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Chapter I

Collaborative Geographic Information Systems: Origins, Boundaries, and Structures

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It is the theory that decides what can be observed.
Albert Einstein (1879-1955)

The scientists of today think deeply instead of clearly.
Nikola Tesla (1857-1943)

Abstract

This study describes the origins, boundaries, and structures of collaborative geographic information systems (CGIS). A working definition is proposed, together with a discussion about the subtle collaborative vs. cooperative distinction, and culminating in a philosophical description of the research area. The literatures on planning and policy analysis, decision support *systems, and geographic information systems (GIS) and science (GIScience) are used to construct a historical footprint. The conceptual linkages between GIScience, public participation GIS (PPGIS), participatory GIS (PGIS), and CGIS are also outlined. The conclusion is that collaborative GIS is centrally positioned on a participation spectrum that ranges from the individual to the general public, and that an important goal is to use argumentation, deliberation, and maps to clearly structure and reconcile differences between representative interest groups. Hence, collaborative GIS must give consideration to integrating experts with the general public in synchronous and asynchronous space-time interactions. Collaborative GIS provides a theoretical and application foundation to conceptualize a* distributive turn *to planning, problem solving, and decision making.*

Introduction

Definitions within a community of practice have multiple benefits. Definitions reduce differences in semantics, and focus a community of practice towards goals that reinforce individual and collective efforts, make knowledge accessible to those at the edges of the community, and expand a study area by integrating related external concepts (Sager, 2000). Moreover, clearly defined concepts in a knowledge domain can better facilitate theory building. There are five types of definitions, and we have chosen to specify a *theoretical definition* for collaborative GIS since this type of definition aims to capture a commonality in the research area, and to relate that commonality to a broader intellectual framework (Sager, 2000). This chapter is organized as follows: firstly, a theoretical definition of collaborative GIS is presented; secondly, a historical footprint is established to reinforce the theoretical definition; and thirdly, the linkages between collaborative GIS and its broader conceptual framework are outlined.

What is Collaborative GIS?

There is a mutual influence between geographic information science and collaborative geographic information systems. GIScience is the rationale or science (axioms, theories, methods) that justifies the design and application of geographic information systems (Goodchild, 1992). Geographic information systems on the other hand are the physical designs and processes that integrate people and computer technology to manage, transform, and analyze spatially referenced data to solve ill-defined problems (Wright, Goodchild, & Proctor, 1997). Collaborative GIS are influenced by both GIS and GIScience. Hence, the name collaborative GIS will be used as systems, science, or both, depending on the context.

Collaborative GIS can be defined as *an eclectic integration of theories, tools, and technologies focusing on, but not limited to structuring human participation in group spatial decision processes*. In particular, the aim is to probe at the participant-technology-data nexus, and to describe, model, and simulate effects on the consensual process outcomes. The participants are typically a mixture of technical experts and the public, the technological tools being computers that are networked or distributed, and the data being spatially referenced maps and attributes. The outcomes do not result from implementing a task-oriented approach, but rather they emerge from a joint and structured exploration of ill-defined problems to benefit planning, problem solving, and decision making. In planning, the intention is to develop steps to achieve a desired outcome, while problem solving deals with the formulation of plans in new contexts. Decision making is the process of choosing among a set of alternatives.

Structuring is defined in the Webster Online Dictionary (http://www.m-w.com) as "the act of building, arrangement of parts, or relationship between parts of a construction." In this regard, structuring in collaborative GIS deals with the creation of process designs, how those designs enable the participant-technology-data interactions, and the relationships between the component parts of the designs. Hence, collaborative GIS is situated within the enhanced adaptive structuration theory 2 (EAST2) framework (Jankowski & Nyerges, 2001a). The framework outlines a detailed set of concepts and relationships linking the content, process, and outcome of collaborative spatial decision making. The content constructs of EAST2 examine the socioinstitutional, group participant, and GIS technology influences. The process constructs examine the social interactions between humans and computers. The outcome constructs address societal impacts of the decisions. Constructs five (group processes) and six (emergent influence) are important for collaborative GIS because they deal with "idea exchange as social interaction" and "emergence of socio-technical information influence" respectively. The interactions that occur in these constructs are more collaboration rather than cooperation.

Questions that engage collaborative GIS research activities include "What collaborative spatial decision making structures can generate meaningful outcomes? How can the attitudes and needs of participants be integrated into the group process? What are the effects of spatial data and cognitive overload on participation quality? How can prior solutions be integrated into the designs of collaborative spatial decision making systems? How can the outcomes of the process be evaluated and assessed for quality?"

The Collaboration vs. Cooperation Distinction

Some of the earliest works of educational psychologists attempted to distinguish collaboration from cooperation within teaching and learning contexts. The notion of "associated life" by John Dewey made the important recognition that human relationships are a key to welfare, achievement, and mastery (Dewey, 1916). This associative educational enterprise was the predecessor of the modern day interpretation and application of collaboration and cooperation in interactions that deal with groups of individuals (Bruffee, 1995).

The difference between collaboration and cooperation is subtle, but important. John Smith (1994) suggests that collaboration is an expectation of a common purpose, and this occurs at the implementation level with a close integration of component parts. On the other hand, cooperation does not come with an expectation of close integration as individual tasks are combined at the hierarchically higher goal level. This means that for cooperative process, individuals can complete subtasks without being in close interaction with other supporting individuals. Bruffee (1995) points out that both collaboration and cooperation encourage group participation, but while cooperation guarantees accountability and risks maintaining authoritative structures, collaboration encourages self-governance and places guarantees of accountability at risk. Moreover, both collaboration and cooperation assume knowledge is socially constructed.

In the participatory GIS literature, collaboration and cooperation have been conceptualized in a hierarchical and cumulative arrangement consisting of four levels (Jankowski & Nyerges, 2001b). These participatory levels are communication, cooperation, coordination, and collaboration. Communication is meant to exchange ideas in social interactions, while cooperation uses the ideas generated from communication to develop an overall agreement, despite individuals may not interact with each other. Coordination occurs when there is a planned implementation of cooperative activity to reinforce collective group gains. Collaboration deals with a shared sense of meaning and achievement in the group process. The goal of collaborative GIS is to leverage collaboration towards a *collective* process. In collective participation, the participatory group, technology, and data operate as a single fused system.

Philosophical Orientation of Collaborative GIS

Understanding the philosophical orientation of a study area is important because it dictates what can be measured, and how measurements can be integrated and synthesized. A philosophical description can be characterized along four dimensions: ontology, epistemology, methodology, and praxeology. Based on a histori-

Table 1. The philosophical orientation of collaborative GIS

Philosophical Dimension	***Summary Description***
Ontology	RELATIVIST In this interpretation, the real world exists in the form of multiple mental constructions that are based on social and experimental processes. These constructions are local and context specific because of the individual perspectives from which they are formed.
Epistemology	SUBJECTIVIST In this interpretation, the investigator and the investigated are combined into a single entity. Knowledge is created from the interaction processes between the investigator and the investigated.
Methodology	HERMENEUTIC and DIALECTIC The individual reality constructions are processed hermeneutically (interpreted based on experience and experiments) and assessed dialectically (synthesis of opposing assertions) for the purposes of achieving one or more consensus constructions.
Praxeology	PLANNING, PROBLEM SOLVING, DECISIONS The consensus constructions guide individual and collective action. The actions (with associated individual reflections) take the form of problem solving, planning and management, and decision making, with the aim to improve human, societal, and environmental conditions.

cal examination of collaborative GIS, a description of its philosophical dimensions is proposed in Table 1.

Ontology is about the essence of existence and its explicit specification when conceptualized concretely (Gruber, 1992). The ontology is usually organized into a hierarchy of top (general concepts), domain (specific knowledge domain), task (vocabulary), and application (context dependent) levels (Gómez-Pérez, Fernández-López, & Corcho, 2004; Torres-Fonseca & Egenhofer, 2000). For collaborative GIS, the ontology is relativist where the real word is socially and experimentally formed from multiple mental constructions.

Epistemology is the study of knowledge and its associations to truth and belief (Rescher, 2003). The interaction of the investigator and the investigated is a crucial consideration in the knowledge formation process. For collaborative GIS, the epistemology is subjectivist where the investigator and investigated are integrated as one entity.

Methodology is the study of methods, and seeks to examine how knowledge is obtained and verified (Fuller, 2002). The processing and assessment of mental constructions of reality are of importance. For collaborative GIS, the methodology is such that the processing is hermeneutic and the assessment is dialectic, with the outcome being a reduced set of consensus constructions.

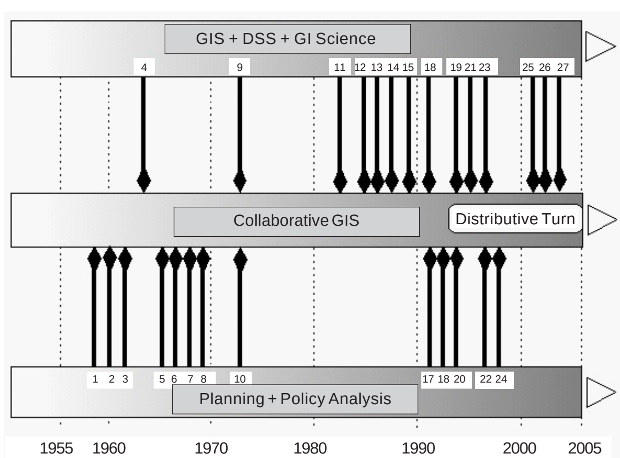
Praxeology is the science of human action, and considers how that action can impact societal, human, and environmental situations (Oakeshott, 1975). Collaborative GIS has been applied extensively in the knowledge domains of geography and environmental studies. The three predominant action-oriented aims that can be synthesized for GIS applications are planning, problem solving, and decision making (Duckham, Goodchild, & Worboys, 2003).

Collaborative GIS: Origins and Boundaries

The origins of collaborative GIS are diverse and some level of aggregation is therefore necessary to clearly understand its origins and boundaries. A first strand of relevant knowledge is from the planning and policy analysis arena where environmental decisions are made. A second strand of knowledge is the aggregation of decision support systems, geographic information systems, and geographic information science. The key concepts from these strands of knowledge are chronologically presented in Figure 1 and summarized in Table 2.

The history shown in Figure 1 can be categorized into four cumulative and overlapping periods: argumentation, reasoning, representation, and synthesis, which can be mapped to data, information, knowledge, and intelligence (Klosterman, 2001). The argumentation period covered the 1950s and 1960s and focused on logical structures to construct lexical arguments, and to use those

Figure 1. A historical footprint of concepts related to collaborative GIS



arguments in planning and decisions. The reasoning and representation period covered the 1960s and 1970s, with much effort directed to showing relationships between arguments and processing those arguments with mathematical formalisms. During the 1970s and 1980s, the practical integration of planning concepts and computer-based decision making began to take hold. This was partly due to earlier progress made in decision support systems and geographic information systems. With the planning and computer integration solidifying, the 1980s and early 1990s were the synthesis years when the spotlight was turned towards groups and computer technology in decision interactions. The synthesis was further accelerated by the increasing importance of environmental matters during the time; integrated management using computer based data integration was seen as a promising way to manage the environment. With the emergence of Web GIS and supporting communication technologies during late 1990 and early 2000, the collaborative GIS focus is now converging towards a distributive paradigm, where systems and processes are aligned to incorporate a wider cross section of participants in the planning and decision making process.

Table 2 provides a summary of key concepts that have influenced the evolution of collaborative GIS. The integration of these concepts provided the foundation for contemporary spatial group decision systems (Balram, 2005). An early form of collaborative spatial decision making was the Strabo technique, designed to elicit and forecast planning strategies based on a consensus of expert opinions (Luscombe & Peucker, 1975). The Strabo technique produced map and error summaries to aid decision makers in assessing a group's perspective about geographic planning problems. Technological limitation presented an immediate hurdle for the Strabo technique, with a critical challenge being how best to quickly obtain geographical summaries of expert feedback for input into the next iteration of the workshop group discussion. Nevertheless, the Strabo demonstrated the valuable contributions of expert groups in the spatial planning process.

The rapid advances in GIS software, hardware, and networking technologies have resulted in many new opportunities to integrate spatial mapping and analysis tools into group decision-making processes. In this respect, Armstrong (1994) argued for a greater integration of group mapping and visualization technologies into spatial decision making. Godschalk, McMahon, Kaplan, and Qin (1992) reported on a group design that allowed participants to manipulate criteria during the decision-making process. The key role of data in the decision-making process was also recognized, and collaborative multimedia technologies were used to make data more accessible (Shiffer, 1992). A loose-coupled electronic meeting and map overlay system was also designed for land-use planning applications (Faber, Watts, Hautaluoma, Knutson, Wallace, & Wallace, 1996). The issues of qualitative and quantitative data integration using multicriteria analysis was also at the forefront of research efforts in collaborative spatial decision making

Table 2. Summary description of key concepts that influenced collaborative GIS (Note: The timelines represent the best estimate. There are time lags between when the concepts were formed and when they appeared in some published format.)

ID	Year	Concepts of influence	Summary Description
1	1958	Argumentation (Toulmin, 1958)	Sets out to establish a conclusion based on facts. The fac are connected to the conclusion by another argument call warrant. The warrant is further supported by a backing. Together, these form an argumentation structure.
2	1960	Sketch planning and modeling (B. Harris, 1960)	Deals with the rapid and partial description of scenarios us computer-modeling methods. This was the precursor to present day planning support systems (PSS).
3	1960 - 1970	The Delphi process (Linstone & Turoff, 1975)	The Delphi process is used to explore consensus among decision-making groups. It consists of multiple iterations a feedbacks.
4	1963	Geographic information systems (Tomlinson, 1967)	A collection of computer tools and approaches to capture, manage, and transform spatially referenced data for planr and decisions.
5	1966	Mental maps (Gould, 1966)	Maps in the form of mental images are stored in our consciousness, and they seem to document spatial environmental relationships. Research was focused on clarifying the characteristics and uses of mental maps.
6	1968	Communicative rationality (Habermas, 1971)	A theory that assumes human rationality is a necessary consequence of successful communication. In the theory, implicit knowledge can become explicit through communication and discourse.
7	1969	Design with nature (McHarg, 1969)	Proposed a method for land use and human-settlements planning that involved manual inclusion and exclusion of r based features. The layered analysis approach suggestec here has been adopted by geographic information system design.
8	1969	Ladder of citizen participation (Arnstein, 1969)	Clarified the levels of participation and nonparticipation us ladder metaphor. The bottom rung corresponds to manipulation, and the top rung corresponds to control by citizens.
9	1971	Decision matrix framework (Gorry & Scott Morton, 1971)	Used a matrix to show the interaction between levels of management and decision-making structure at multiple le This was the precursor to decision support systems (DSS
10	1971	Wicked problems (Rittel & Webber, 1973)	A class of problems for which no analytical solutions exist These problems possess 10 characteristics. One characte is that a wicked problem has no definitive formulation.
11	1982	Human computer interaction (Badre & Shneiderman, 1982)	Deals with the design, evaluation, and implementation of interactive computer systems for use by humans.

Table 2. continued

ID	Year	Concepts of influence	Summary Description
12	1985	Group decision support systems (DeSanctis & Gallupe, 1985)	Proposed a system design where the purpose and configuration depended on the length and duration of the decision process, and on the physical proximity of the group members.
13	1985	Computer supported cooperative work (Bannon & Schmidt, 1989)	Addresses the design and deployment of computer technologies to support interactions between groups, teams, and organizations.
14	1985	Hypermaps (Laurini & Milleret-Raffort, 1990)	The spatial referencing of documents and cartographic products in a networked (Internet) environment.
15	1989	Multicriteria spatial analysis (Jankowski, 1989; Malczewski, 1996)	An approach integrating qualitative and quantitative information with MCE in a group spatial decision-making structure.
16	1992	Geographic information science (Goodchild, 1992)	The science that deals with geographic information technologies, designs, and their impacts on individuals and society.
17	1992	The argumentation turn in planning (Fischer & Forester, 1993)	An approach using argumentation to define problems, and structure viable solutions. Argumentation deals with rational persuasion towards changing the perspectives of others.
18	1992	The communicative turn in planning (Healey, 1992)	An approach that used communication to resolve disagreements and conflicts towards consensual solutions. A key goal is to improve local participation in policy processes.
19	1993	Virtual reality GIS (Faust, 1995)	A traditional GIS with a virtual reality interface and interaction method. The intention is to improve communication and collaboration in decision making and simulation contexts.
20	1993	Bioregional mapping (Aberley, 1993)	An approach using biophysical and cultural knowledge as a basis to construct maps of environmental places and spaces. The maps combine scientific and traditional information.
21	1993	Web geographic information system (Palo Alto Research Center, 1994)	Uses a distributed network (LAN, Internet, wireless) to share, process, and transform spatially referenced data.
22	1996	The deliberative turn in planning (Forester, 1999)	An approach where participants deliberate under conditions that support reasoned reflection. Deliberation is the process where individual reflection on issues can lead to a change in perspective.

(Carver, 1991; Jankowski, 1989; Malczewski, 1996). These developments highlight stages in the evolution of a research area that would later come to benefit from a coordinated research direction.

The collaborative spatial decision making (CSDM) research initiative of the National Center of Geographic Information and Analysis (NCGIA), USA, and the first specialist meeting in September 1995 added focus to the research direction of CSDM by emphasizing the design of “highly interactive group-based

Table 2. continued

23	1996	Collaborative spatial decision making (Nyerges & Jankowski, 1997)	A framework integrating aspects and concepts relevant to group, spatial, decision making.
24	1997	Ladder of empowerment (Rocha, 1997)	Clarifies various levels of empowerment by using a ladder metaphor. The bottom rung of the ladder is individual empowerment and the top rung is community empowerment.
25	2001	Geovisualization (MacEachren & Kraak, 2001)	Methods and techniques focusing on the novel display and integrated understanding of large volumes of spatial data.
26	2002	Geocollaboration (MacEachren, Brewer, Cai, & Chen, 2003)	A visual approach to collaboration using geospatial technologies in group processes.
27	2002	Agent interactions (Gimblett, 2002)	A paradigm where human entities are represented as agents in computer environments, and possible collaboration scenarios are explored through simulations.

decision making environments.” The research thereafter reflected this new focus, and there now exists a well-established and growing body of literature on the theory and application of collaborative, spatial, decision making (Densham & Rushton, 1996; Feick & Hall, 1999; Horita, 2000; Jankowski, 1995; Jankowski & Nyerges, 2001b; Jankowski, Nyerges, Smith, Moore, & Horvath, 1997; Jiang & Chen, 2002; Klosterman, 1999; Kyem, 2000, 2004; Malczewski, 1996). However, the multitude of variables that are usually involved in the CSDM process makes it a challenge to conduct experimental studies and compare results across implementations. This was a driving factor in the development of the Enhanced Adaptive Structuration Theory 2 by Jankowski and Nyerges (2001a). The EAST2 framework outlined a detailed configuration of “concepts and relationships linking the content, process and outcome of collaborative spatial decision making.” The content constructs examined the socioinstitutional, group participant, and GIS technology influences. The process constructs examined the social interactions between humans and computers, and focused on structuring the group decision-making process. The outcome constructs addressed societal impacts of the outcome decision.

Geographic data and the structure of the collaborative group process are two important microlevel factors that influence the group constructs of the EAST2 framework. Effective participation and decision making is dependent on access to scientific data and information (Craig, Harris, & Weiner, 2002; Jankowski & Nyerges, 2001b; Nyerges, Jankowski, & Drew, 2002; Sieber, 2000). During group deliberations, many alternative scenarios are generated as a result of the diversity in participant beliefs and interests, and as these scenarios become less distinct, more data and knowledge is required to develop informed solutions. But obtaining this knowledge is difficult, and when available, it is usually partial, transitory, and contested. New and synergistic opportunities for generating relevant knowledge are obtained by aggregating participant knowledge and spatial map data (Jankowski & Nyerges, 2001a). The merging of context-dependent participant knowledge and context-independent spatial data with digital maps and user-friendly exploration tools enhances critical thinking and creativity, producing a comprehensive understanding of values and change structures. The result is broader participant satisfaction, better management plans, and improved decision making (Geertman, 2002).

In recent times, a number of studies have reported on integrating digital map data into the group modeling and decision-making process (Fall, Daust, & Morgan, 2001; Horita, 2000). The general trend has been to use this data either to support existing arguments, or to choose among a predefined set of alternatives. When the data is not integrated into the decision-making process, two negative consequences occur. First, arguments and counterarguments among participants using independent data can lead to more confrontation, due to inherent differences in knowledge sources. Second, participants do not have the flexibility to define or explore common spatial scenarios and therefore, opportunities to develop new perspectives and understanding about an environmental situation are restricted. Despite these disadvantages, the use of prepackaged data in the process has persisted because of the perceived cognitive difficulties that digital map data and supporting technologies impose on participants. However, practical experience has shown that embedded digital-map technology can be modified to suit the needs of a targeted end-user, and that the technologically uninitiated is capable of adapting to new levels of sophistication in short time intervals (Mitcham, 1997; Talen, 1999).

The explicit integration of spatial map data and visual exploration tools into the group decision-making process can be achieved by embedding a collaborative geographic information system into the participatory structures of the process. A collaborative GIS is a tool and a system consisting of a networked collection of computer hardware, software, and user groups with the objective to capture, store, manipulate, visualize, and analyze geographically referenced data and knowledge, so as to provide new information in an institutional setting for solving unstructured planning problems (Armstrong, 1994). As a sociotechnical system, the collaborative GIS facilitates synchronous interactions, as stakeholder and scientific knowledge are combined using exploratory tools to share, annotate, analyze, and visualize numeric, text, and map data in search for solutions within shared geographic place and space (Faber et al., 1996). The collaborative GIS allows for elicitation of knowledge, simulation of data, scenario development, and encouraging spatial critical thinking about all issues. In order to best implement the collaborative GIS to articulate participant ideas, a careful structuring of the group decision-making process is needed for equitable and sufficient issues representation.

Structuring the group decision-making process can help focus the discussions so that constructive ideas are generated during argumentation. Usually, the structuring is conducted in stages involving shared understanding of the environmental situation, criteria identification and ranking, data and knowledge availability, and the generation of alternative scenarios (Godschalk et al., 1992). This is an effective way to integrate individual perspectives, resources, institutions, and organizations towards common solutions. A consequence of integration has been process structuring using top-down, bottom-up, and facilitator-based workshop settings, with advisory committees (Vasseur, LaFrance, Ansseau, Renaud, Morin, & Audet, 1997), participatory democracy (Moote, McClaran, & Chickering, 1997), and cooperative strategies (Lejano & Davos, 1999) being a few of the implementation strategies. Not surprisingly, critics have suggested that some of these implementations are inherently confrontational, and can stall the decision process. But many researchers have pointed out the many long-term partnerships and planning benefits that can accrue by carefully embedding discursive strategies into the participatory decision making process (Healey, 1993; Webler, Tuler, & Krueger, 2001; Wilson & Howarth, 2002).

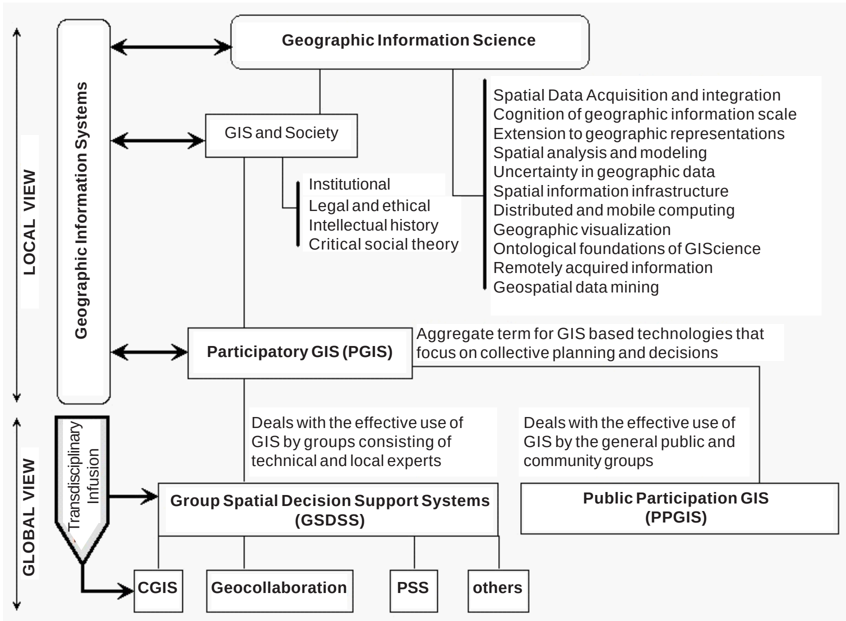
The Delphi method is a focus-group approach that has been applied in a number of recent studies to structure and incorporate discursive strategies into decision making processes (Gokhale, 2001; Hess & King, 2002). The focus group assembles a small number of individuals in a face-to-face collaborative setting to elaborate the details about a particular issue that is initially chosen for discussion by an investigator who structures or moderates the discussions. The Delphi uses a collaborative approach to create a process of building relationships, awareness, learning, and negotiation. During the Delphi, a neutral facilitator elicits individual, anonymous judgment about an issue from a group by using iterative feedback involving a series of rounds of questioning, in order to explore ideas or achieve a convergence of group opinion (Linstone & Turoff, 1975). There are four phases to the Delphi, with the first phase emphasizing the exploration of ideas through individual comments in a structured, brainstorming session. The second phase captures the collective opinions of the group, focusing on agreements and disagreements. The reasons for the disagreements are explored in the third phase. In the fourth phase, an analysis of the opinion convergence on the issues is presented back to the group for final evaluation. The Delphi allows for improved understanding of the decision problems, goals, and objectives, and is useful when there is limited knowledge and data, strong conflict, and when interpersonal interaction is difficult to organize (Linstone & Turoff, 1975). The Delphi has been integrated within a collaborative GIS design to structure environmental planning and decision-making processes (Balram, Dragicevic, & Meredith, 2003, 2004).

Participation in the collaborative, spatial, decision-making process has been an ongoing issue of concern in environmental and community planning (Brandt, 1998; Ghose, 2001; Harris & Weiner, 1998; Sieber, 2000; Talen, 2000). At the basic level, participation can be interpreted to mean the inclusion of a wide range of stakeholder inputs to all stages of the planning and decision-making process. In order to structure and operationalize the concept of participation, Arnstein's "Ladder of Citizen Participation" (Arnstein, 1969) and Rocha's "Ladder of Empowerment" (Rocha, 1997) are two frameworks of analysis widely used in the planning and decision-making literature. The central arguments of both "ladders" and their adaptations to specific contexts is that through a process of collaboration, participation becomes a knowledge sharing and knowledge producing activity capable of initiating social and political change (Baum, 1999; Healey, 1997). Also, a useful adaptation to Arnstein's ladder is presented in Whitman (1994). Whitman attributes varying levels of expert (those possessing "specialist knowledge" of relevance) involvement in each stage of the Arnstein ladder. At the lower end (individual involvement) of the Arnstein ladder, Whitman attributes a detached expert who is removed from the end user in the decision-making process. At the upper end (community involvement) of the Arnstein ladder, Whitman attributes an absent expert, and action is initiated from collective community initiatives. Collaborative GIS targets a middle ground and works at the "partnership" level of the Arnstein ladder, which has been mapped to the "expert as a team member" in the Whitman ladder. Adopting this position in the "ladder" hierarchy makes the focus one of balancing issues of concern gathered at the individual, expert, and public levels.

Collaborative GIS: A Structure of the Research Area

The intellectual landscape of collaborative GIS can be structured by considering two scales. The first scale can be termed a local interdisciplinary view, where the research agenda of geographic information science situated in the upper hierarchy guides the research directions of collaborative GIS located at a lower

Figure 2. The intellectual structure containing collaborative GIS



level in the hierarchy (Figure 2). The second scale can be termed a global transdisciplinary view, where the adoption of new ideas into group spatial decision support systems (GSDSS) from diverse disciplines, coupled with improvements in Internet and wireless technologies are evolving towards a *distributive turn* to planning, problem solving, and decision making.

GIScience is now fairly well established as a discipline, with a diverse set of themes and subareas complete with research challenges and agendas (McMaster & Usery, 2005). Figure 2 shows the themes of GIScience and the subareas, such as spatial data acquisition and integration, cognition, scale, and so on. Of the subareas, GIS and Society is the most relevant for collaborative GIS (Elmes, Epstein, McMaster, Niemann, Poore, Sheppard et al., 2005). GIS and Society addresses institutional, legal and ethical, intellectual history, critical social theory, and participatory GIS issues. There may be some disagreement on whether participatory GIS or public participation GIS should be higher in the GIScience hierarchy. We suggest that PGIS is a more general concept, and should appear higher in the hierarchy. Both GSDSS (small groups) and PPGIS (large groups) are directly related to group decision making, and are members of the participatory GIS category. Collaborative GIS, geocollaboration, and planning support systems are all GSDSS implementations. However, the presence of fuzzy linguistic terms such as “small,” “groups,” and “public” will make the structure presented here open to further refinement.

The local interdisciplinary view of collaborative GIS is guided by the geographic information science research agenda. The concepts are interdisciplinary, meaning that the goal is to synthesize two or more disciplines with the intention of creating a coordinated whole. In this view, the research and application focus of collaborative GIS is towards establishing stronger linkages with GIScience. Geographic information systems intervene at all levels of the hierarchy.

The global transdisciplinary view of collaborative GIS is guided mostly by the concepts of theory, experimentation, and simulation as means to explore reality. The concepts are transdisciplinary, meaning that multiple perspectives are integrated and transformed to create new knowledge to solve complex societal problems. It is in this transdisciplinary direction that current collaborative GIS initiatives seem to be focused. The most likely scenario is a *distributive turn* to planning, problem solving and decision making. There are already signals in the research literature (for example: Dymond, Regmi, Lohani, & Dietz, 2004; Schafer, Ganoe, Xiao, Coch, & Carroll, 2005) to suggest that a distributive turn is underway.

Conclusion

Progress in collaborative GIS is hinged on an understanding of the historical background of concepts, and the dynamics that are shaping its future. This study has proposed a working definition of collaborative GIS, and presented a philosophical description of the research area. A discussion about the historical background adds justification to the proposed definition. Conceptual linkages between GIScience, public participation GIS, participatory GIS, and CGIS are also presented. An important conclusion is that collaborative GIS is centrally positioned on a participation spectrum that ranges from the individual to the general public, and that argumentation, deliberation, and maps are the common means used to structure and reconcile differences between representative interest groups. Collaborative GIS must give consideration to integrating experts and the general public in synchronous and asynchronous space-time interactions. It is suggested that collaborative GIS theory provides a foundation to conceptualize a *distributive turn* to planning, problem solving, and decision making.

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