, the text and / or the image URL. Every route is represented by a fragment consisting of a number of pairs of coordinates.

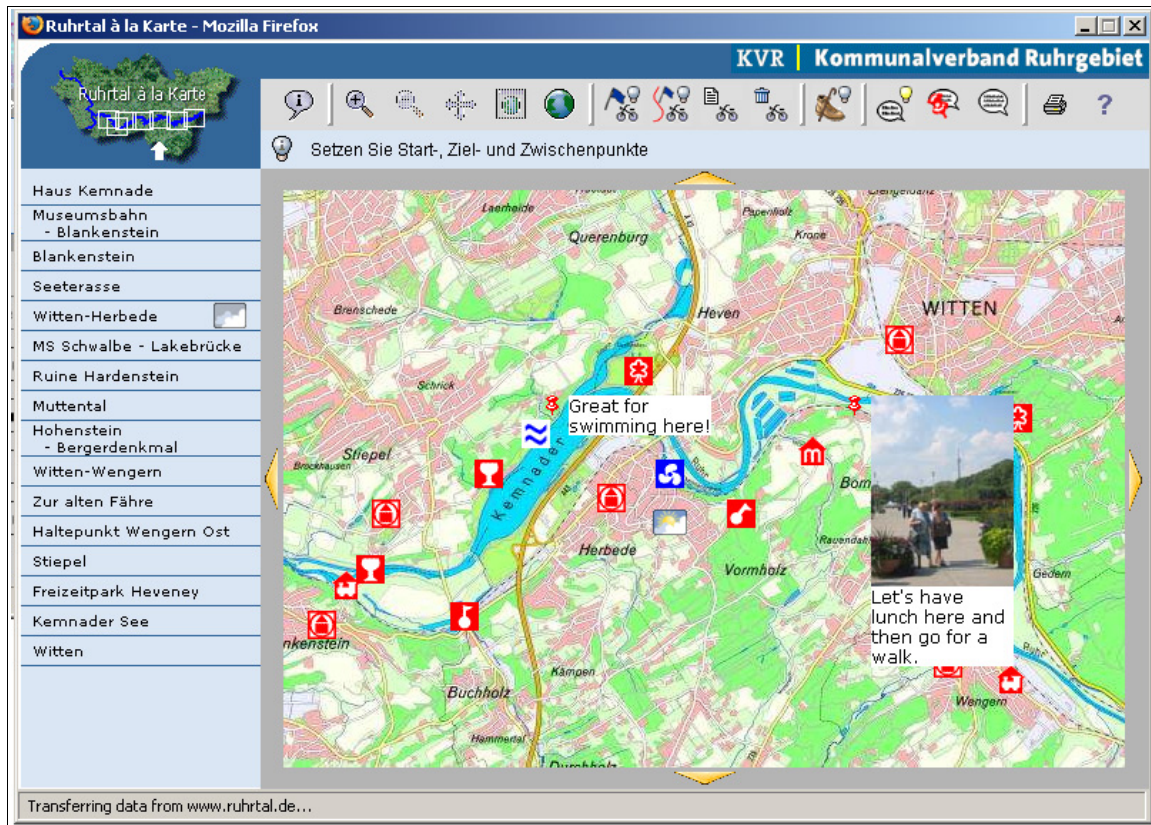


Figure 24: Screen shot from the *Ruhrtal à la Carte* website, generated from the URL [http://www.ruhrtal.de/?kNr%3D5%26anno%3D3%7C2592037%7C5700143%7CLet%27s%20have%20lunch%20here%20and%20then%20go%20for%20a%20walk.%7Chttp%3A//www.flashfonic.de/photos/2004-08-16/small/IMG\\_1186.jpg%7C100%7C%261%7C2588198%7C5700143%7CGreat%20for%20swimming%20here%21%7C100px%7C%26](http://www.ruhrtal.de/?kNr%3D5%26anno%3D3%7C2592037%7C5700143%7CLet%27s%20have%20lunch%20here%20and%20then%20go%20for%20a%20walk.%7Chttp%3A//www.flashfonic.de/photos/2004-08-16/small/IMG_1186.jpg%7C100%7C%261%7C2588198%7C5700143%7CGreat%20for%20swimming%20here%21%7C100px%7C%26)

## 4.4 Evaluation

### 4.4.1 Summary

This chapter presented a number of applications which support the exchange of spatially referenced information. This overview showed how different tools solve the problem of offering users the opportunity to create map annotations, and to store and analyse them. The only application which allows to associate map objects with comments is the Spatial Discourse prototype. It uses an approach of database storage for the annotations and references similar to the one proposed in section 3.3.3. However, this application can be considered too complicated for non-professional use, both on the forum side (Dito) and on the map side (CommonGIS). Moreover, both applications run separately, exchanging data over a server-side data pipe, which forces users to switch between two windows.



The Interactive Landscape Plan Königslutter am Elm is a good example of how users should be guided when creating spatially referenced annotations. The user feedback to this project has shown that an easy-to-use interface is crucial for the success of such a system, because frustrated users will not use the system again.

The tools presented in section 4.3 are from other fields, but they are related to the topic of augmenting maps with additional information. MoMoSat shows how map annotations can be created from mobile devices with GPS. This might be interesting in the future, when cell phones are powerful enough to run such applications, and when mobile users are permanently connected to the web. Citizens could send comments or proposals to the municipality directly from the location where they find something to report. The Map Bureau pointMapper shows how metadata on the semantic web could be spatially referenced, and the Ruhrtal à la Karte project introduces a simple way of encoding spatial references in URLs. Both of these applications require special clients, but they show options for storing and sending spatial references.

### **4.4.2 Comparison Table**

Table 2 gives an overview of the features offered by the tools described in this chapter, comparing the aspects of the analysis as listed in section 4.1. Some fields are left empty, when the literature did not contain any information on these aspects.



	<b>Virtual Slaith- waite</b>	<b>Orange County Mapping</b>	<b>Inter- active Land- scape Plan</b>	<b>Spatial Discourse</b>	<b>SUDSS</b>	<b>MoMo- Sat</b>	<b>Point- Mapper</b>	<b>Ruhrtal à la Karte</b>
<b>Purpose</b>	Public participation	Citizen information	Public participation	Participatory spatial planning	Spatial group decision support	Spatial information management in groups	Adding spatial metadata to web contents	Planning recreational activities
<b>Intended Users</b>	Lay-persons	Lay-persons	Lay-persons	Lay-persons	Lay-persons	Professionals	Lay-persons	Lay-persons
<b>Vector / Raster Maps</b>	Vector	Raster	Raster	Both		Raster	Both	Raster
<b>Map Server</b>	-	ESRI ArcIMS	UMN Map-Server	-	-	WMS	-	WMS
<b>Discussion Support</b>	No	No	No	Yes	Yes	No	No	No <sup>1)</sup>
<b>Discussion Structure</b>	-	-	-	Flexible		-	-	-
<b>Map Annotations referenced by</b>	Map features and coordinates	Images containing map and annotations	Coordinates	Map features		Map features	Coordinates	Coordinates
<b>Standards used</b>	-	-	-	-	-	WMS, WFS	RDF	WMS
<b>Adoptable to other use cases<sup>3)</sup></b>	No	No	Yes	Yes	Yes	Yes	Yes	Yes
<b>Analysis Functions</b>	Map feature identification	Map feature identification; distance and area measurement; search for map features	Viewing other citizens comments and sketches	Various powerful GIS functions (e.g. interactive visual analysis tools)			-	- <sup>2)</sup>
<b>User Interface</b>	Applet	DHTML page	DHTML and Applet <sup>4)</sup>	Applet (for the map) and DHTML page (for the forum)	Stand-alone application	Different clients available, depending on the kind of device	Flash	DHTML page

Table 2: Comparison table for the aspects of the different tools analyzed in this chapter.

*Notes:* 1) No open discussion, just exchange of links to annotated maps via e-mail. Links can also be used in newsgroups or discussion boards, but the tool itself does not support discussions.  
2) When the tool is showing a map which has been generated dynamically from a link, the user can view annotations and routes created by the sender; no analysis functions for geodata.  
3) Generally, all tools can be adapted to other use cases. This field indicates whether they have been designed with adaptability to other use cases in mind.  
4) The Applet opens when the user wants to comment on the map.

### 4.4.3 Relevant Concepts for the Prototype

The solution which comes closest to the approach of the hypothesis is Spatial Discourse, but it consists of two applications which have been connected, so that the users have to switch between two windows. Moreover, Spatial Discourse consists of two advanced tools which can be assumed to be far too complicated for non-professional, untrained users.

Hence, the prototype should basically provide a trimmed-down version of the program, with an integrated user interface. The user interface of the interactive landscape plan presented in section 4.2.3 gives an example of an interface specifically designed for lay persons. It is very well structured and offers only basic functions, which allows for a quick orientation of novice users. Thus, it can be used as a model for the design of the prototype's user interface. Moreover, the prototype should also offer numbered sketches, because they allow users to easily refer to the graphic objects they have created.

The Ruhrtal website introduces a tool which allows users to augment maps from remote web servers with additional content such as images. This feature should be adopted for the prototype as well. Ideally, the tool should also allow users to use data which is not already available on the web, but resides on the client computer. In this case, the user would have to upload the data to the server, so that other users can access it. Another feature that should be adopted from the Ruhrtal website is the tool which allows users to add URLs to the map. It allows for quick references to data which cannot be shown on a map, such as websites or PDF documents.

The online voting tool introduced in the SUDSS prototype might be beneficial, as well. It allows content providers to conduct surveys in use cases where different options have been developed; for example in the Osnabrück scenario, there might be different options for re-designing the Neumarkt, and a survey could show which one is preferred by the citizens.

## 5 Requirements of the Prototype

This chapter presents the requirements of the different parts of the prototype which are derived from the theoretical background presented in chapter 2 and from the review of existing applications in chapter 4. This leads to a detailed system specification based on the hypothesis (section 1.4). The requirements are described from the user's perspective, as independent of technical issues as possible. The first section deals with requirements related to the discussion part of the prototype. The second section outlines requirements of the mapping component. The third section presents requirements concerning analysis and query functions, both for users and for content providers. The fourth section describes how the user interface should be designed to offer an intuitive work flow for inexperienced users. The fifth section deals with requirements related to interoperability, which necessarily includes technical aspects and describes content providers' requirements for an easy integration into existing spatial data infrastructures. Section six completes this chapter with a conclusion.

### 5.1 Discussion

The discussion structure used for the prototype must be easy to understand, but meaningful at the same time, because complex, powerful argumentative models such as IBIS or TBL are judged to be too complicated for use without prior instructions, as explained in chapter 2. Known structures allow users to familiarize themselves with the new tool very quickly. A structure that is ubiquitous in the work with computers is the tree structure. It is not only used for newsgroup discussions, as presented in section 2.2.2.1, but also for the display of file systems or web site navigation bars, so that even users with little computer experience know this structure. Beyond that, it offers a good overview of the course of discussion. From a conceptual point of view, this structure is not the perfect solution, since it does not allow for many-to-many relationships between contributions. Every contribution can only refer to at most one of the other contributions. But a structure which supports many-to-many relationships certainly asks too much of lay persons, as it requires the introduction of a special graphical representation, similar to gIBIS or Compendium (see section 2.2.2.3), which is hard to use without prior instruction.

A labelling mechanism, similar to the ones used for more enhanced discussion structures such as gIBIS, should be introduced to augment the messages with additional information. An easy-to-understand set of labels marking contributions as *question*, *suggestion*, *pro*, *contra*, or *neutral* should be offered. This offers a simplified subset of the advanced label types of gIBIS, which is less flexible, but much easier to understand. These labels help authors to clearly mark their contributions, but they require no special introduction. Readers can grasp the main attitude of a contribution at first glance and get an overview of the types of reactions to a topic. Beyond the categorizing labels, simple formatting options for the contributions' texts should be provided, so that users can format text as bold, italic, underlined and so forth. These formatting options allow users to emphasize the main points in their statements.

Apart from the requirements concerning the discussion structure and functions available for the users, security issues are crucial for a future application of the prototype in real use-cases. This might be especially important for participatory planning scenarios, where stakeholders might have an interest to manipulate a discussion. Hence, the prototype should provide basic security mechanisms which support the identification of participants. Moreover, the system should be designed in a way that does not allow for a manipulation of the discussion by unauthorized persons, e.g. by breaking into the backend data base to delete discussion contributions.

## 5.2 Map Functions

The following functions which provide users with the basic means of map navigation have been extracted from a cross section of the functions provided by the Internet GIS clients presented in Peng and Tsou (2003), and from popular web mapping services such as MapQuest or Map24<sup>22</sup>. The map displaying the subject of the discussion should provide only the basic navigation tools, “zooming” and “panning”, to avoid irritating novice users with too many options to choose from. A tool which zooms out to the full map extent is helpful, too. Besides these navigation tools, it is useful to be able to switch layers on and off, so that the user can concentrate on those layers he is interested in.

Labels should be used to support users in identifying real world objects on the map. This can assist users who are not very familiar with maps in finding the places they are

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<sup>22</sup> MapQuest can be found at <http://www.mapquest.com>; Map24 can be found at <http://www.map24.com>.

looking for. As too many labels on the map can be irritating, it is desirable to have pop-up labels which appear when the user places the mouse pointer over a map feature for a certain period of time, e.g. one second. This mechanism can also be used to provide information on author and title when pointing to a spatial reference for a discussion contribution.

### **5.3 Query and Analysis Options**

The prototype implementation should allow both users and content providers to query the discussion for contributions which match certain criteria. This should include all attributes of a contribution (author, title, body text, label, date), as well as its spatial references. A search tool which integrates these two kinds of information on a contribution would allow for combined spatial-thematic queries. Thus, a query like “Find all contributions which were written during the last week, which are labelled as contra arguments, and which refer to the planned location of the bus terminal” would allow users and content providers to find the specific contributions quickly, even if the discussion consists of a large number of contributions.

A simple selection tool should allow users to highlight all contributions that refer to an object or area on the map. This would allow for a quick overview of all contributions which refer to a certain object or area. Moreover, a statistics tool would be useful, which summarizes all information on a selected map object or area. This would allow for an overview of the number of contributions associated with the object (or area), their predominant labels, and the time period in which they were written. These statistics could especially be useful for content providers, as they enable them to easily see which objects or areas are the most contested ones.

Beyond these spatial-thematic query tools, users should be able to highlight spatial references by simply clicking a contribution. Starting from the map side, clicking an object should highlight all corresponding contributions. This allows for an easy-to-use interactive exploration of the discussion and its spatial references. This method of interactively highlighting map features and corresponding data outside of the map is adopted from current GIS such as ArcGIS.

## 5.4 User Interface and Work Flow

A general consideration has been mentioned several times throughout the previous chapters: The prototype should offer an integrated user interface which hosts both the map and the discussion. This solution provides a far more user friendly design than split solutions, which force the user to switch between two windows permanently. To make full use of the integrated user interface, it must present both parts next to each other, so that the user has an overview both of the map and the discussion. The prototype should allow for dynamic adjustment of the size of both components, so that users can increase one component's size to focus on it (while the other one's size is automatically decreased).

The discussion part of the user interface should be organized similar to newsreaders and e-mail clients, because adopting a known structure allows for a quick orientation for new users. The common design of a newsreader consists of an “overview” area showing the tree of contributions, and a “message” area below which shows a selected contribution's text and some additional information (title, author, date). This design should be adopted, with a special focus on details such as marking unread contributions, which is usually indicated by a title written in bold letters. Moreover, the node in the discussion tree which is associated with the contribution that is currently displayed in the “message” area should be highlighted in the overview area.

The map part of the user interface should be limited to a map with basic navigation tools as described in section 5.2. A scale bar can be useful to give users an idea of the real-world distances shown on the map; information on map objects should be displayed in tool tips. The option to switch different map layers on and off becomes more important with an increasing number of layers. This function can be realized through check boxes, which indicate which layers are currently shown, and which are hidden. It can also serve as a basic legend, showing the colour and symbol of the corresponding layer next to the check boxes. As layer management is not needed throughout the work with the map, there should be an option to hide it, because it occupies a rather large part of the screen.

The same requirement applies for the query tool, which should allow for simple full text searches as well as advanced searches. While the former should allow users to simply “scan” all contributions for certain key words, the latter should be designed in a way that guides users when defining the properties of the messages they are looking for. This

should be realized in a way similar to the search dialogue of the e-mail client Mozilla Thunderbird, as shown in figure 25. It is easy to use, but provides a powerful means of defining advanced search criteria. The statistics tool, as described in section 5.3, should work without user interaction. If it is visible, it should update automatically once the user's selection of map features changes, and show information on the labelling, dates, etc. of the selected features.

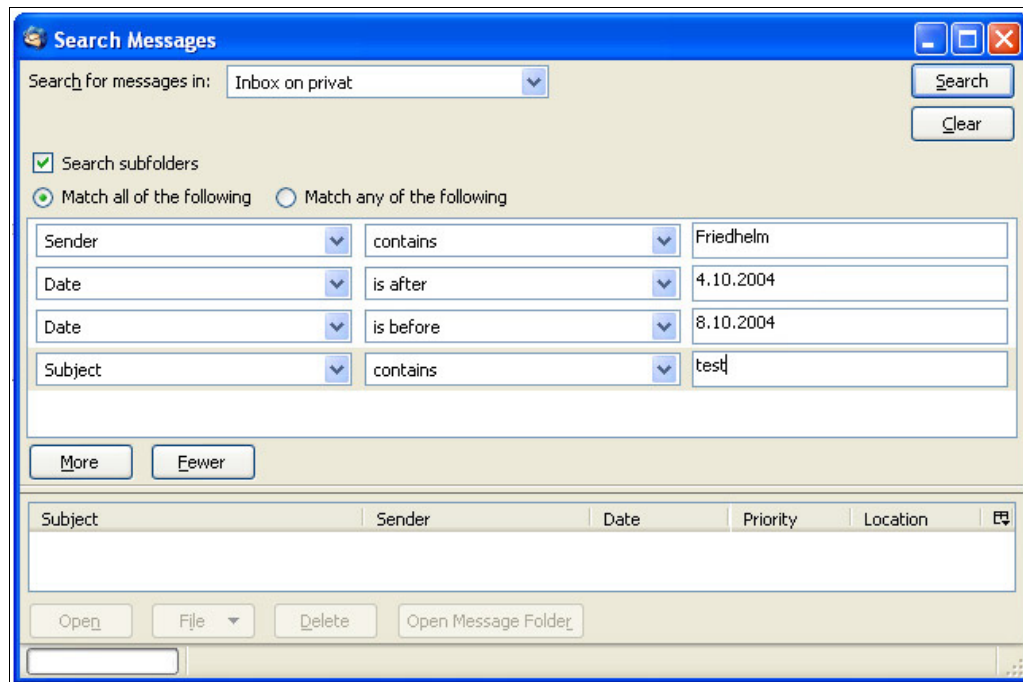


Figure 25: Screen shot of Mozilla Thunderbird search dialogue.

The work flow when creating a new spatially referenced discussion contribution is the crucial point in the design of this prototype. Generally, the work flow should be flexible, leaving it up to the user whether to start from the discussion side (write the contribution first, and add spatial references in a second step) or from the map side (select spatial references first, and then write the contribution). This was formulated as a requirement for the Spatial Discourse prototype by Voss et al. (2004). In an ideal case, it should be possible to edit both the contribution and the spatial references independent of any operation order until the contribution has been sent. The final submission step “fixes” the contribution and stores it permanently, so that the author cannot edit it any longer. Editing or deleting contributions after they have been sent should not be possible as this would lead to inconsistencies in the discussion structure, e.g. when a contribution which

has been answered is deleted, or when the statement of a contribution is changed, so that answering contributions do not make sense any longer.

Concerning spatial references, it should be possible to select existing map features, as well as to create new graphic features, which serve exclusively as spatial references and have no further meaning to the map. For this purpose, the map needs two more tools which allow users to select existing map features and to create new map features. In both cases, the map features selected or created should be highlighted in a special way, so that the user recognizes which features are referenced by the contribution he is currently working on. The colour for highlighted features should be adjustable by the user to guarantee that highlighted features can be clearly recognized, independent of the other colours used in the map. The “create” tool should allow users to create points, polylines and polygons. It must be noted that these added features must *not* alter the underlying geodata, but they must be stored with the contributions, as outlined in section 3.3.3.

Peng (2001) states that a proper system design and a friendly user interface are essential for a system targeted to the general public, as opposed to systems for professionals. Users should be provided with an intuitive work flow and context sensitive help, so that they receive additional information in case they do not know what to do next. An especially beneficial form of information are tool tips which appear when the user places the mouse pointer over buttons or other control elements; they should provide information free of technical jargon which can be understood by everyone (Jankowski and Stasik 1997a).

## 5.5 Interoperability

In the course of this work, there has been a special focus on the use of existing geospatial information technology standards. This should be reflected in the prototype implementation. Moreover, the prototype should be designed in a way which allows for easy adaption to other use cases than the Osnabrück scenario chosen for this thesis. Using the tool for other scenarios in spatial planning, or from other fields requiring computer support for spatially related discussions, demands an exchange of the underlying geodata. Thus, it should be as easy as possible to integrate existing geodata into the client, or to integrate the prototype into existing spatial data infrastructures.

This goal can be reached by adding support for geodata standards and commonly used file formats. The predominant standard for the exchange of maps on the web is the OGC



WMS standard, as presented in section 3.1.4. As many municipalities and non-governmental organisations (NGOs) already use this standard, it is important for the prototype to support the retrieval of maps from WMS. With this feature, existing map servers can be integrated, and the effort for the set-up of the tool decreases. Moreover, this enables the tool to integrate spatial data from more than one source, using cascading WMSs. Moreover, support of other OGC services such as the Web Feature Service (OGC 2002), which delivers GML-encoded vector data, would be desirable, to achieve the best possible adaptability of the prototype.

Support for the display of different file types which are used for maps should be at hand to enable content providers to integrate data that are not available through any of the services mentioned above. This includes both vector and raster files, so that the prototype should support GIS data formats, but also geo-referenced image files such as JPG, TIFF or PNG files. This mechanism allows content providers to overlay the current state of an area, which is in many cases available through WMS (or at least through geo-referenced static images), with planned objects, which can be stored in GIS vector files.

Besides interoperability issues related to the retrieval of geodata, the client should be designed in a way which allows for the translation into other languages. In an ideal case, this should be realized through external language files, which are used to fill the buttons, labels, etc., with text in the local language. This feature would make the tool applicable globally, independent of language barriers.

## **5.6 Conclusion**

The design of the prototype should be focussed on the usability for non-professionals. Thus, an intuitive and self-explanatory user interface is especially important. To familiarize novice users with the tool as fast as possible, it should adopt common designs for the map and for the discussion components. The number of functions should be reduced to a minimum, to avoid confusing users with too many options to choose from. Concerning interoperability, the tool should support existing GIS standards such as OGC WMS and allow for the integration of vector and raster file formats for data which are not available through web services. The externalization of strings to configuration files would facilitate the translation of the tool into other languages .

## 6 Prototype Implementation

This chapter presents the prototype implementation developed in the course of this thesis. The focus is on the technical realization of the features proposed in chapter 5, with explanations of design decisions for or against different implementation options. The first section gives a rough overview of the system architecture, presenting the main building blocks and their interaction. The second section presents the implementation of the forum used for the prototype. The third section presents the map implementation. The fourth section describes how both parts have been integrated and how the conceptual link between map objects and discussion contributions has been implemented. The last section briefly summarizes the chapter.

### 6.1 Architecture Overview

The prototype is completely implemented in Java, using an Applet on the client side and a number of *Servlets* on the server side. Servlets are Java programs that are executed by the server upon HTTP requests from clients. They are run inside a Servlet *container*, for which Apache Tomcat<sup>23</sup> has been used. The prototype Servlets are used for two purposes: They retrieve maps from OGC WMSs, and they provide an interface which allows the client to communicate with the back end database. Without the Servlets, the Applet could not access remote WMSs due to the Sand Box it is running in (see section 3.1.3)<sup>24</sup>. Moreover, this necessity leads to a thinner client, as parts of the functionality remain on the server, so that the client can be loaded faster. Concerning security, the database can be set up in a way that does not allow access from remote machines, and all communication is handled by the Servlets, which run on the same machine. Thus, it is not possible to manipulate the database over the Web, which would be possible if the Applet would access the database directly, as this would require the database to accept requests from remote hosts. Hence, the Servlets used for the prototype allow for a faster loading and more secure solution.

Figure 26 gives an overview of the main components of the prototype. The client consists of an Applet, while the server hosts the Servlet container, as well as the database. For the

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<sup>23</sup> Apache Tomcat can be obtained free of charge from <http://jakarta.apache.org/tomcat/>.

<sup>24</sup> As an alternative, a digital certificate which must be accepted by the user would allow the Applet to access remote web servers. However, it must be kept in mind that not every user will trust the authors of the Applet and accept the certificate - those users would not be able to use the prototype.

prototype, a MySQL database was used. There are two groups of Servlets: The first group is in charge of managing map retrieval from remote WMSs, providing functions to select the map size, extent and layers (for details, see section 3.1.4). The second group provides access to the back end database, with special Servlets which query the database for datasets matching given criteria, and Servlets writing new datasets to the database. The different functionalities have been distributed to different Servlets to facilitate maintenance. All communication between the server and the client, and accordingly the server and the WMSs, is handled by standard HTTP requests, therefore no special socket connections are required.

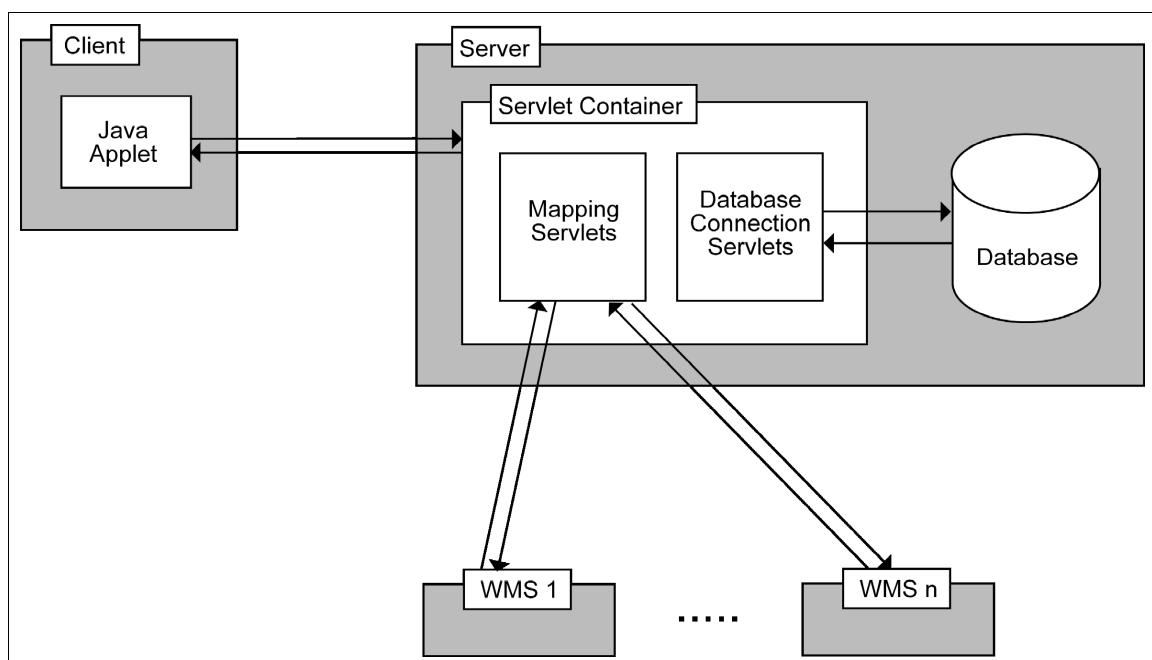


Figure 26: Overview of the main components of the prototype.

## 6.2 Forum

### 6.2.1 User Interface

Conceptually, the forum part of the prototype is organized as a tree structure, as explained in chapter 5.1. This organisation has been mapped to the user interface, which has been designed similar to newsreaders and e-mail clients. Figure 27 shows a screen shot of the user interface section covered by the forum, which consists of an overview of the discussion tree in the top frame, and the full text of the contribution which is

currently selected in the bottom frame. The discussion tree displays an icon for every contribution which specifies its type. The type can be a question, suggestion, pro, contra or neutral, as explained in section 5.1. A small arrow pointing down in the bottom right corner of the icon indicates that a contribution has follow-up contributions, which can be expanded by double-clicking the contribution's title. This simple interface structure allows users to get an overview of the discussion, and quickly access the full text of contributions they are interested in. In the current version, the discussion can be read by everyone, without logging in. Active participation requires users to login with their e-mail address and password, which can be entered on the form shown in figure 28. This panel is reached by clicking the login button on top of the discussion tree (see figure 27), which serves as a logout button, once the user has logged in. The account which is required to login can be created by new users by filling in the form shown in figure 29; it is reached by clicking the bottom button on the login interface (see figure 28). Logged-in users can answer existing contributions or start discussion threads on a new topic by clicking the corresponding button at the bottom of figure 27. This opens the interface shown in figure 30. The interface allows users to enter a title and a message for their contribution. If they answer an existing contribution, the form fields hold this contribution's title and message, so that they can be edited by the answer's author, e.g. to refer to specific citations. Moreover, the user can choose the contribution's type, which will be indicated by the labels mentioned above, once it is inserted into the discussion tree. When a user sends his new contribution, it is sent to the server and written to the database. The discussion tree is updated, and the interface showing the discussion is presented to the user again.

Discussion | Map Layers | Search and Analyze

Log in to discuss: Log in...

Title	Author	Date
why shopping centre?	Carsten Keßler	11-22, 2004 10:22
Re: why shopping centre?	Lisa Stratmann	11-24, 2004 20:11
do you really think so??	Jürgen Witte	11-25, 2004 22:40
Bad for Small Shops	Julia Meissner	11-25, 2004 08:13
Shopping centre pushes economy	Friedhelm Bäcker	11-24, 2004 19:25
Refurbish pedestrian tunnel	Bernd Schumann	11-25, 2004 18:42

☐ Reload author's map configuration

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Jürgen Witte (juergen@witte.de)  
November 25, 2004 22:40

All the big car-parks are on the other side of the Neumarkt, so people simply don't pass the shops on Johannisstrasse because they will enter the shopping centre from the other side.

Answer Start new thread

Figure 27: Forum component of the prototype.

Discussion | Map Layers | Search and Analyze

Log in to discuss: Log out

E-mail:

Password:

Login

No account yet? Create new account

Figure 28: The prototype's login interface.

Discussion | Map Layers | Search and Analyze

Log in to discuss: Log out

First name:

Last name:

E-mail address:

Password:

Confirm password:

Create new account

Figure 29: Interface to create a new user account.

Figure 30: Interface for writing new discussion contributions.

### 6.2.2 Database Design and Communication

The tree structure has not only been mapped to the user interface, but also to the database which serves as a persistent storage for the discussion. Every discussion contribution has an unique ID, which is used by subsequent contributions which give answers to this contribution. They store the ID as a reference to their parent node in the discussion tree, so that the tree structure is mapped to the database. Contributions which start a new thread and thus have no contribution they answer are marked with a “0” in the “answers” field shown in figure 31. It shows the database tables related to the discussion<sup>25</sup>, storing data on registered members, on the contributions which make up the discussion, and on available contribution types. The tables are linked via the member IDs and contribution type IDs, which are used to identify a contribution's author and its type.

Communication between the user interface and the database is realized through Servlets, as sketched in section 6.1. When the discussion tree is loaded, a Servlet is called via HTTP request which returns a string containing the list of contributions, which is decomposed by the Applet, creating the contribution objects from the data in the string to

<sup>25</sup> This refers to the tables which serve *exclusively* for the discussion; the complete database design, containing the spatial references for the discussion contributions will be presented in section 6.4.

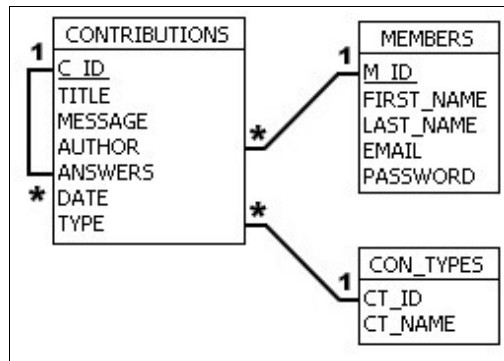


Figure 31: Database tables storing the discussion contributions, registered users and contribution types.

build the tree. The procedure to check a combination of e-mail address and password when a user tries to log in is similar. Operations which write new contents to the database turn the procedure around: They encode the information which has to be written to the database in the parameters of the HTTP request when calling the appropriate Servlet. The Servlet uses these data to create the SQL<sup>26</sup> statement which enters the data to the database. Before the Servlet is called, the Applet executes a pre-verification of the entered data, e.g. whether all required fields have been filled in. If this is not the case, the user is prompted to do so.

## 6.3 Map

### 6.3.1 User Interface

The user interface for the map part of the prototype is shown in figure 32. It offers functions to zoom into the map by dragging a box around the zoom area, and to pan or reset it so that it shows the whole map extent. Moreover, it offers two tools, which serve for the integration of map and discussion, and will be described in section 5.3. The tools are activated by clicking the corresponding buttons on top of the map, which show symbols for each tool and a short description as a tool tip when the user moves the mouse pointer over it. A scale bar next to the tools helps users estimating the real world distances shown on the map. It updates automatically upon every change of the map scale. The right hand side of the screen shot shows the panel for layer selection, which allows users to switch all map layers on and off.

<sup>26</sup> The Structured Query Language (SQL) is a “standardized method for accessing and manipulating data in a relational database” (Kline 2000, p.1).

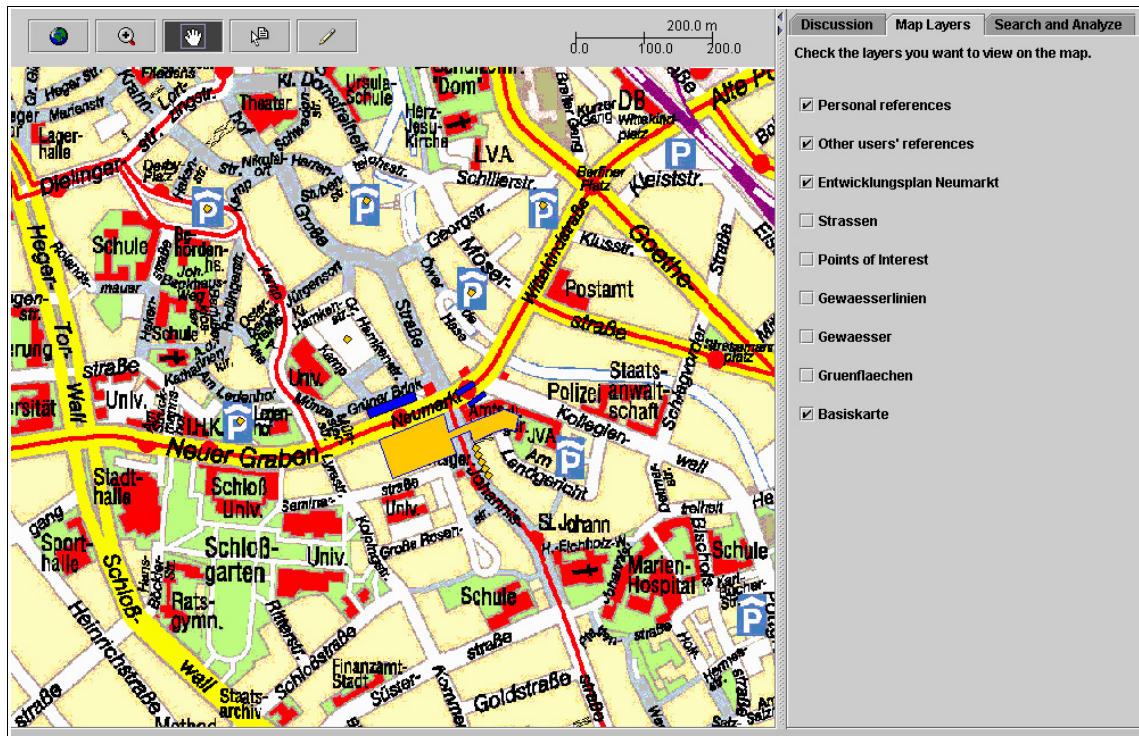


Figure 32: Screen shot of the prototype's map component.

### 6.3.2 Client Side Functionality

The map itself is composed of a number of layers, which are retrieved from three different sources: The top layers display spatial reference objects created by users, which are loaded from the database or created by the user who is currently logged in. Below these layers, there is a layer which can display a shapefile, which is loaded from the server. In the current version, only a single shapefile is supported, because multiple shapefiles would entail problems in the selection of map objects as spatial references. The background map is retrieved from a mapping Servlet, which in turn loads its layers from a number of WMSs, as described in the following section. The shapefile and the WMS map have to be referenced in the same spatial reference system (SRS). As the spatial reference objects are created by the Applet, the same SRS is used for them.

Although the layers derive from different sources, this is transparent for the user, as the layer selection works in the same way for all layers. This is realized through a Servlet which lists all WMS layers currently available, and another one which allows for switching those layers on and off (for details, see the following section).

The combination of a shapefile on a background WMS map enables content providers to overlay a map of the current state of an area, which is in many cases already available on WMSs, with a map of planned objects, stored in a shapefile. The map objects loaded



from the shapefile can be augmented with tool tips showing additional information which is read from the shapefile attribute table, e.g. the name of a street. A parameter on the HTML page which embeds the Applet controls which data are shown in the tool tips, so that this can easily be adopted by content providers.

### 6.3.3 Server Side Functionality

The mapping Servlets shown in figure 26 are based on the *Web Map Client Core*, which has been developed at the Institute for Geoinformatics in Münster, Germany<sup>27</sup>. It is a server-side OGC compliant WMS client which is capable of loading and storing OGC Web Map Context (WMC) Documents, as described in section 3.3.4. Its main function is to collect the map layers from remote WMSs, overlay them, and deliver them to the client-side Applet. An initial WMC Document specifies the layers and extent of the map which is shown in the client on start up. This initial context file allows content providers to control which layers from which WMSs will be passed to the client Applet when it is loaded. Technically, loading the initial context starts a session associated with the client, which is modified every time the user changes the map scale or layers. This modified session context is stored when a new contribution is sent, so that readers of the contribution can reconstruct the map as it was when the author wrote his contribution.

The session holding the current state of the map is manipulated through Servlets, which allow clients to change map extent and layers through specified parameters in the HTTP requests. Other Servlets allow clients to query the current state of the map, e.g. its extent or the list of layers. This information is used to update the client when a stored WMC Document has been loaded, so that the Applet's map viewer can be adopted to the new map extent. This is necessary to zoom the map layers which are not loaded from the Web Map Client Core to the same extent. The most important Servlet is responsible for generating the map and passing it to the client; it is usually called by the client after every change in the context, to retrieve the changed map.

Reading and writing WMC Documents is handled by a XML parser which generates Java objects from the documents, mapping the WMC Document tree structure to a Java object hierarchy (*unmarshaling*). This object hierarchy is part of the client's session, so that it is generated for every client that is currently working with the Web Map Client Core. All operations changing the context which are invoked by the Servlets are carried out on this

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27 The Web Map Client Core is currently used in the Balance project (<http://www.balance-eu.info/>).

object hierarchy, rather than directly on the WMC Document. When a context is stored, the objects are parsed into a WMC Document again (*marshaling*). Figure 33 shows the life cycle of an object hierarchy representing a map context. The Servlet which loads a modified context into the session is not shown in this figure. The procedure is similar to the one sketched in the figure, except for the fact that the session is already existing and its context object hierarchy is replaced by the one unmarshaled from the loaded WMC Document. Moreover, the map retrieval from remote WMSs is not shown. It is invoked by the getMap Servlet, which returns the map to the client.

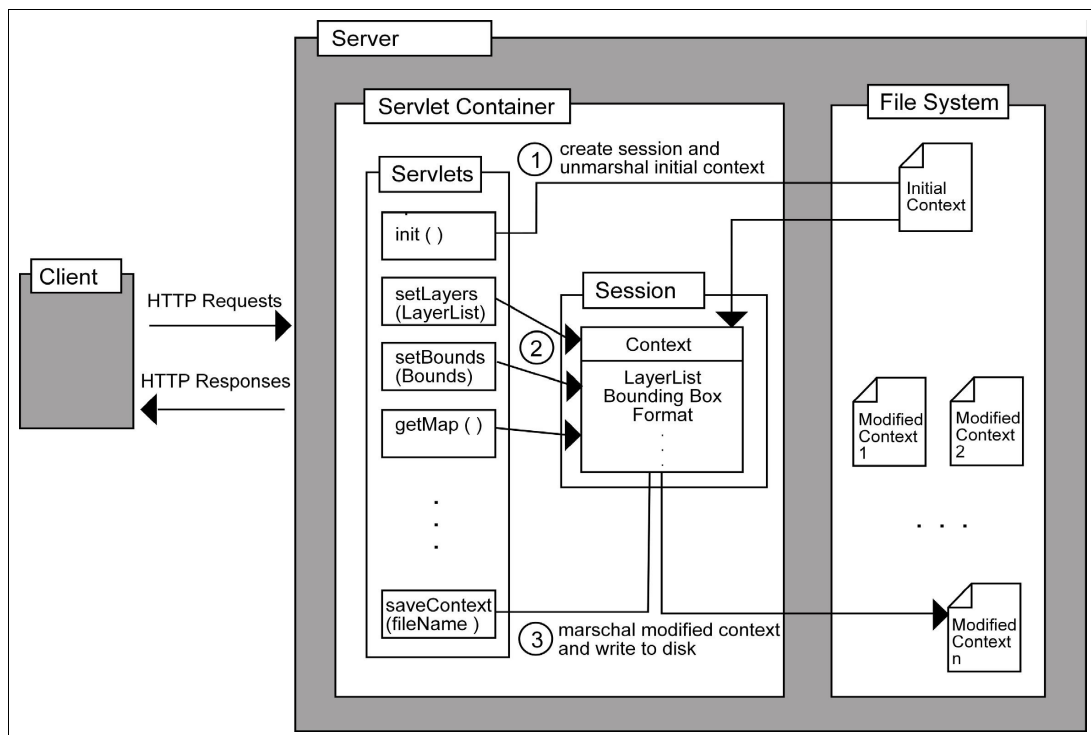


Figure 33: Life cycle of a web map context. For every client, a session containing the context object hierarchy unmarshaled from the initial WMC Document is created (1). All modifying operations invoked by the Servlets are carried out on this object hierarchy (2), which can be marshaled into a WMC Document again for persistent storage (3).

Beyond the maps produced by the Web Map Client Core, the server also delivers the spatial reference objects from the database to the client. Figure 34 shows the database tables which store the reference objects. The Locations table contains a location's ID, its type, a start coordinate and an end coordinate. The type field is related to the *Geo\_Types* table, which holds three types of spatial objects, and their IDs: points, lines and polygons. Both the start and end coordinate fields are related to the Coordinates table, which holds an ID, a x- and a y-coordinate in every dataset, representing one point. As the start- and

end-coordinates in the locations table refer to coordinate IDs, it is possible to assign a block of coordinates to one location (e.g. a location of type polygon with start coordinate 31 and end coordinate 36 represents a polygon consisting of six points). For locations of type point, the end coordinate field is left empty.

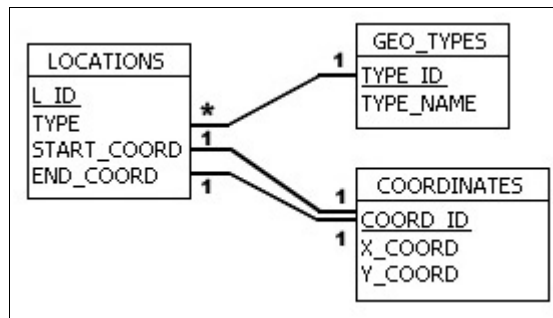


Figure 34: Database schema for the tables storing spatial reference objects.

When a location is inserted into the database as a reference for a new contribution, duplicate identical entries are avoided by comparing the new location to the existing locations. If a location with exactly the same coordinates is already present in the database, its ID is used for referencing; otherwise, a new location is created, and the new ID is used for referencing. The coordinates of a new spatial reference object are calculated from the corresponding screen coordinates by the Applet.

## 6.4 Linking Map and Forum

The previous sections presented the two building blocks of the prototype – the map and the forum – separately. This section presents the integration of these parts, both from the user's point of view and from a technical point of view.

### 6.4.1 User Interface Functions

#### 6.4.1.1 Exploring the Discussion

The prototype offers a number of functions which support users in quickly grasping the connections between discussion contributions and spatial reference objects. The exploration of a discussion can be started both from the map and from the discussion tree. On the map, objects which are referenced by contributions are augmented with tool tips showing the title of the referencing contribution. If more than one contribution refers to a map object, the number of referencing contributions is displayed in the tool tip when the

user moves the mouse pointer over it. Users can access the referencing contributions by using the “Select Contributions by Reference” tool, which is offered in the tool bar hosting the map tools, as shown in figure 35. Clicking a spatial reference objects on the map causes the discussion tree to mark all contributions which reference this object. If only one contribution is referencing this object, its message and additional information are automatically shown, and all referenced map objects are highlighted.



*Figure 35: The map tool bar, showing tool tips with short descriptions of the tools when the user moves the mouse pointer over them.*

Users who want to explore the current state of the discussion from the discussion tree are also offered an interactive connection between the map and the forum. Clicking a contribution in the discussion tree automatically highlights all spatial reference objects associated with it when its message text and additional information are loaded. Thus, users can get a quick overview of the map objects a contribution references. Optionally, users can check the “Reload author's map configuration” check box. This will cause the Applet to reload the map as it was when the author wrote his contribution. This has been realized by storing a WMC Document for each contribution.

The tools in the “search and analyse” tab shown in figure 36 allow for a more detailed analysis of the discussion. The search component provides a simple full text search. The set of results can be reduced to contributions with references on the map extent which is currently showing, which allows for simple combined spatial-argumentative queries. The contributions matching the search term entered by the user are highlighted in the discussion tree. The statistics component shows information on the map features which are currently highlighted on the map. When the user moves the mouse pointer over a map feature, or when a number of map features are highlighted because the user has selected a contribution, statistics on the types of the contributions referencing these objects are shown. Thus, the user can get a quick overview over the predominant opinion towards these objects. The conflict area identification component at the bottom of the tab allows users to generate a colour shading for the map layer containing the reference objects. By

activating the check box, the features on this map layer are shaded from yellow to red, according to the number of contributions referencing them. This allows for a quick overview of the most discussed objects.

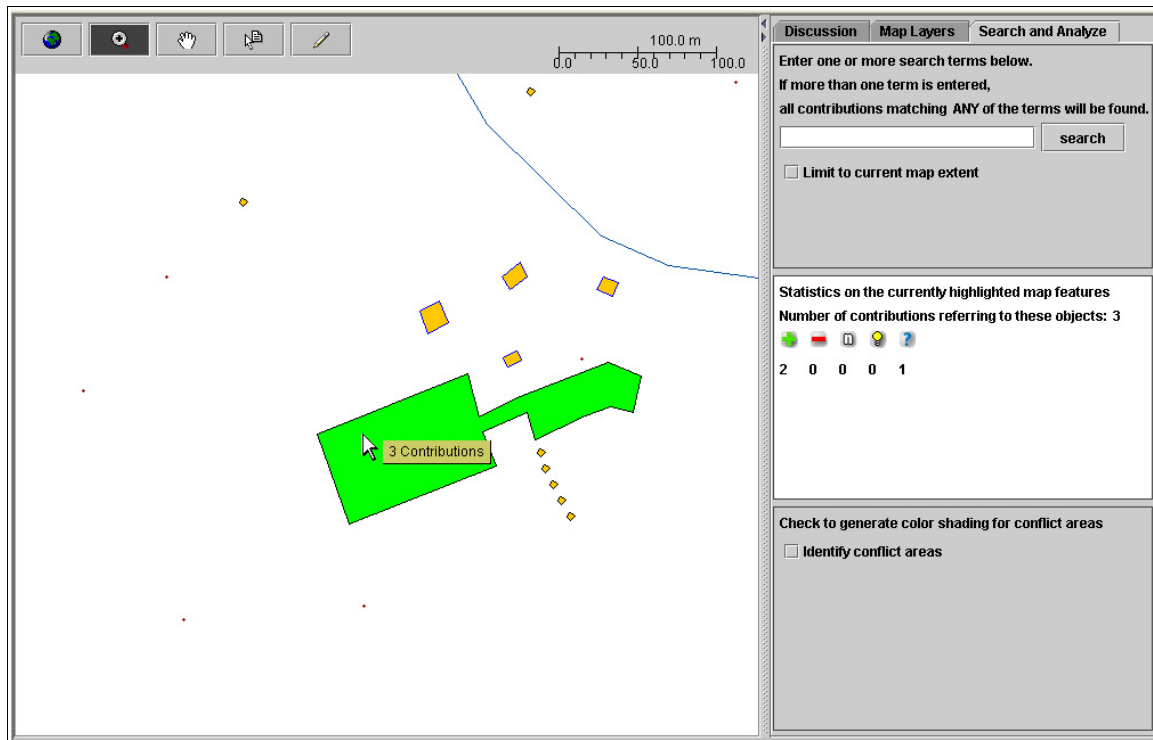


Figure 36: Interaction of the map and the statistics tool.

#### 6.4.1.2 Active Participation

Users who want to participate in the discussion can do this by answering an existing contribution or by starting a new thread, as described in section 6.2. Additionally, they can augment their contributions with spatial reference objects. For this purpose, the “Add Reference” tool has been added to the map's tool bar. It provides two different ways of adding spatial reference objects: First, the user can select existing spatial reference objects, which can be either from the layer showing the loaded shape file, or from the layer showing the spatial references created by other users. Secondly, the user can create new reference objects, which are restricted to points in the current version. These two tools are combined in an intuitive fashion; if the user clicks an existing reference object, it is highlighted and added to the user's personal reference objects. If the user clicks on a location which shows no reference object that can be selected, a new point object is created and added to the user's personal reference objects.

There is no fixed operation order for the creation of spatial reference objects and writing a new contribution, so that it is left to the user either to write the text first and then select the spatial reference objects, or vice versa. The editing of a new contribution and its spatial reference objects is flexible, allowing users to edit contribution and reference objects alternately. Both can be modified until the contribution is finally sent to the server, which “fixes” it and writes it to the database. This final step of writing a contribution also clears the layer holding spatial reference objects created by the user, so that he can write another contribution referencing other map objects. Moreover, the discussion tree and the layer displaying the spatial reference objects from the database are updated, so that they include the contribution which has just been sent.

### **6.4.2 Database Design**

The design of the database is strongly linked to the requirements of the prototype. The storage of identifiable spatial objects and the support of many-to-many relationships between contributions and spatial reference objects had to be mapped to the database. Figure 37 shows an overview of the seven tables making up the back end database for the prototype, and the relationships between them.

The two central elements are stored in the *Contributions* and *Locations* tables. Both tables are related to each other via a third table called *References*, which stores pairs of contribution and reference IDs. This configuration allows for many-to-many relationships between them, as explained in section 2.3. The layouts for the discussion tables and for the tables storing the spatial references have been explained in sections 6.2.2 and 6.3.3.

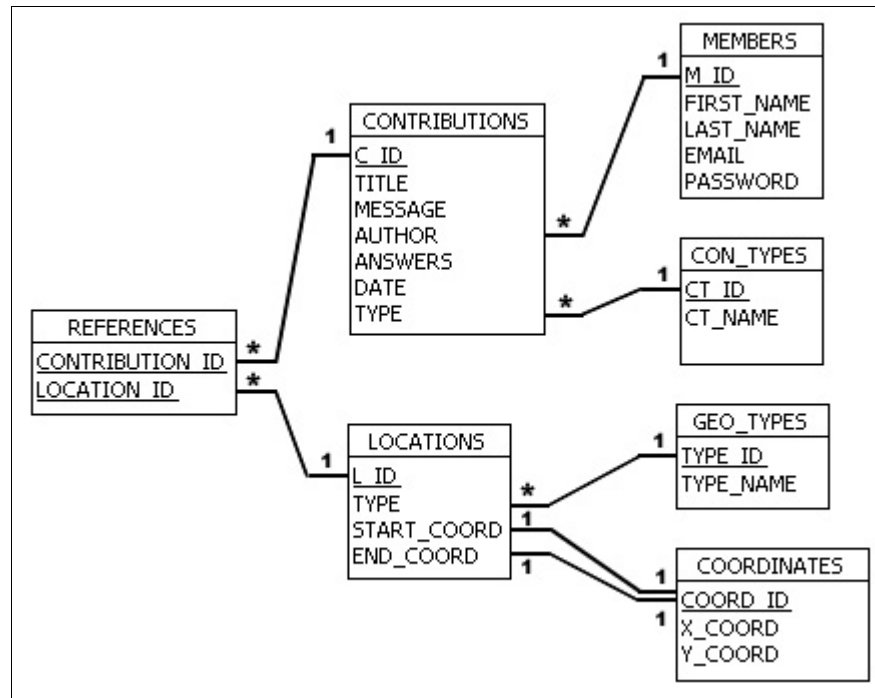


Figure 37: Database schema for the prototype backend database.

## 6.5 Summary

This chapter presented the prototype implementation developed in the course of this thesis. Concerning the user interface, both the map and the forum have been designed similar to other applications from their fields, to facilitate orientation for novice users. Both parts have been integrated in a single user interface which allows for interactive exploration of the discussion both from the map and from the discussion tree. The work flow when writing new contributions is flexible, allowing the user to edit the contribution and its spatial reference objects alternately.

The implementation is written in Java, so that the tool can be used independent of the user's computer platform. Communication between the client-side Applet and the back end database, which serves as a persistent storage for the discussion and spatial reference objects, has been realized with Servlets. An OGC compliant WMS client on the server allows content providers to integrate maps from remote WMSs into the application; moreover, it equips the prototype with the functionality to store a map configuration for every contribution, which can be reloaded by readers.

## 7 Conclusions and Future Work

The final chapter draws the conclusions of this thesis and evaluates the prototype implementation regarding the hypothesis in section 1.4. The first section analyses whether the prototype can verify all parts of the hypothesis and give reasons for those parts which could not be verified. Moreover, it compares the presented solution to the requirements listed in chapter 5. The second section draws the conclusions from these results, and the last section gives an outlook on future work to promote the development of tools for spatially related, asynchronous discussions.

### 7.1 Evaluation of the Prototype Implementation

#### 7.1.1 Evaluation Regarding the Hypothesis

The prototype implementation presented in chapter 6 can verify the hypothesis to a large extent. The following paragraphs will discuss the different parts of the hypothesis and show how they were implemented in the prototype. Reasons will be given for the parts of the hypothesis which could not be verified.

*“It is possible to implement a web-based public participation system, that integrates a map and a discussion forum to enable spatially related discussions.”*

The first part of the hypothesis could be verified completely. The prototype consists of a web-based system, and a map and a forum have been integrated into a common user interface. Both components have been linked using the argumentation map model presented in section 2.3, allowing users to write discussion contributions with spatial reference objects. Many-to-many relationships between discussion contributions and map objects are supported; users can either select existing map objects from certain layers, or create graphical reference objects themselves. In the current version, this function is restricted to point objects, but the database structure supports lines and polygons, which allows for the future integration of these types of graphical objects into the user interface.

*“The system offers basic GIS functions such as panning, zooming, layer selection or querying on the map side and a structured discussion on the argumentation side.”*

All GIS functions mentioned in the hypothesis have been implemented in the prototype. However, the query function implemented in the current version is reduced to the



information displayed in the pop-up tool tips which appear when the user moves the mouse pointer over a map object. This information is only available for the layers which are loaded from a shapefile or from the database. A query function for the layers loaded from WMS has not been implemented yet, although the WMS interface specification allows for coordinate-based queries on special *queryable* layers (OGC 2001a). This function is also already supported by the server-side Web Map Client Core<sup>28</sup>.

The prototype offers a structured discussion, using a tree representation, which is more meaningful than a flat, linear hierarchy, and easier to understand than more flexible structures such as IBIS.

*“The system offers combined spatial / argumentative queries.”*

A number of simple tools for combined spatial / argumentative queries have been implemented in the prototype. Users are provided with a special tool on the map which allows for the highlighting of discussion contributions by selecting the corresponding reference objects. When an object on the map is clicked, all contributions which refer to this object are highlighted in the discussion tree. The search interface allows users to search for contributions which contain a search term. This simple full-text search tool is extended by an option to reduce the set of matches to contributions which reference objects that are shown in the currently selected map extent. The statistics tool shows detailed information on the objects which are currently highlighted on the map, especially on the types of contributions referencing them. The conflict area identification tool allows for a visual search for the most discussed map objects.

*“The system relies upon open standards to enable the integration into existing spatial data infrastructures.”*

The statement that such a system can be implemented using open standards is the only part of the hypothesis that cannot be verified thoroughly. Standards have been used in the implementation by adding support for OGC WMS, which enables content providers to use maps which are already available from WMSs, and the support for WMC Documents for the storage of map configurations. Other geodata standards such as support for OGC WFS could be implemented in future versions of the system. However, the system also

<sup>28</sup> The actual query function is provided by the WMSs, so that this function would only be available if the WMSs used for map retrieval support it; queryable layers are optional and are not part of the mandatory WMS functions.

contains functionality which is not covered by any existing standards; in fact, the existing standards are not flexible enough to be used for the prototype.

This is the case for the discussion. Although Usenet newsgroups provide a standardized, widely accepted way for structured, asynchronous, distributed discussions, they are not suitable for spatially referenced discussions, as explained in section 3.2.2. Instead, a proprietary solution for the storage of the discussion has been developed, which is bound to the prototype and cannot be used by other clients (unless they are specifically developed for it). Moreover, the link between discussion contributions and spatial reference objects has been implemented in a proprietary way, which was necessary due to the lack of an existing standard for this kind of problem. Although XIMA documents might possibly result in an OGC standard, they do not allow for clearly identifiable reference objects, as explained in section 3.3.2. A model that supports such objects requires an implementation which integrates the storage and management of spatial reference objects, to guarantee the integrity of relations between discussion contributions and their reference objects. Hence, the database designed for the contributions was extended to store spatial reference objects, as well as the relations between the two.

### **7.1.2 Evaluation Regarding the Requirements of the Prototype**

Although the prototype can verify the hypothesis to a large extent, it does not meet all of the detailed requirements listed in chapter 5. It is limited to the most important functions in order to demonstrate the power of the underlying model. The following paragraphs will compare the implementation to the previously defined requirements.

Concerning the discussion, all requirements except for the message formatting options have been met. The discussion uses a tree structure, and labels are provided to mark the contributions' types. The map provides basic navigation functionality as well as a scale bar and is designed similar to other web mapping applications, to facilitate orientation. Layer selection is supported to enable focussing on layers of interest. Tool tips are only provided for the layers loaded from a shapefile or from the database. A simple set of query and analysis functions allows for the highlighting of contributions by selecting a spatial reference object, and for highlighting spatial reference objects by selecting a contribution. The query tool does not meet the requirements completely; it offers only a simple full text search, which can be restricted to contributions with reference objects in the currently selected map extent. Hence, it allows for simple combined spatial /

argumentative queries, but it does not make full use of the information stored with the discussion contributions (e.g. date, type).

The user interface integrates the map and the discussion, allowing the user to dynamically resize the components, or to hide one of them. The discussion component resembles newsreaders, but it does not support highlighting unread contributions for every user yet. The requirements for the map interface have been met completely. The user interface of the query tool could not be designed similar to the one shown in figure 25, as it does not offer complex query functions yet. The statistics tool shows information on currently selected map features. Context-sensitive help is provided in tool tips which appear on every button of the user interface when the user moves the mouse pointer over it.

The work flow when creating a new spatially referenced contribution is flexible, leaving the operation order up to the user. Reference objects can be either selected on the map or created, which is reduced to points; polylines and polygons are not supported by the user interface yet. As these objects are written to the database, they do not alter the underlying geodata.

To ensure the prototype's interoperability, support for OGC WMS has been added; support for WFS has not been implemented yet. Moreover, content providers can configure a shapefile which is to be loaded, as well as the data shown in the tool tips, through parameters in the Applet tag<sup>29</sup> which embeds it into an HTML page. Static images are supported by the map viewer, but the prototype still lacks an option to integrate them. In the current version, the user interface is only available in English, and it is not possible to translate it through external language files.

## 7.2 Conclusions

The thesis has demonstrated that it is possible to implement a system as described in the hypothesis, whereas parts of the implementation could not be based on standards, either because there are no standards or because existing standards were not applicable for the demands of the prototype. The analysis of existing applications which add spatial references to different kinds of information have shown that there is no application that fully implements the argumentation map model. Most of the tools offer only rudimentary support for the exchange of spatially referenced information. The only system that

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<sup>29</sup> For details on the configuration of the prototype, refer to the installation manual contained on the CD attached to this thesis.

supports spatially referenced discussions is Spatial Discourse, which is also the only system which uses spatial objects rather than coordinates as spatial references. However, Spatial Discourse does not implement any standards for geodata web services, so that it is not easily integratable into existing infrastructures. Moreover, it does not offer an integrated user interface and is too complex for a system targeted at the general public.

Concerning the use of standards, the thesis has shown that there is no standard for adding spatial references to other kinds of information, respectively for linking information to spatial reference objects. All systems presented in chapter 4 use proprietary solutions to create the link between maps and annotations, with some of them adopting standards such as URLs or RDF files. The OGC discussion paper on XIMA documents, which provide a GML-based method to annotate maps and images, is an attempt to develop a standard for tagging geospatial data. However, XIMA documents are not suitable for use in an object-based model like the argumentation map model, because they describe relationships between annotations and portions of maps, instead of spatial objects.

The analysis of Usenet newsgroups for the prototype's discussion component led to the conclusion that a system needs to have full control over both the discussion contributions and the corresponding reference objects to take full advantage of the underlying argumentation map model. A solution with an external management of the discussion (as with newsgroups) does not allow for analyses which embrace both the discussion and spatial reference objects. Hence, an integrated solution was not only developed for the front-end user interface, but also for the backend database, as this was the only system design which fully supports all requirements of the hypothesis.

## **7.3 Outlook and Future Work**

### **7.3.1 Further Development of the Prototype**

The further development of the prototype should concentrate on the implementation of those features which have been described in chapter 5, but which have not been implemented yet. The focus should be on the query and analysis tools, as they become more important with an increasing number of discussion contributions. Moreover, support for more standards for geospatial data such as GML should be added, and it should be possible to integrate geodata encoded in other file types than ESRI shapefiles. Support for queryable WMS layers could be used for two functions: First, users could

retrieve information on map features on WMS layers; second, this information might be usable to identify spatial objects on the WMS layers, so that discussion contributions could be linked to them. However, this is only a vague idea which needs to be analysed thoroughly to see whether it is realizable.

Besides new functions which should be added to the prototype in the future, the development should also aim at improving performance. One problem of the prototype in its current design is that its start is slow due to the need to transfer about 1.5 MB of data to the client. This problem could be solved by shifting parts of the functionality from the client to the server. Moreover, the performance of the prototype cannot be regarded as user friendly, e.g. some operations on the map take up to a few seconds. While some operations cannot be accelerated as they require the exchange of data with the server<sup>30</sup>, other operations which are executed on the client-side need to be re-designed for faster response of the user interface. For both cases, a progress bar should be integrated into the user interface so that the user knows that the application has not frozen.

### 7.3.2 Usability Tests

Throughout the thesis, there has been a special focus on a user-friendly design of the prototype. Hence, the user interface was designed similar to existing applications, to facilitate familiarizing with the tool. However, no users were involved in the development of the prototype, so that it can only be assumed that the prototype is user-friendly. Once the missing functions have been added to the prototype, it should undergo a usability test. The test should be performed by a group of lay persons, possibly in a scenario similar to the one used for this thesis. The results of the test should be used for further improvements of the prototype.

### 7.3.3 Development of a Standard for Spatially Referenced Information

The lack of a standard for spatially referenced information outside GIS forces developers to build proprietary solutions which are not compatible with each other. Hence, it is not possible to exchange spatially referenced information between two different kinds of tools. Inside GIS, different kinds of information can be linked to map features. If the data reside outside GIS, like the discussion contributions of the prototype, there is no

<sup>30</sup> This problem might even be worsened by shifting parts of the functionality from the client to the server, as this would mean that both components have to communicate more often. Hence, a balance between a thin, fast starting, but slow responding client, and a thick, slow starting, but fast responding client must be found.

standardized way to describe spatial references. The development of a standard for spatially referenced information needs to be carried on to provide developers with compulsory interface definitions. The development of XIMA documents should be fostered, extending the current model so that it supports annotations which refer to identifiable spatial objects. Once a standard exists, new, interoperable solutions will emerge which allow for the seamless exchange of spatially referenced information such as contributions in a discussion structure.

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## Appendix

The CD-ROM starts automatically when it is inserted into a drive and shows an HTML page that lists the contents; if the autostart feature is disabled, *index.htm* has to be opened manually to view it. The CD-ROM contains:

- The full source code of the prototype. The files *ArguMapClient.zip* and *ArguMapServer.zip* contain folders with the source code for the prototype client and server. Both folders contain projects which can be imported into the Eclipse IDE. The file *wmc.zip* contains compiled versions of the Servlets as JAR files.
- A setup guide for the prototype.
- The thesis as a PDF file.

The contents of the CD-ROM can also be found on the web at <http://www.carstenkessler.de/argumap/>.

# **Independent Study Declaration**

The thesis entitled “Design and Implementation of Argumentation Maps” was composed by myself and is based on my work. Where work of others has been used it is fully acknowledged in the text.

This work has not been submitted to obtain any other educational qualifications.

Münster, November 27<sup>th</sup> 2004

Carsten Keßler