GIS, SOCIETY, AND DECISIONS: A NEW DIRECTION WITH SUDSS IN COMMAND?

T.J. Moore, Department of Geography
University of Washington, Box 353550, Seattle, WA 98195-3550
tjmoore@u.washington.edu

Geographic information systems (GIS) have become easier to use and very popular in recent years. However, many users are finding that while the technology currently provides an impressive and expanding toolbox for scientific and technical analyses to support problem-solving, the application of GIS in group decision-making contexts -- particularly in the public sphere -- tends to identify weaknesses in the technology. This paper proposes a vision for a new kind of GIS for an altogether different role: societal decision-making. Following the evolution of terminology in the literature, the name proposed for this class of technology is "Spatial Understanding and Decision Support Systems" (SUDSS). The name offered for that class of activity in which the technology may be applied is "COllaborative Mapping, Modeling, and Analysis for Negotiation and Decision-making" (COMMAND). The paper provides a very brief introduction to the recent developments within society, and within the research literature, which make this proposal a timely one. Then, an overarching framework is outlined, and possible features of a SUDSS are presented. A particular focus of this discussion is centered on potential design components that may facilitate group discussion distributed over space and time. The paper concludes with a short discussion concerning why the underlying design philosophy may be an important change for the discipline of geography and for society.

INTRODUCTION

Problems like the NIMBY (Not-In-My-BackYard) Syndrome have caused the long-term delay, or outright cancellation, of many proposed projects with locally undesirable impacts because, in part, of the sense that the decision-making process has been removed, historically, from the hands (or voices) of those about to receive the newly proposed burdens (e.g., see Couclelis and Monmonier, 1995). So, in the sphere of public policy in the United States and elsewhere, "public participation" and "community visioning" are becoming more widely accepted as potential ways to promote a more inclusive decision-making process. However, is GIS technology sufficiently designed for societal decision-making tasks?

Great strides have been made toward improving the power and user-friendliness of GIS technology for a wider audience. Furthermore, spatial databases are quickly growing in size. Nevertheless, as GIS technology matures, researchers, software developers, and software users (including technical specialists and decision-makers) are beginning to better understand that their technology may not be sufficiently designed to openly facilitate decision-making, particularly at the group-level. Therefore, the GIS research community spawned a number of research initiatives directed at exploring elements of the role of this technology in society and decision-making (e.g., National Center for Geographic Information and Analysis [NCGIA] Research Initiatives 6, 17, 19, 20, and 21).

This paper presents a vision of a new fold of technology, called Spatial Understanding and Decision Support Systems (SUDSS), which may help users develop a sense of shared understanding about a problem *and* the possible solutions, all while the participants are distributed over space and time. The kind of activities that SUDSS can be applied to are collectively called COllaborative Mapping, Modeling, and Analysis for Negotiation and Decision-making (COMMAND).

THE RESEARCH CONTEXT

The contributions to the literature on this subject have been growing rapidly (e.g., Armstrong, 1994; Carver, 1991; Couclelis and Monmonier, 1995; Densham, 1991; Faber *et al.*, 1994; Heywood and Carver, 1994; Jankowski, *et al.*, 1997; Malczewski 1996; Nyerges, 1995; Nyerges and Jankowski 1994, 1997; and Shiffer 1992, 1995), partly as a result of research initiatives sponsored by the NCGIA.

The SUDSS acronym proposed here continues to build on recent directions in the literature. Couclelis and Monmonier (1995) have called for an extension of spatial decision support system (SDSS) tools into the realm of "spatial understanding," in what they refer to as spatial understanding support systems (SUSS). The authors justifiably note that current GIS/SDSS tools do not provide support for problem exploration and the generation of shared understanding among diverse stakeholders. Using NIMBY public-policy problems as the canvas for their work, the authors then began their inquiry into possible alternative software functionality which might yield the "narratives" of social context that seem to be so desperately needed. Heywood and Carver (1994) refer to this missing element as an "idea generation system." Whatever the name, the call is clear: the technology requires a design which allows the users more time to creatively and flexibly explore spatial data and their relationships, and then reflect upon, and discuss, this information at a group level.

EXPLORING SUDSS

Framework

Figure 1 presents a generalized framework of the modular components of a SUDSS. These components are categorized into three groups: 1) discussion group (issue management subsystem, or IMS), 2) geographic group (geographic information subsystem), and 3) quantitative and qualitative decision-making group (with the group aiding, process modeling, and decision modeling subsystems). The discussion group is composed of the issue management subsystem, which will be a primary focus of the remainder of this paper. The geographic group (geographic information subsystem) contains tools such as: database management, spatial analysis, data presentation, a data dictionary, and a data quality filter (see, for example, Paradis and Beard, 1994). The decision-making group is composed of decision modeling tools (e.g., multicriteria decision techniques for choice tasks), process modeling tools (simulation modeling of, e.g., environmental, economic, and social conditions; sensitivity and uncertainty analyses), and group aiding tools (such as group voting resources; a group whiteboard).

This framework is presented in Figure 1, with a general schema organized to reflect that the IMS and the GIS are the central players shaping the fundamental features of a SUDSS environment. The qualities of the other subsystems are more likely to be different across applications, depending upon the needs of the users.

Overview of an IMS

The IMS is envisioned to provide the core functionality to allow group members to participate in a somewhat structured, distributed, and asynchronous computer-supported discussion devoted to spatial understanding, alternative generation, and alternative selection. The subsystem will provide users with the ability to contribute "nodes" to a running conversation which address matters of interest and concern. This computer-supported conversation could be organized by the users into a set of "discourse maps" on separate, but broad, topics of relevance to the overall decision at hand. These discourse maps can be viewed, edited, queried, and archived. To query a discourse map, the participants could use geographic location, location within the discussion, aspatial attributes (e.g., topic keywords), decision task context, time (world, database, or discussion), discussant identification information, node type (i.e., rhetorical construct), or document type (map, text document, etc.). For each contribution to the on-

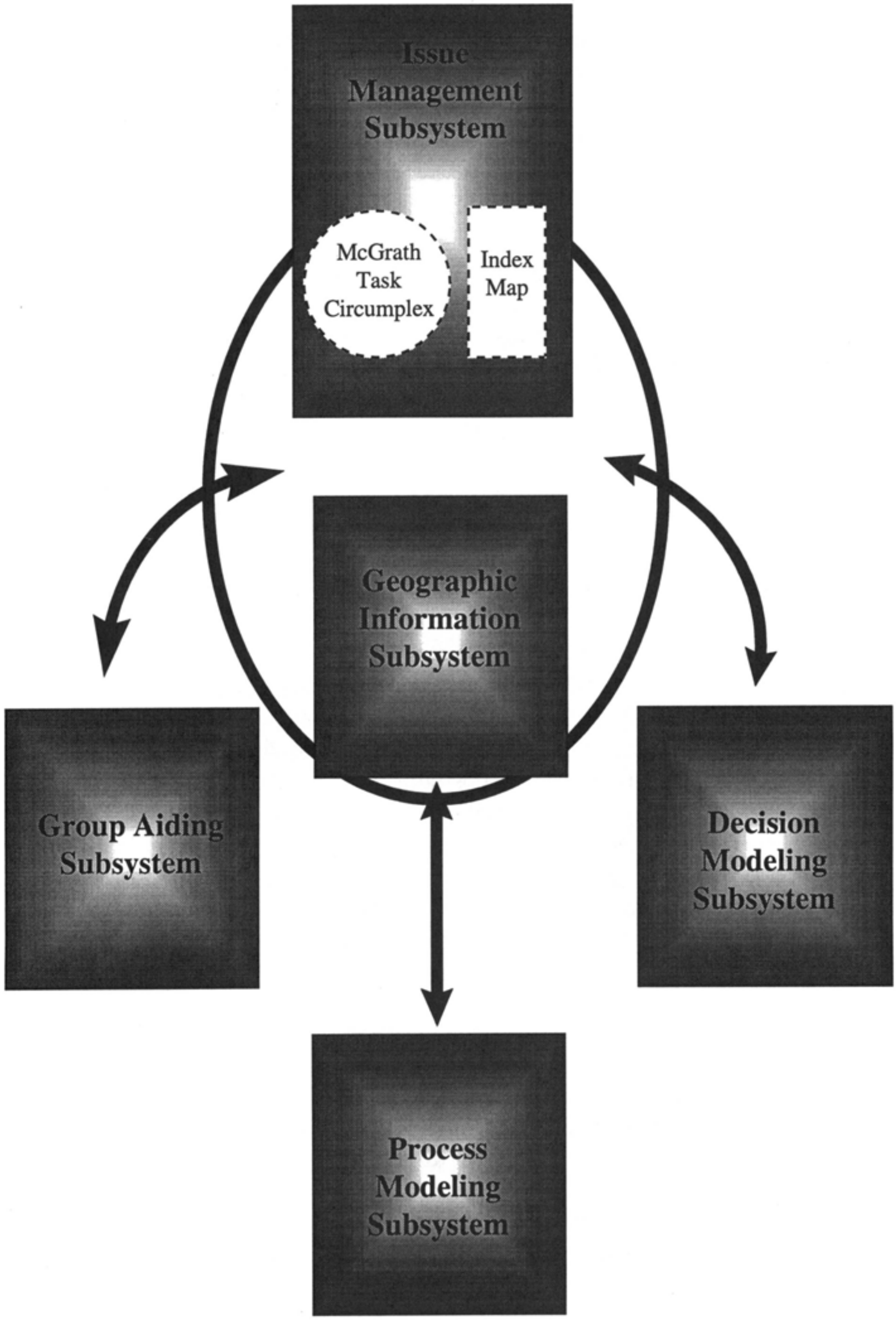

Figure 1. Proposed SUDSS Components and Schema.

going discussion (a node), the participants could create and attach to the nodes, through hyperlinks, multimedia objects which others could then view and consider. Thus, a user could see the conversation, and the "discourse artifacts" (i.e., the multimedia objects), through shared and personal contexts (geographic and otherwise).

A "Language" for an IMS

The IMS is the central organizing interface for display, modification, and retrieval of text, maps, and other multimedia data posted by the discussants in support of their computer-based discussion. In this paper, the basis for the presentation assumes the rhetorical structure proposed originally by Rittel and Webber (1973), and Kunz and Rittel (1970). That is, the IPA (for Issue, Position, Argument) structure of their proposed, and eventually tested, Issue-Based Information System (IBIS). This approach to providing some underlying conceptual organization to the nodes is based on the belief that the model for problem-solving by "cooperatives" must be viewed as an argumentative process. Other possibilities are available (such as Lee, 1990; Cropper, Eden, and Ackermann, 1993), and this could be the subject of further research.

The general structure of the IBIS method is displayed in Figure 2. Three types of nodes can be posted to the discussion. Issues raise the specific questions which participants wish to discuss. Positions propose certain approaches, or solutions, to address the issues. Discussants can then post arguments which support or oppose positions posted in the discussion. These nodes are linked by eight fundamental relationship types as depicted in Figure 2. A software, implemented non-commercially as gIBIS (for "graphical IBIS"), is described elsewhere in great detail (e.g., Conklin and Begeman, 1989). The software has led to a commercial product with friendlier node types and icons (such as "questions," with a question mark as an icon, instead of an "issue").

This proposal goes further than just a rhetorical structure. In order to provide structure within a decision-making context, the IMS interface would also prompt discussants to categorize newly created nodes by the eight task elements in McGrath's task circumplex (McGrath, 1984). This circumplex is a circle with four quadrants: Generate; Choose; Negotiate, and Execute. (In fact the quadrants are further divided in half to generate eight different decision-task slices.) This feature will impose further structure on the thinking of participants; it will require that discussants think not only about how their contributions fit into a rhetorical structure, but also how they fit within a decisional structure.

A final structure is, of course, a geographic structure. By use of an index map in the interface, each discussant can identify the approximate geographic

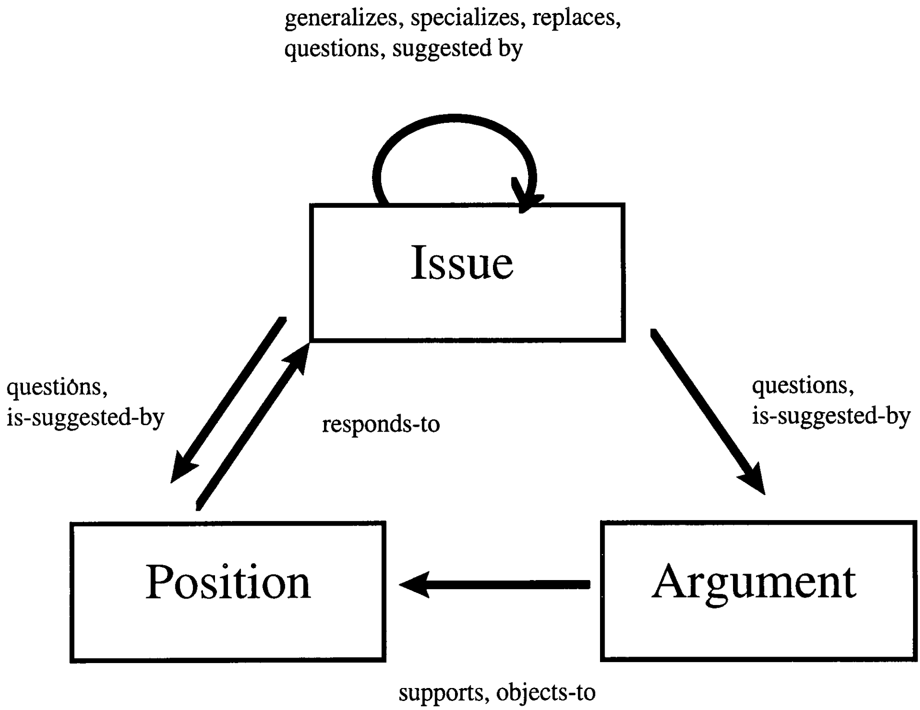

Figure 2. General Structure of the IBIS Method (as in Kim, Suh, and Whinston, 1993).

location that is related to the submitted contribution. The location can be used later to identify nodes based on spatial queries using bounding rectangles, selected features, etc. Furthermore the result of other queries (e.g., complex task/topic queries) may help to identify certain geographical patterns which could further illuminate the discussions and directions necessary for achieving consensus.

Possible Features of an IMS

Figure 3 displays a cursory example of how the IMS interface may look. Note that through pull-down menus or icons, the other subsystems could be accessed (e.g., the GIS interface, a process modeling interface, or the decision modeling or group aiding interface). The issue management interface is first divided up into topic areas (like "meeting rooms") which can be browsed, queried, and updated by discussants. Before the user clicks on a meeting room, all that can be seen is a highly generalized, or "zoomed out," view of the hypertrails that represent the various discussion topics.

Once a topic is selected, the next view shows a more detailed representation of the discourse map (the hypertrail of nodes and links). The user can navigate around this map by using zooming and panning tools, and the "location" in the discourse map is always displayed by a "bird's eye view" of the hypertrail (with a bounding rectangle to represent the view boundaries) in a corner of the map. The nodes are identified by some author-supplied keyword/title and by icons which symbolically represent the type of node. Also, the software would use a document-centered convention, so that documents created in other applications and in other subsystems can be attached to nodes in the computer-supported discussions.

Query capabilities would be available to allow the user to select and browse nodes and supporting documentation that meet specific user interests. This query tool could also be used to explore patterns in the discussions. When a query is submitted, all selected nodes will be shaded a similar color for easy visualization on the discourse maps. Additionally, if a selected node for a query has associated features on a map which were identified by a contributing author, then a minimal bounding rectangle (see Frank, 1988), or MBR, will be highlighted in the index map. If desired, the user can zoom in to the selected objects in the index map. One might envision the interface for the index map to follow upon work previously disseminated in this area (e.g., Evans, Ferreira, and Thompson, 1992).

To capture the essence of how the conversation develops over time, and to possibly assist a user in browsing along a discourse "thread," the time at which a node is added to the discourse could be used by a geographic brushing tool.

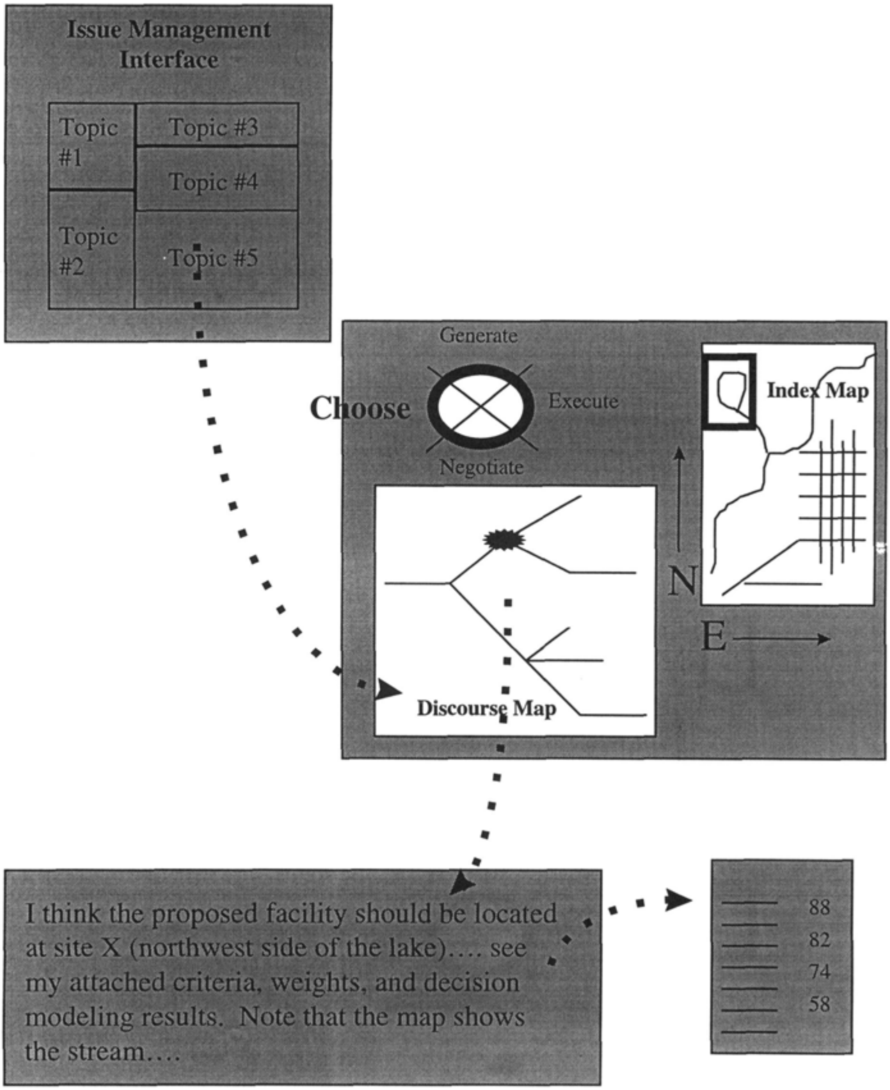

Figure 3. Hypernavigating the SUDSS Interface.

Monmonier (1992) described a research application to study the effectiveness of brushing at communicating information via dynamic maps. Here, we might imagine that as the user sweeps across a timeline, the discourse map nodes are cumulatively highlighted in the sequence in which they were contributed to the discussion. The user can stop at any point on the timeline to investigate the extent of the conversation at that selected time. Likewise, the decision task circumplex "slices" and the discussion nodes and MBRs in the index map could be cumulatively highlighted based on the sweep along the timeline.

DISCUSSION AND CONCLUSIONS

For GIS research and development, the creation of SUDSS-like tools for COMMAND presents a significant future challenge. Even in conventional settings, with non-GIS software, the software development process does not always take full advantage of usability testing methods. However, Internet-based usability studies could make the process of testing the software somewhat easier. The issues of why and how to perform these tests for collaborative spatial decision-making activities and for the development of SUDSS-like tools is beginning to receive attention (Golay and Nyerges, 1995; Nyerges, 1995; Nyerges and Jankowski, 1994, 1997; and Jankowski and Stasik, 1996).

One of the potential benefits of this approach would be that the activity to support an on-going, long-term, multiparty discussion would also create a database that can be searched at a later date. In effect, the records archive would be digitally catalogued for posterity while the policy discussions are occurring. This could improve the "institutional memory" of participating decision-making organizations. If successful, this approach could have enormous potential for long-term discussions related to policy and planning – for example, state or federal environmental review processes.

Another possible benefit is for people who cannot attend public meetings because of an odd work schedule, conflicting family responsibilities, etc. The distributed nature of a SUDSS in space and time, if Internet-based in implementation, would provide at least the opportunity for the information to be readily accessible at home. Whether, or how, the average citizen would use a SUDSS-like tool is admittedly still a question. However, the excitement about emerging technologies on the World Wide Web suggests a real and wide interest in hypermedia-based, distributed communications.

However, for each potential benefit there is also probably a cost. For example, we could easily turn the above discussion about "greater access" into a discussion about the danger of broadening the gap between the information "haves" and "have-nots." The actual (as opposed to intended) effect of a technology in society is bound not only to its capabilities and applications, but also to the historical, political, and social milieu surrounding the tool's use.

The point that I would like to make here is that the hierarchical structure of existing GIS technology, along with the one-dimensional nature associated with its application, both tend to promote particular solutions according to specific "world-views." We need to promote further research and development into problem-solving and decision-making techniques with this technology, but we must also emphasize exploration and communication among individuals and groups with many different "world-views." I think that what we are learning is something that the influential words of Ian McHarg identified so beautifully, but it is something that, in my opinion, has never been completely captured within this technology. (McHarg, 1969) In a chapter on the health of cities, McHarg writes:

> "...the surviving and successful organism, species and community are fit for the environment. If this is so, then the fit creature or community is, by definition, creative; the unfit or misfit, less than fully creative, or reductive. As we have seen, fitness must be revealed in form, and so form then reveals not only fitness but creativity. Form is meaningful, revealing the adaptive capabilities of the organism and the community; it should also reveal, if we could observe this, that these are creative." (McHarg, 1969, pp. 187-188)

In this sense, movement toward a SUDSS design could open up the collective creativity that shapes the form of planning and public policy, for all to then contribute and view.

This, I believe, is what Daniel Sui means when he calls for a new GIS leading to a more democratic society. He says we need: ". . . a shift of our philosophy from viewing GIS as an instrument for problem-solving to viewing it as a socially embedded process for communication." (Sui, 1996) When we get to that point, then we will be able to respond to Nick Chrisman's challenge of dealing: "... with mutli-disciplinary ways of knowing, as implemented in competing GIS representations." (Chrisman, 1996)

What we are seeing in GIS research, in other areas of academia, and in society in general, is a search for ways to improve the interaction of voices and connect this interaction to real action for the common good of a community. The goals of increasing public participation and building a sense of community in a postmodern world are not easy to achieve, whether it is in the field of GIS or elsewhere. For GIS technology to improve its contributions to "societal" decision-making, we must recognize that the underlying structure of the tool must respond to three critical human needs for "community"-building: 1) increasing communication and participation, 2) increasing connections and obligations to others, and 3) respecting the individuality of others (adapted from Daly and Cobb, 1989). So as I see it, SUDSS in COMMAND could be a very unique and valuable form of computer-mediated communication. That's because this technology may not let us soar, freeing us from the so-called "Tyranny of Geography," but rather it may just make it easier for us to put our feet back down on the ground.

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