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Argumentation maps: GIS-based discussion support for on-line planning

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Abstract. Information technology plays a growing role in planning procedures. A procedure step which has not been supported by specific computer tools up to now, is asynchronous discussions. Such discussions can occur in public participation as well as between planners during plan design. In this paper I introduce argumentation models as a way of structuring debates, and review existing tools for recording argumentation. A limited number of tools support design-related or map-related discussions. Their short-comings for analyzing geographically referenced arguments are discussed. Finally, the concept of 'argumentation maps' is described, which combine the strengths of rigorous argumentation modeling and detailed geographic location to support map-based discussions in on-line planning.

1 Introduction

Information technology is playing a growing role in urban and regional planning procedures. Approaches range from knowledge-based computer aided design (CAD) systems to assist planners in creating valid zoning plans, to multicriteria decision support for site location, and to hypermedia information systems and online geographic information systems (GIS) for public participation. An important issue for system development in several of these contexts is supporting discussion procedures. Owing to the German planning system, where written comments are more important than the outcome of public meetings, in this paper I focus on discussion support in a 'different place, different time' setting.

Since the mid-1990s, Internet newsgroups have become a popular tool for discussing any kind of subject. Some experiences have been reported on the use of newsgroups as a part of public planning forums. From argumentation theory, we know concepts for structuring discussions that go beyond the simple question – reply pattern of newsgroups. An example are issue-based information systems (IBIS) that have been implemented in software tools like gIBIS/QuestMap and Zeno. Both in newsgroup discussions and in IBIS, the subject of discussion (such as the elements of a draft zoning plan, or a set of potential sites for facility location) is only verbally described in discussion contributions. That is, geographic locations are expressed only in words, referring, for example, to administrative names or codes. A few approaches, though, consider explicit links between messages and graphical representations, especially maps.

In this paper I introduce argumentation models for formalizing debates, with a focus on IBIS (section 2), and present some argumentation support tools (section 3). In section 4, existing approaches to linking argumentation with maps are outlined and discussed. In section 5 I propose a generic model for connecting plan elements with typed discussion contributions as a conceptual base for developing argumentation maps. I conclude with a general discussion of the issues involved and goals for further research and development.

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2 Formalizing debates

The analysis of argumentation processes is a way to discover, use, and archive the rationale in decisionmaking problems. In spatial planning, analyzing discussions between stakeholders can reveal the design rationale behind land-use plans. "A design rationale ... is a representation of the reasoning behind the design of an artifact" (Buckingham Shum, 1996). To make the reasoning of planning decisions (re)usable for visualization and analysis, it is crucial to formalize debates.

Formalization can be presented in a logical manner in order to support logical analysis such as consistency checks between arguments. It can also be given in a computer language manner in order to support computerized handling of arguments. In the following sections, I describe different levels of formalizing debates with argumentation models and further elaborate on the issue-based approach.

2.1 Argumentation models

Formalizing debates with argumentation models means (1) giving speech acts a logical type, and (2) describing a grammar that defines allowed rhetorical moves. The simplest example of an argumentation model is a question/answer model. Single discussion contributions are either of type 'question', or of type 'answer'. A question starts a new thread of discussion, whereas an answer replies to a question or adds to a previous answer.

An implicit assumption is that contributions of speakers in a debate, or written contributions, represent, or can be split into, argumentation elements that have a nonambiguous type. Such atomic elements may be hard to acquire in real time for discussion meetings, whereas in asynchronous, written discussions, it may be difficult to agree with authors of long, complex contributions on splitting them and giving them a type. In both cases, modeling the debate may require a human facilitator.

Some benefits of argumentation models are:

(1) simple rules of order for a discussion procedure through types and grammar;
(2) clear overall structure of what has been said or written;
(3) complex contributions become clearer when broken down into typed argumentation elements.

Toulmin (1958) was the first to propose an argumentation model. The types of argumentation elements in this model are 'claim', 'data', and 'warrant'. A claim is a proposition one wants to establish. A data item is a fact that supports a claim. A warrant is a rule or principle that allows one to make the step from data to claim. Figure 1 shows the pattern of a single argument in Toulmin's logic. The sample argument reads "Harry was born in Bermuda [data]. So Harry is a British subject [claim], since a man born in Bermuda will be a British subject [warrant]". A network of claims, data, and warrants emerges if data are challenged and must, in turn, be based on other data.

Another important argumentation model was introduced by Kunz and Rittel (1970). Their issue-based information systems (IBIS) are described in detail in the following section.

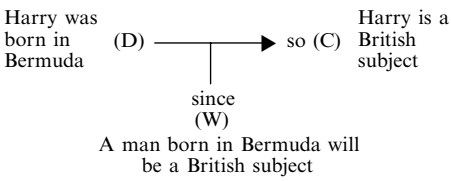

Figure 1. Toulmin's argumentation pattern with data (D), warrant (W), and claim (C) (source: http://www.lcl.cmu.edu/Cavalier/Forum/info/ToulLogic.html).

2.2 Issue-based information systems

IBIS have been introduced as a "manually operated" method in Kunz and Rittel (1970, page 1) "to support coordination and planning of political decision processes" and in general to treat wicked planning problems. The key 'issues' of a decisionmaking problem are seen as the central elements for structuring argumentation processes. In total, the application-independent IBIS concept supports argumentation elements of three logical types (Brewka and Gordon, 1994):

(1) *issues*—the questions to be decided or goals to be achieved;

(2) *positions*—the alternative solutions which have been proposed for resolving an issue or achieving a goal;

(3) *arguments*—assertions about the properties or attributes of each position, which speak for or against choosing it.

Kunz and Rittel (1970) distinguish four types of issues: 'factual' ("is X the case?"); 'deontic' ("shall X become the case?"); 'explanatory' ("is X the reason for Y?"); and 'instrumental' ("is X the appropriate means to accomplish Y in this situation?"). Isenmann and Reuter (1996) add a fifth type, 'definition' issues, which question the meaning of notions used in a discussion. But this distinction of issue types is not always used to implement an IBIS-supported debate.

Conklin and Begeman (1988) describe the legal rhetorical moves, the grammar, of IBIS in terms of nodes and links (see figure 2). Eight link types (generalizes, specializes, replaces, questions, is_suggested_by, responds_to, supports, objects_to) can relate the three node types (issue, position, argument) to one another. For example, a position responds to an issue, an argument (in the narrow sense) supports a position. Nodes and links are the base to represent debates as graphical networks.

The Zeno argumentation model (Gordon and Karacapilidis, 1996) is an IBIS variant that adds reason maintenance aspects to pure argumentation recording. The authors extend IBIS with additional node types (comment, decision, preference) and with a labeling mechanism for dialectical graphs. A dialectical graph is a directed finite graph representing all the positions and arguments for a set of issues. A labeling algorithm defines positions to be 'in' or 'out', according to a proof standard that is assigned to an issue. For example, "preponderance of the evidence" is a proof standard under which a position is in, if its valid supporting arguments outweigh its valid objecting arguments. Labeling is a dynamic procedure that is expected to stimulate IBIS-structured debates.

The comment node-type is intended for speech acts that are independent from other nodes in the argumentation tree. The decision node-type represents a choice among the alternative positions to an issue. Finally, preferences are a specific type of position that helps to deal with conflicting arguments. Preferences express a priority assessment between two positions. The well-formedness of dialectical graphs follows roughly the legal rhetorical moves of IBIS (as in figure 2). Gordon and Karacapilidis

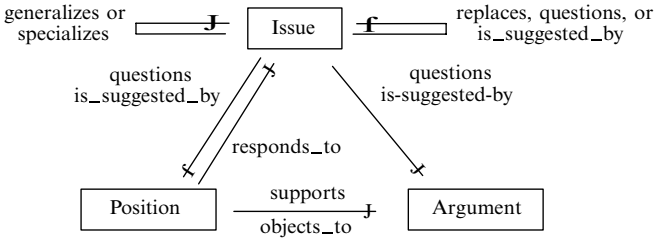

Figure 2. Legal rhetorical moves in IBIS (modified from Conklin and Begeman, 1988, page 141).

(1996) model issues as sets of positions, and arguments as binary relations between positions, both instead of simple nodes.

Shortcomings of the IBIS method have been discussed by Conklin and Begeman (1988) and Tweed (1997). In particular, two groups of observations are made: first, a tendency of a discussion to 'go meta', when participants do not agree on the correct use of the IBIS structure; second, the administrative overhead of recording the argumentation, the necessary skills to recognize what is an argument, and the risk of losing the context of an argument when structuring a debate. Both issues must probably be accepted as inevitable drawbacks of formalizing debates and have to be weighted against the above described benefits.

3 Argumentation support tools

3.1 IBIS implementations

3.1.1 *gIBIS*

Conklin and Begeman (1988; 1989) describe gIBIS, a graphical IBIS implementation for large, complex design problems that supports thinking and communication among distributed team members. gIBIS is especially intended for the capture of early design deliberations. gIBIS slightly extends Rittel's IBIS schema (Conklin and Begeman, 1988, see figure 2) with an 'other' type for nodes and links, an 'external' node for non-IBIS material, and a 'generalize/specialize' relation for positions and arguments. Based on this model, debates can be represented as graphical networks, as implemented in the successor of gIBIS, QuestMap (see figure 3).

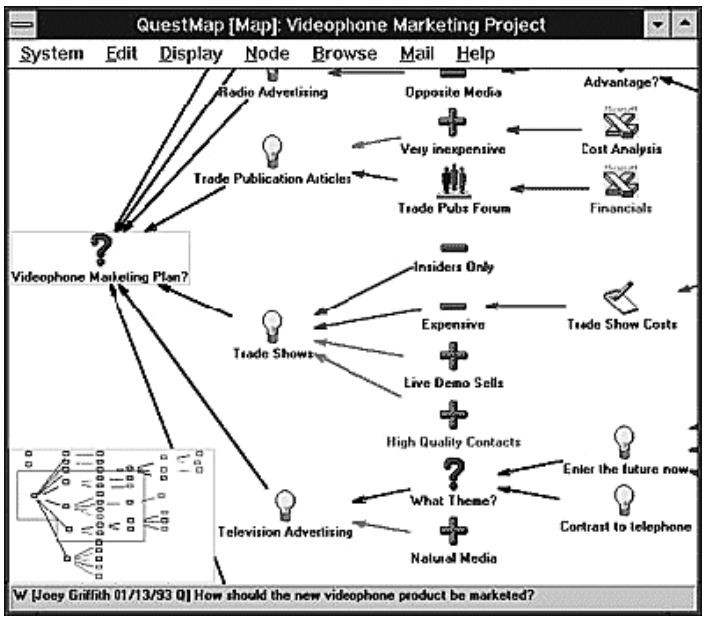

Figure 3. Visualization of argumentation with QuestMap (source: http://www.gdss.com/omq/aboutQM.htm).

3.1.2 *Zeno*

Zeno is a groupware tool that offers special support for moderated and unmoderated discussion procedures. It has been under development since 1996 by the Cooperative Design group, now Mediation Systems team, within GMD, the German National Research Center for Information Technology (see http://ais.gmd.de/MS/). The Zeno

concept arose from research in artificial intelligence (AI) and law, and more specifically in computational dialectics (Gordon, 1994) and mediation systems (Gordon et al, 1997; Rinner and Schmidt, 1998).

Among the shared workspace types offered by Zeno are discussion forums. These are designed to store and provide access to argumentation messages. Forums in Zeno contain three default subdirectories: 'incoming', 'published', and 'index'. The first receives incoming messages by discussion participants in their original state. The second contains those messages that are approved by the mediator. Published messages may have been modified by their author on the mediator's demand, for example, if the content was imprecise or offensive to another participant. If the discussion procedure is unmoderated, incoming messages are automatically published. The index of a forum is a specific view on the published messages that depends on the argumentation model on which the forum is based. At the time of writing, one model is implemented in Zeno, the above mentioned variant of the IBIS model.

In the Zeno system, different types of arguments are represented by different icons, and a tree-like browser displays the interdependence of arguments by their order and indentation. The argumentation browser provides a type of visualization for discussions that has been adapted from common file managers or desktop explorers of different computer operating systems. The bottom of figure 4 shows the argument browser for some contributions that are in the argumentative context of the message displayed in the center part (here, a single text line). The message display is completed by information on author and date of arrival at the server.

The Zeno system has been evaluated in several real-world projects as well as in role playing. Part of the evaluation was supported through a cooperation with the planning agency of the city of Bonn within the consortium of the European Union research

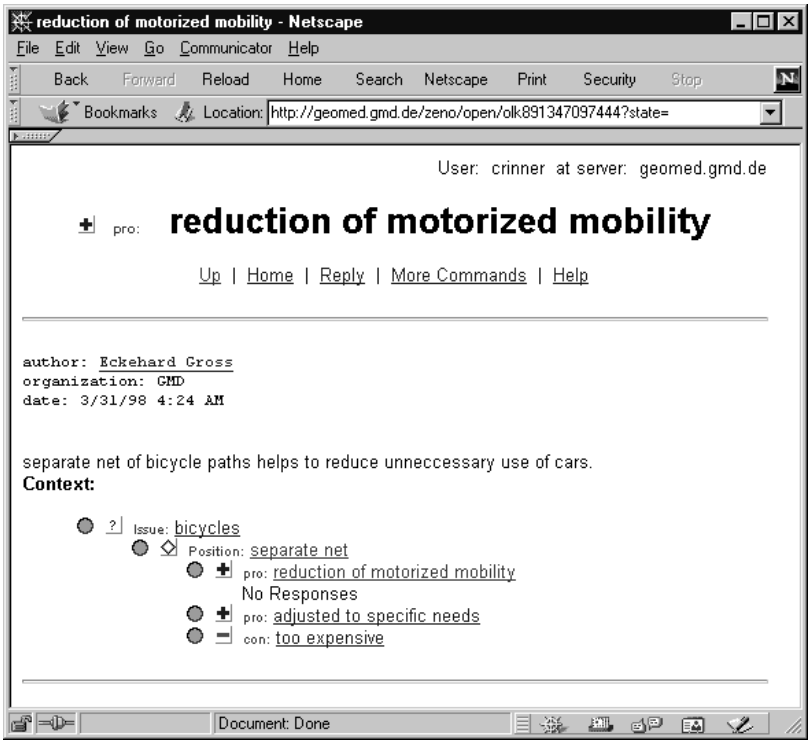

Figure 4. Display of a contribution in a Zeno discussion forum (source: http://geomed.gmd.de/).

project GeoMed. Schmidt-Belz et al (1997) report a validation of Zeno by two groups of test users. Their assessment of the design, handling, and functionality of the basic version has been used by GMD to reimplement the improved full version of the system. Schmidt-Belz et al (1998) add a real-world experiment to the previous planning games. Citizens of Bonn could access Zeno, retrieve information, and participate in a discussion about a planned housing area during a two-week, anticipated public participation procedure. The disappointing results are summarized in section 3.3.

In contrast to those practical experiences with Zeno, Märker (1999) performed a theoretical evaluation of the potential of IBIS as a communication medium in planning procedures. On the one hand, the author comes to the conclusion that IBIS can, in principle, support an early, equal, open, and transparent participation of stakeholders in (urban) planning. On the other hand, Märker estimates that the technical selectivity of network-based IBIS applications will limit the factual participation opportunities for a large number of citizens, and that the use of IBIS depends on the goodwill of the authority in charge of the planning procedure.

3.2 Newsgroups

Usenet newsgroups are open discussion forums that are accessible to any Internet user who has a news reader software installed. This software often comes together with web browsers and therefore can be expected to be installed on any networked personal computer. The newsgroups are organized in a hierarchical structure, depending on area of interest and, in part, on language and geographic factors.

Each newsgroup in turn is organized into thematic threads; a new thread is started when a message with a new subject line is posted to the newsgroup. Threads consist of the initial message which is in most cases a question, and of answers to this question

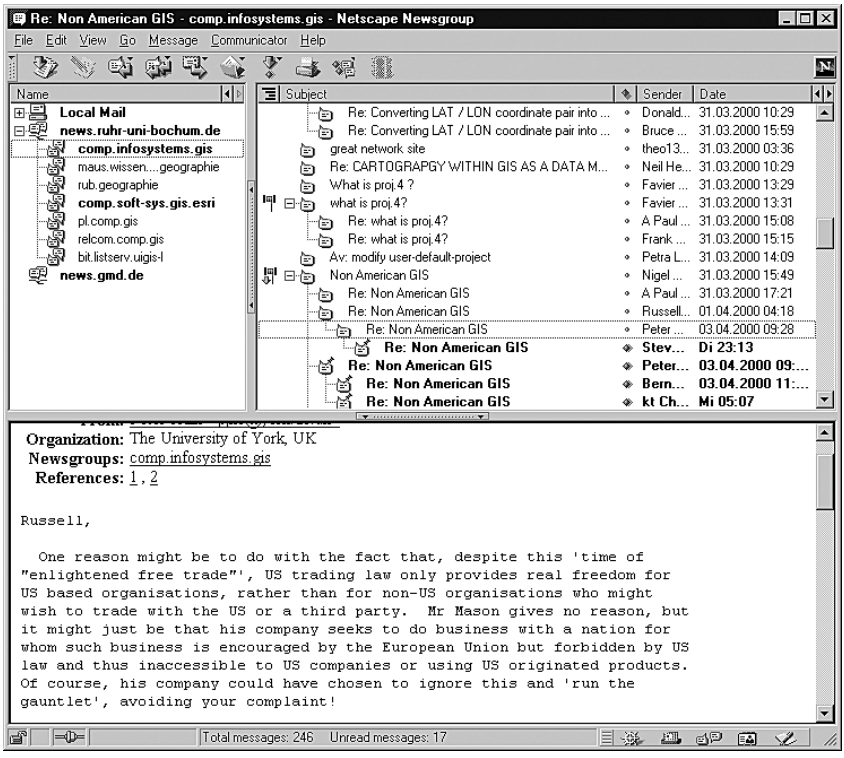

Figure 5. Threads in the newsgroup comp.infosystems.gis.

or to previous answers. Thus, newsgroups have only two types of argumentation elements—'question' and 'answer'—and a trivial grammar, allowing a question as root for a thread and multiple answers as replies to a question or to other answers.

This model is used by news reader software to indent message titles in overview listings of newsgroups. Figure 5 shows questions (for example, requests for information or technical support, or other type of statements) and related answers in the newsgroup comp.infosystems.gis. Besides the list display, the newsgroup model is also reflected in the Re: prefix of the answers' subject line.

3.3 Evaluations of planning forums

Empirical tests of IT supported planning forums have been carried out in parallel with conventional procedures. Burg (1999) summarizes four implementations in different European countries (Germany, United Kingdom, and Sweden) with very modest results, on-line contributions ranging from 0.1% to 6% of all contributions.

A similar picture was observed when GMD's Zeno was tested in a two-week preliminary public debate in Bonn; a reasonable number of visitors viewed documents in the workspace but no one sent a contribution on-line (Schmidt-Belz et al, 1998). Technical problems with the respective implementations and with Internet access in general, as well as the public's lack of confidence in the new medium, can only partly explain these disappointing results.

In a public GIS experiment, Stasik (1999) found that participants who were not true stakeholders, showed a low interest in the actual planning problems. These findings suggest that it is better to evaluate discussion tools in carefully composed, maybe professional, target groups.

4 Subject-centered discussion support

In general, participants in on-line discussion forums have to refer to the subject of their contributions with words. For example, a geographic feature in a planning discussion is determined by its administrative name, a postal area by its zip code. Some computer tools provide explicit references of comments to text documents ('text annotation'). Only a few approaches consider linking discussion contributions with graphical representations, such as maps. The following sections present software and research prototypes that provide access to discussions from within text documents and graphical displays which are the subjects of these discussions.

4.1 Text annotation

4.1.1 *DocReview, D3E*

The publicly available DocReview tool, described by Hendricksen (1999), allows authors of HTML documents to invite colleagues to comment on their texts via the Internet. When initiating a review process for a document, the author sets up areas of the document to be annotated. As a default, these review segments are HTML paragraphs (<P> tag).

A similar approach is implemented in the Digital Document Discourse Environment (D3E) by Sumner and Buckingham Shum (1998). Figure 6 (see over) shows the tiled-window interface of D3E applied to a research paper. To the left is a HTML version of the paper for reading, to the right is a list of discussion threads referring to different, predefined sections of the paper.

4.1.2 *ThirdVoice*

In a commercial tool, ThirdVoice (http://www.thirdvoice.com/), people surfing the Internet can annotate web pages. Annotations can be placed at any point in the text and are stored on a server of the software provider. Other visitors to an annotated web page

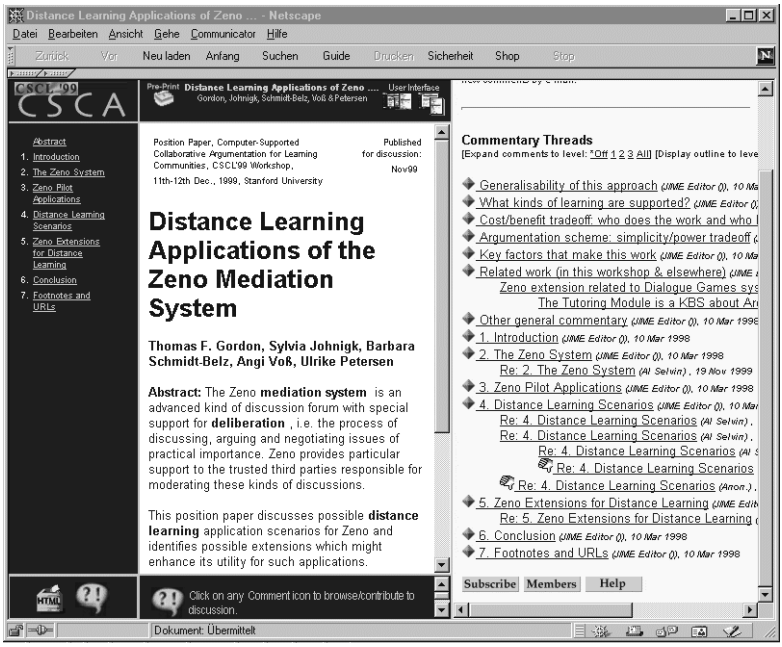

Figure 6. The D3E system, applied to a paper for the workshop on Computer-supported Collaborative Argumentation for Learning Communities (source: http://d3e.open.ac.uk/csc199/Gordon/Gordon-t.html).

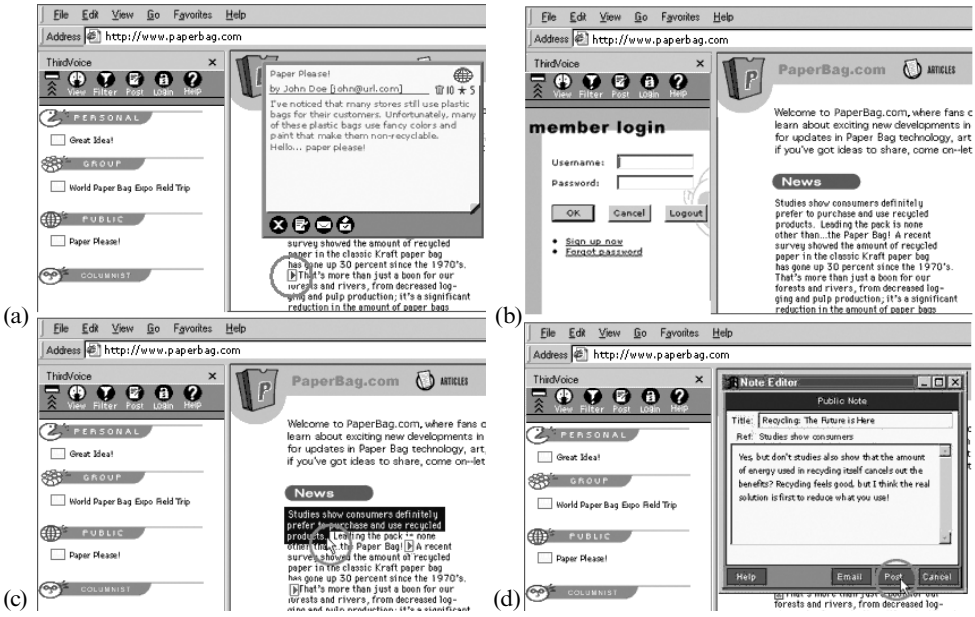

Figure 7. The ThirdVoice tool: (a) reading an existing comment; (b) member login to the server; (c) markup of a text position; (d) posting an annotation (source: http://www.thirdvoice.com/).

who have the ThirdVoice plug-in installed, see the comments in the text and can add their own ones (see figure 7).

This resembles very much the vision of web pioneer Tim Berners-Lee, who imagined the web as a very interactive medium which it has not yet become (Holloway, 1997).

4.2 Discussing maps

4.2.1 *PHIDIAS*

PHIDIAS is a hypertext system for supporting designers (McCall et al, 1990) that integrates graphic objects with a structured model of argumentation. PHIDIAS combines an IBIS variant (PHI, 'procedural hierarchy of issues') with a vector graphics module. The sample sessions presented by McCall et al are in the CAD field, namely interior design. In a graphics window, PHIDIAS provides domain-specific construction tools. During a design deliberation, the user can query a dynamic issue base that contains design-related argumentation (see figure 8). These issues, answers, and arguments may, for example, be about the best placement of a refrigerator in a kitchen design. The issue base can be accessed either via an explicit query statement or implicitly by clicking on finished objects in the graphics window. Thus, the designer can retrieve helpful information previously entered into the system about a CAD building block such as a refrigerator.

4.2.2 *CrossDoc*

A prototype of a visual argumentation support tool which also uses the IBIS model was presented by Tweed (1997). His CrossDoc implementation helps users in constructing map-based document networks (see figure 9). The author envisions applications in

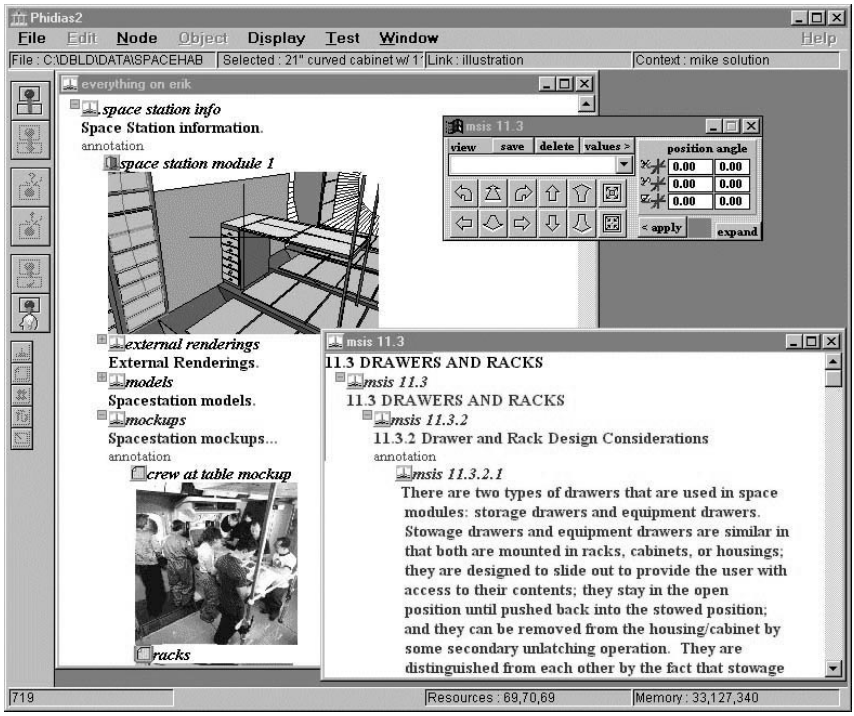

Figure 8. The PHIDIAS cooperative design system (source: http://phidias.colorado.edu/phidias/).

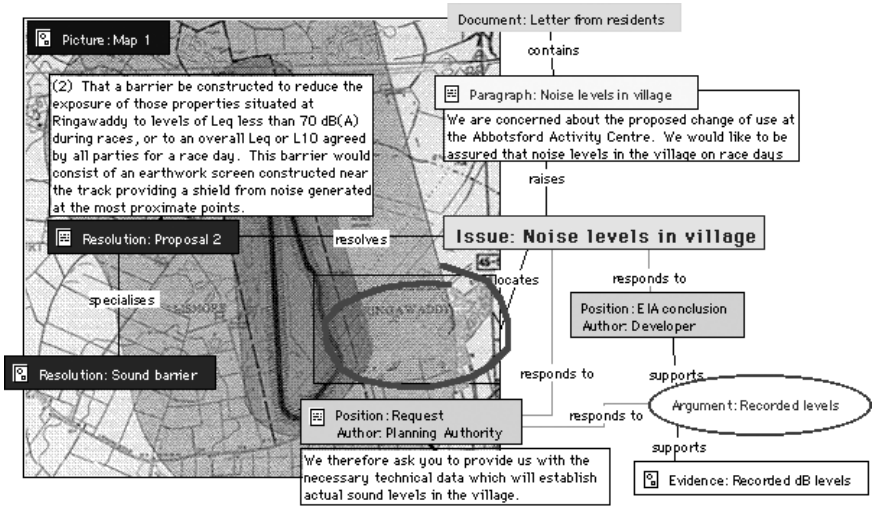

Figure 9. Map-based document network using CrossDoc (source: http://www.qub.ac.uk/tbe/arc/people/staff/chris/CDAbout.html).

domains as different as web design, management, technical information, but also environmental planning procedures.

A limitation of CrossDoc is that it was specifically developed for the Apple Macintosh platform. Similar to PHIDIAS, CrossDoc was designed as a single-user system, to be used to record design decisions in a desktop computer environment.

4.2.3 *VRMLView*

Lehmkühler (1998) presented an experiment combining a three-dimensional (3D) planning view with a newsgroup discussion forum. To the right, in the background of figure 10, a 3D view of a planning area is defined in the virtual reality modeling language (VRML). Through a hyperlink mechanism, users can access a newsgroup forum when clicking in the graphical area. In contrast to the previous approaches,

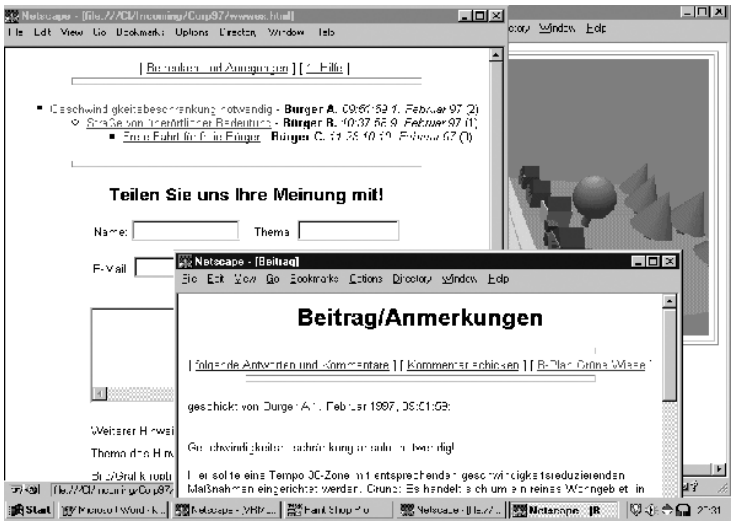

Figure 10. VRMLView—a newsgroup forum linked to 3D web graphics (modified from Lehmkühler, 1998).

hyperlinks are not specific for individual planning elements but the 3D plan is connected as a whole to the forum.

4.2.4 *Virtual Slaithwaite*

Virtual Slaithwaite is a case study for map-based planning support including debates. A tool of the University of Leeds, developed around their on-line mapping system GeoTools, supports on-line public comments about planning issues. The screenshot in figure 11 shows the planning map with annotation dots in the right frame. In the left frame, the comment loaded is that which is attached to the annotation dot selected by the user. The Virtual Slaithwaite prototype is the only map-based annotation tool known to me that has been tested in real conditions. Kingston et al (1999) describe the case study in detail and report encouraging aspects. In particular, the public appreciated giving comments with unlimited length.

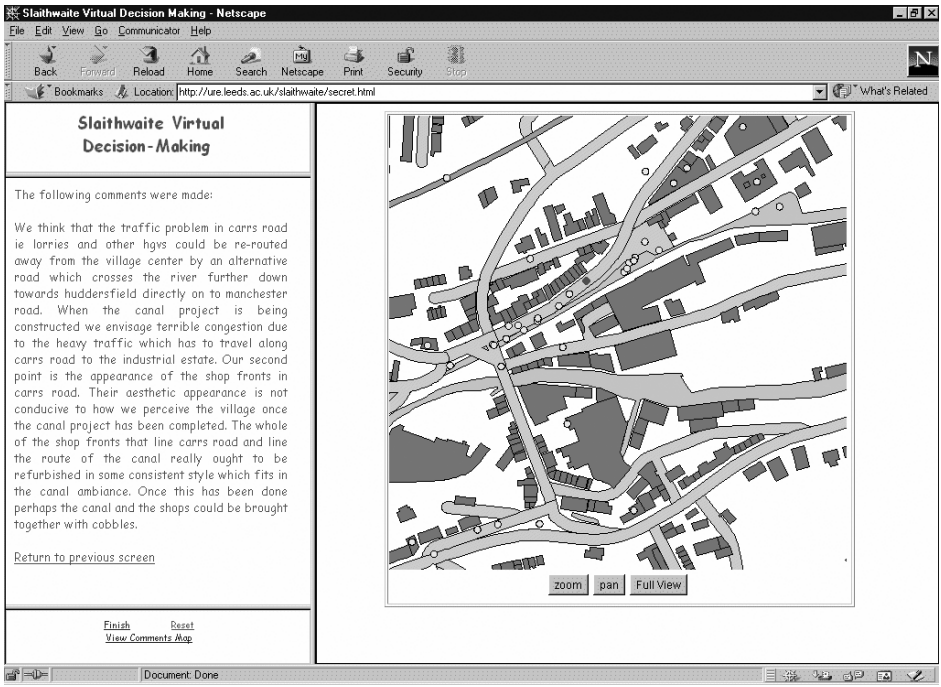

Figure 11. Screenshot of the Virtual Slaithwaite application (source: http://www.ccg.leeds.ac.uk/slaithwaite/).

4.3 Reference of arguments

The parallel between commenting on-line texts (section 4.1) and annotating on-line maps (section 4.2) is in the reference of the arguments: placing annotations at an arbitrary point in the text (as with ThirdVoice) is similar to locating comments at arbitrary map coordinates (as with Virtual Slaithwaite); linking annotations to predefined text segments (as with D3E) resembles referring to geographical objects on maps. Table 1 shows the analogy between documents and maps in this respect.

The kind of reference to choose depends on the trade-off between providing more flexibility to the user, and providing more opportunities for post hoc analysis. Locating arguments at any desired map coordinates is most flexible for the user, whereas attaching arguments to specific geographical objects helps with compiling statistical

Table 1. Analogy between document and map components as reference for arguments.

Document	Map
Paragraphs	Layers
Phrases	Geographical objects
Words	Points, lines, areas
Letters, digits, punctuation	Coordinates

information about a debate. The concept presented in the following section advocates linking argumentation elements to geographical objects (plan elements).

5 Designing argumentation maps

In order to describe the usage of map-based discussion support tools, four 'use cases' of argumentation maps are introduced in this section. A model for explicitly connecting plan elements with typed discussion contributions is proposed as a conceptual base for developing map-based argumentation tools. Finally, the link is made to on-line GIS.

5.1 Use cases

Argumentation map use cases involve three types of actors: users, a discussion forum, and a mapping or GIS component. There are some general relations between actors: users want to discuss a map, the forum provides contents and attributes of discussion contributions, and the GIS provides a map display and tools for processing georeferences of contributions.

The use cases identified for argumentation maps are 'navigation', 'participation', 'exploration', and 'evaluation'. These correspond to typical GIS functions as shown in table 2. Presentation, input, retrieval, and analysis are used as a high-level grouping of GIS functions with ascending complexity. These functional groups also reflect a chronological end-user perspective, where presentation of existing data comes before input of new data, data retrieval, and advanced analysis.

Navigation means map-based browsing through existing geographically referenced discussion contributions to get an instant overview of a debate. Icons would represent single contributions on a planning map. Different sets of icons should be available at the user's choice to display different types of argumentation elements or other attributes of arguments. Pointing to or clicking on an icon should display the content and some metadata of the related contribution on the screen.

The participation use case describes the input of new discussion contributions. Participants are expected to submit the text of their contribution together with references to map locations or to specific planning elements, depending on the type of map at hand. If a draft plan can be published as vector data, users will preferably be asked to designate some plan element(s). If the plan is available in raster format only, then users will click on arbitrary coordinates to locate the geographic references of their

Table 2. Correspondence between GIS functions and argumentation map use cases

GIS function	Argumentation map use case
Presentation	Navigation
Input	Participation
Retrieval	Exploration
Analysis	Evaluation

contribution. To determine the type of an argument, users can either be provided a choice list of supported types, or incoming messages can be classified by a human facilitator. In both cases, it must be possible to discuss and change the initial type assigned to a contribution.

Cartographic exploration requires interactive dynamic visualization of geographically referenced (discussion) data. To explore the current state of a debate means to play with a thematic map showing some aggregated data about contributions, such as the total number of messages, the numbers of messages of different types (for example, pro versus contra arguments), or the number of messages per author, each with relation to the plan elements. Map-based exploration provides an insight into the spatial distribution of discussion contributions (and their characteristics) over the planning territory. Cartographic exploration (also termed as 'exploratory data analysis with maps' or 'geographic visualization') is a recent scientific concept which reconciles the communicative and the analytical functions of maps. An introduction is given by MacEachren (1994); a powerful tool with applications is presented by Andrienko et al (1999). Spatial analysis performed through the exploration of a map or map series creates a link between cartography and geographic information science.

Finally, the evaluation use case covers traditional argumentation analysis and in/out labeling mechanisms, but also provides a link to classical spatial analysis with GIS which is based on measuring and counting, building distance buffers around geographic objects, and intersecting layers to create new geographic objects that respond to selected criteria. GIS analysis can be useful in combination with argument navigation or exploration. On the one hand, GIS functions like selecting and buffering can precede navigation or exploration tasks. On the other hand, GIS functions can be used to modify a plan after the visual assessment of a discussion in a navigation and exploration task.

The whole range of use cases with object-based hyperlinks, data input, and visualization of aggregated data can be supported by computer systems only if an object-based model of geographically referenced argumentation is used. The following section introduces such a model.

5.2 An object-based model

The model in figure 12 (see over) is designed to overcome the loose coupling of newsgroup messages to planning maps via verbal references in two respects: first, by breaking down messages into structured argumentation elements; and second, by making geographic references explicit by linking messages to plan elements instead of the plan as a whole or of coordinate positions. The model provides a set of useful attributes of georeferenced arguments with the aim of supporting the above described use cases.

A discussion is supposed to consist of argumentation messages that can be split into atomic, logically distinguished, argumentation elements according to an argumentation framework, such as the IBIS model. Argumentation elements have a type and are hierarchically structured according to the framework's grammar.

A draft plan which is subject to one or more discussion procedure(s), consists of geometric elements that have a meaning in relation to a planning project, either as a planned object or as a background object. These plan elements have typical spatial properties (position, area, shape, and so on), temporal properties (planned commencement of construction, expected lifetime, and so on), and spatial relations (neighborhood, distance, direction, and so on) among them.

A spatially referenced argument connects an argumentation element to one or more plan elements. If a single plan element is connected, the target of the argument

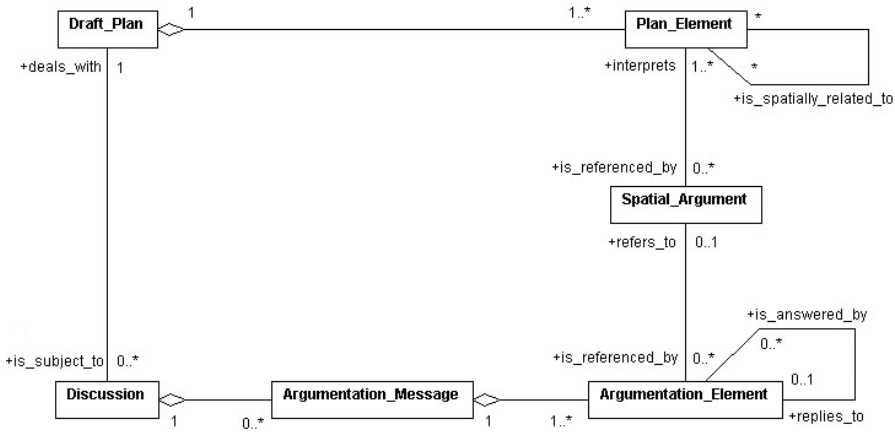

Figure 12. Object-based model of georeferenced argumentation (class diagram, Unified Modeling Language).

is a property of this element. If multiple plan elements are connected, the target of the argument is a spatial relation among them.

Besides the full text of the argument, it can be useful to extract some property of the argument with respect to the plan, for example, the 'design intention' of the argument; that is, what has to be done with the plan geometry in order to comply with the argument. Claims could be to 'keep' a plan element as it is, to 'create' a new element, to 'remove' an element, or to 'change' its position.

Developers and/or administrators of argumentation maps would have to choose useful lists of values for the proposed attributes in relation to the planning project at hand and to the available GIS data.

5.3 The connection to on-line GIS

The relation of argumentation maps to on-line GIS lies in the cooperative nature of planning discussions. An Internet-based system would be appropriate for map-based public participation, whereas Intranet-restricted access could be chosen for preliminary discussions among planners of different departments.

In on-line GIS, the traditional raster versus vector debate has been revived. Indeed, the argumentation map model requires an object-oriented, or at least object-based, GIS data model, and a vector mapping tool. These are still uncommon in available Internet map servers. If a raster map is used, a point-in-polygon search can be used to implement the advanced argumentation map use cases. For example, to draw bar charts of the number of contra arguments for some planning areas, the arguments' coordinates would have to be related to vector areas.

The GIS component of an argumentation map has to provide simple mapping and hyperlink functions for navigation. Storage facilities are needed to save user input, although in an Internet context, dynamic links can be maintained between distributed storage points using uniform resource locators (URLs). The exploration use case requires specific interactive mapping functions that may not be provided by standard GIS. Spatial analysis features are useful for advanced applications.

Concerning the user interface, the planning map is the central component. A filter mechanism for annotation symbol display is useful to avoid information overload. Direct manipulation tools for interactive mapping are a necessary part of the user interface.

The computing platform has to provide a network and a client/server mechanism for multiuser (public) access. The client component should probably run in common web browsers as these are becoming the most popular software platform today, which is—in principle—independent from the hardware. Java as the client programming language has the advantage of providing rich functionality and vector as well as raster compliance in contrast to solutions with HTML and JavaScript. Java can be assumed to be available without additional installation on most computers, in contrast to proprietary solutions using browser plug-ins. Plug-ins with specific functionality can be a solution in an Intranet setting, where there is full control of the software on the networked computers.

6 Discussion and outlook

In this paper I have analyzed the combination of argumentation models with maps to support cooperative planning on a methodological level and with reference to existing computer tools. The cooperative setting for this analysis was asynchronous debates in spatially distributed groups.

In an intuitive way, the proposed conceptual model for argumentation maps specifies the overall entities to be considered when examining georeferenced debates. In contrast to current approaches, the model provides a rigorous structure for argumentation and spatial references of arguments. Argumentation maps have been introduced as discussion support tools with typed discussion contributions and structured spatial references of these contributions. Argumentation structure builds upon existing argumentation models, whereas the references of arguments to maps can copy approaches of the reference of annotations to documents.

Implementations of argumentation maps are needed to evaluate the envisioned features. I am working on a tool which implements different aspects of argumentation maps, but this still fails to meet the specification given in this paper. A comprehensive framework for investigating the use of participatory GIS, which could help to structure empirical tests of argumentation maps, was presented by Nyerges and Jankowski (1997). Tool evaluation should give insight into the following questions:

(1) How to handle the trade-off between structured spatial references of typed atomic argumentation elements and the freedom of expression in unrestricted message texts that are linked to freely selected map locations?

(2) Do the benefits of rigorous message processing outweigh the effort of additional and more accurate user input?

(3) What benefits are owed to the use of argumentation models and which are owed to map use?

(4) What are the implications of the existence of a human mediator who would edit comments?

(5) How to support different user profiles such as casual versus trained users? How to account for differences in supporting public participation versus internal negotiations within planning agencies?

(6) Should users be provided with tools to modify plans in addition to writing comments?

The argumentation map model could also provide a means of connecting geographic objects that do not have a direct spatial relation but are related through the arguments of participants. Thus, argumentation maps define argumentative neighborhood between distant geographic objects and may reveal spatial conceptions of participants.

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