



Research Article

Geographies of the information society

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Abstract. This article presents the Varenius perspective on the societal dimensions of geographical information technologies and the geographical dimensions of information technologies in general, and puts them in the context of the research literature of the last ten years. The central themes examined are: theoretical perspectives on the societal implications of geographical information technologies; the changing significance of key geographical concepts in the information age; and societal aspects of the practical application of geographical information technologies. The relationships between these themes and three NCGIA Varenius research initiatives on geographies of the information society are summarized, and some directions for future research in this broad area are outlined.

1. Introduction

This review article introduces the theme of the third component of the Varenius project, known as the Apex, relates it to the other two major Varenius themes, and presents its constituent research areas as reflected in the three research initiatives organized by the panel. By exploring recent writings and calls for papers in this area, the article also attempts to elucidate more generally the state of research and thinking on the geographies of the information society as of 1998, as viewed from the perspective of geographical information research. Its purpose is thus threefold. First,

we introduce the three Apex research initiatives held in October and November of 1998, in the context of a more general assessment of the field. In chronological order these are: (1) 'Place and Identity in an Age of Technologically Regulated Movement', (2) 'Empowerment, Marginalization, and Public Participation GIS', and (3) 'Measuring and Representing Accessibility in the Information Age'. Second, the paper will serve as a benchmark by which to assess, a few years from now, the specific contributions of the Varenius project to that increasingly vital research area. Third, we hope that this effort by a small group of researchers associated with the Varenius project will elicit a broader discussion and alternative interpretations of the issues involved, leading to further concerted research programs in the area.

The title 'geographies of the information society' must be qualified for the purposes of this essay, as it can mean many different things. It can mean the *actual geographies* that evolve on the surface of the Earth in the information age: the changes in and among places resulting from the increased ability to store, transmit, and manipulate vast amounts of information, and the new patterns of geographical differentiation, privilege and disadvantage that these changes are bringing about (the geographical consequences of 'informationalism': see Castells 1989, 1996, Graham and Marvin 1996). Or it can mean the *virtual geographies* that are directly the product of the information and electronic communication technologies: the geographical study of the invisible but almost ubiquitous information networks, with their nodes, links, connectivities, and flows, along with the social, cultural, economic, and professional networks that coalesce around the electronic ones. 'Cybergeography', or the 'geography of cyberspace', currently the domain of a small though rapidly growing research community, is likely to become a mainstream area of research in the next few years (Mitchell 1995, Adams and Warf 1998, Kitchin 1998). 'Geographies of the information society' can also designate the *conceptual geographies* gradually constructed within individual and social consciousness through the representations of the Earth conveyed by digital geographical information technologies: this would in a sense be closer to the original meaning of geography as 'writing about the Earth'. How might we write about the Earth, in its infinite variety and interacting dimensions, in a context where the possible forms of representation are constrained by and filtered through the stringent logical and technical requirements of digital systems? What are the epistemological implications of tailoring our understanding of the Earth's complexity to that which can be recorded on electronic media, and accessed only with the requisite hardware, software, network connections, and technical know-how? The kind of knowledge that emerges within the fairly well-circumscribed universe of geographical information systems is the product of specific technological, institutional, corporate, and intellectual trajectories, and the geographies that we are able to write in that context are necessarily constrained by the limits of that particular worldview (Sheppard 1995).

Clearly these different meanings of 'geographies of the information society', though distinct, are interconnected. They all are about places and relations among places and the individual and social lives that are an integral part of these, and they necessarily also include the circular connections between how people understand, create, and use these places and relations in the information society. This is why, rather than opt for one or the other interpretation the Varenius Apex has taken an eclectic view, synthesizing questions about actual, virtual, and conceptual geographies. The choice of questions has been guided by two kinds of considerations. First, they must relate to geographical information science and technology, which is the

focus of the Varenius project, and more specifically to the two other major Varenius themes: Cognitive Models of Geographical Space, and Computational Methods for Representing Geographical Concepts. The second criterion is more opportunistic. It considers the state of the art in geographical thinking and writing about the information society as of early 1998, the year when these questions were formulated, and seeks to identify issues that have been widely recognized as being of major import but have not yet been the subject of substantial research efforts elsewhere.

The paper is organized as follows. We first outline briefly the Varenius project and the three Apex research initiatives within it. We then review three major research areas within the wider theme of the geographies of the information society, each of which has a special connection with one of the three Apex initiatives: (a) theoretical perspectives on the societal implications of geographical information technologies; (b) changes in the meanings of key geographical concepts induced by the information age, and the empirical correlates of such changes; and (c) the relationship between the practical application of geographical information technologies and the societal context within which this is occurring. Our review is necessarily eclectic, focusing on aspects of these broader themes that can be directly linked to the three Varenius initiatives. We close by sketching a tentative road map for future research in the geographies of the information society.

2. The Varenius project and the Apex initiatives

The question of how the geographical world is understood by humans and represented in machines is at the core of the Varenius research agenda. The thematic area entitled Cognitive Models of Geographical Space investigates how people understand geographical entities and relations, how they reason and talk about these, in what respects these cognitive models are similar or dissimilar with the formal representations of these entities and relations in geographical information technologies, and how can the latter be better in tune with the former. The Computational Methods for Representing Geographical Concepts area views similar questions of geographical concept definition and adequacy from the perspective of computer languages, data models, visualizations, and interoperating systems. The Apex thematic area is in many ways the societal counterpart to the individual cognition stressed in Cognitive Models of Geographical Space. Here it is the social origin and evolution of geographical concepts that is highlighted, along with the societal issues arising from the changing patterns of opportunity, privilege, power, disadvantage, discrimination, equity, or liberty that these changing concepts reflect. The three Apex initiatives bring the geographical information science perspective to bear on these issues, investigating the role of geographical information science and technologies in helping both to construct and to study these evolving information-age geographies. Moreover, an increasing number of social theory scholars suggest that, before the combined commercial, government, and academic enterprise pursues the next generation of geographical information technologies, we might well try to identify the social bases and limitations of the current generation (Goss 1995a, Pickles 1995b, Sheppard 1995, Curry 1997a). How have the current models of geographical space in our systems been developed? What cognitive and social understandings of geographical space may have been left out? How have these *lacunae* affected the utility of the systems for different groups, or for different purposes? How might they be filled? The three Apex initiatives are designed to address selected aspects of these broad and profound questions, along with some more technical but

equally important ones dealing with how we can understand, measure and represent the evolving new geographies.

The purposes and foci of the three Initiatives are best seen in the original calls for papers (see www.ncgia.ucsb.edu/varenius/initiatives/ncgia.html). The rationale for each is summarized in the following excerpts from the calls.

2.1. *Place and identity in an age of technologically regulated movement*

This initiative investigates geographical aspects of the interplay between information technologies and society, in particular the dissolution of traditional territorial identities and the formation of new ones around new kinds of communities and places held together largely by electronic connections:

'The nation-state is rather new, but identity and boundaries have always been related, just because identity-formation involves the differentiation of oneself or one's group from others. ..[T]he nation-state has promoted a powerful image of identity, as something that can be described in terms of borders in a landscape and lines on a map... [G]eographically-based forms of identity have remained important, even central, in the lives of most people. But with the advent of modern communication technologies, apparent alternatives to place-based identity systems have become increasingly visible. Indeed, the Internet or cyberspace has been touted by many as constituting the most far-reaching challenge yet to the strength and persistence of place-based identity... [I]t is often overlooked that the Internet and the dramatically increased flow of ideas has emerged within a larger context, of the unprecedented flow of people and goods... [T]he increased flows of goods and people, and the rise of new mechanisms for the regulation of each raises interesting questions about the future of geographically based identities. Place is a basic and enduring geographical concept, and the prospect that it needs to be rethought as a result of new information technologies in general, and geographic information and geographic information technologies in particular, poses a basic research challenge.'

2.2. *Measuring and representing accessibility in the information age*

This initiative investigates the effects of information and communication technologies on accessibility, the resulting changing meanings of that fundamental geographical concept, the societal and geographical implications of these changes, and the role of geographical information technologies in both bringing about and helping study these changes:

'Concepts of potential and realized interaction and accessibility are central to geographic theory and models. Current models are based, however, on physical notions of distance and connectivity that are insufficient for understanding new forms of structures and behaviours characterizing an information age...Through technological, structural but also social developments, an increasing range of transactions takes place in virtual space, or in some new hybrid space combining the physical with the virtual... Accessibility, both within and to communications and transportation networks, is the central concept in the geographic definition of opportunity... Since the information age has not made the information society ubiquitous, it is essential that geographical and planning models incorporate measures that reflect restructuring of geographical space and space-time differentials in accessibility to virtual networks... By helping to reconceptualize accessibility through appropriate representations of accessibility opportunity and inequality, this Varenius initiative seeks expanded models of space (and time) that encompass both the physical and the virtual.'

2.3. *Empowerment, marginalization, and public participation GIS*

This initiative approaches the GIS and Society theme from a more applied perspective, focusing on the potential role of GIS as a tool (or, on occasion, liability)

in the democratic process of grassroots community self-determination. This initiative was developed to attract significant numbers of community-level GIS practitioners as well as academics:

'GIS is alternatively seen as a powerful tool for empowering communities or as an invasive technology that advantages some people and organizations while marginalizing others... This initiative will examine the two-edged nature of the GIS sword by defining and executing research projects that involve researchers looking critically at the use of GIS by community groups or by others using the technology in ways that impact individuals and communities.

Collectively, we use the term Public Participation GIS (PPGIS) to cover the range of topics raised by the intersection of community interests and GIS technology. ... This initiative is concerned with the social, political, historical, and technological conditions in which GIS both empowers and marginalizes individuals and communities.'

Each of these initiatives fits within a wider research area reaching far beyond the Varenius effort, namely: (a) theoretical perspectives on the societal context and implications of geographical information technologies, and on the geographical implications of information technologies in general; (b) the study of changes in the meanings of key geographical concepts induced by the information age, and the empirical implications of these changes; and (c) issues of democracy and individual rights arising from the practical application of geographical information technologies. In the following three sections we view each of the three Apex initiatives against the background of past research in these three broad areas.

3. Theoretical perspectives on geographical information technologies and society

Research examining the two-way relationship between geographical information technologies and the societal context within which they are being developed and applied has undergone an explosion in this decade, triggered by a debate between social theorists and GIS specialists in the early 1990s. Initially this debate was highly antagonistic. An acrimonious exchange between Taylor (with Overton) and Openshaw pitted a social theoretic perspective critical of the positivist and reductionist nature of GIS against a visionary perspective of GIS as liberating and unifying geography (in chronological order: Taylor 1990, 1991, Openshaw 1991, 1992, 1993, Taylor and Overton 1991, Taylor and Overton 1992, Dobson 1993). This abstract discussion of philosophical and methodological limitations and possibilities was followed by more empirical arguments, highlighting a number of negative social impacts associated with the spread of GIS applications (Pickles 1991, Smith 1992, Lake 1993). As a consequence, by 1993 there was little constructive communication between GIS researchers and practitioners on the one hand, and social theoretic critics of the GIS research agenda on the other. Two 'cultures of indifference' focusing on the same technology had emerged (Pickles 1999).

This began to change at a workshop on Geographic Information and Society organized by the NCGIA in November 1993 in Friday Harbor, WA, shortly before the publication of *Ground Truth*, a landmark book on that general theme edited by John Pickles (1995a). The meeting brought together representatives of both viewpoints and evolved into a constructive engagement between the two. Publication of a special issue of the journal *Cartography and GIS* (Poiker and Sheppard 1995) enriched the discourse on these questions, giving proponents from both sides a chance to air their different perspectives constructively in print. It is interesting to compare that issue with the Pickles volume for a sense of how debates shifted as a

result of the meeting. A further major outcome was the NCGIA Initiative 19, entitled 'GIS and Society: The Societal Implications of How People, Space, and Environment are Represented in GIS' that was launched by a group of Friday Harbor meeting participants with the purpose of laying out an agenda for research in the area of GIS and society.

The specialist meeting for Initiative 19 took place in Minnesota in March 1995 and drew equally and in a very constructive atmosphere on the ideas and perspectives of both social critics and GIS researchers (Harris and Weiner 1996, Pickles 1999). Participants at that meeting identified the following themes as worthy of further research: limits of representation in GIS; the societal impact of GIS use; a critical history of GIS; ethics, privacy and GIS; alternative GIS, or GIS2; the use of GIS in debates about global change; and gender and GIS. Some of these themes have since been pursued systematically by Initiative 19 participants and others.

By 1998 Michael Curry could assert that it was time to move beyond the GIS and society debate (Curry 1998). This does not mean that a common perspective has emerged, nor that it should emerge; tension between research perspectives is healthy for the development of any research program. Some continue to claim that there is still too little reflection within the GIS community on societal context and the social implications of the technology, whereas others argue that these problems have been over-rated or can be addressed within the domain of ongoing GIS research. Yet things have changed a great deal since the debates of the early 1990s. Both sides now recognize that a number of GIS researchers have a track record of concern for the social implications of geographical information technologies, and that such concerns are becoming more widely shared within the GIS community. It is equally clear that critics often work from a sophisticated understanding of geographical information technologies, and that the debate no longer is between those who only understand GIS and those who only understand social theory. New bi-partisan networks of collaboration have resulted just as we witness the emergence of new debates taking shape along new, less well-defined boundaries. These are as much within as between the two groups that originally constructed themselves as being in polar opposition to one another (Chrisman 1987, Edney 1991, Sui 1994, Curry 1995, Miller 1995, Obermeyer 1995, 1998, Pickles 1997, Wright *et al.* 1997, Flowerdew 1998, Harris and Weiner 1998, Couclelis 1999).

Theoretical perspectives on geographical information technologies inform all three Apex initiatives, and remain an active area of research outside the themes focused on by Varenus. For example, Nyerges and Jankowski (1997) examine how collaborative decision-making with GIS can be conceptualized through the lens of structuration theory, and Harvey and Chrisman (1998) are actively exploring how contemporary theorizations of the practice of science provide insight into the two-way relationship between society and geographical information technologies. There is an extensive literature outside geography addressing these issues. Yet the initiative most directly related to the theoretical issues underlying the Initiative 19 research tradition is that entitled 'Place and Identity in an Age of Technologically Regulated Movement'. This initiative seeks to unravel the societal implications of both the vastly increased personal mobility and the increasing use of information technologies, and in particular geographical information technologies, to monitor and record the movements of people from place to place and at any time. It addresses profound questions regarding the ongoing detachment of community, identity and territory from contiguous spatially bounded places. At the same time, questions of privacy,

surveillance, and democracy loom large. The initiative addresses these issues in the context of the following more specific questions, spelled out in the call for papers:

- What have been the traditional means for the regulation of borders? In what ways have they been successful in promoting territorially based identities?
- How has the development of modern communications and especially geographical technologies altered the regulation of flows of people, goods, and information?
- To what extent has the regulation of borders at various scales—from neighbourhood to nation state and beyond—moved away from geographical borders, and been replaced by ubiquitous forms of control?
- How are these various regulatory regimes related to personal and group identity?
- How have alternative, non-place-based identities been promoted and maintained? How have they been controlled, and how successful have these controls been?
- What lessons relevant to the world of the Internet can be learned from these experiences?
- What future is there for borders and boundaries in a world where ‘there is no there’?

4. Representing the changing meanings of geographical concepts

The meanings of geographical concepts, as with all concepts, keep evolving under the combined effects of a changing empirical world and changing societal modes of thinking about and acting in that world. Geographical information technologies contribute to the ongoing redefinition of geographical meanings on both these fronts, by affecting both the tangible urban and regional structures that we study as well as our ways of dealing—conceptually, politically, or practically—with these new geographies. Moreover, geographical information technologies have the peculiar distinction of both contributing to changes in the meanings of geographical concepts, and of attempting to provide suitable and sufficiently robust representations for these meanings. This section considers that double aspect of geographical concept change, and outlines how the Varenus project and its immediate precursors have been addressing that issue.

The implications of the diffusion of geographical information technologies for how the geographical world is represented and understood were a major theme in Initiative 19. Geographical information systems are the most successful technologies in history for representing, manipulating, analysing and storing knowledge about the geographical world. At the same time, their power to privilege certain kinds of representations and to generate their own variety of geographical meanings cannot be overestimated. Considerable critique has focused on the ontological and epistemological assumptions underlying GIS, in particular the Euclidean, Cartesian, and positivist conceptions of geographical space on which it is built (Pickles 1995b, Sheppard 1995). According to that critique, GIS tend to embed a powerful and particular ontology of space deep into the practices that surround their application. As a consequence, many key geographical concepts are being implicitly redefined by both GIS developers and users to fit the constraints of that positivist, Cartesian ontology. Take for example the fundamental concept of *place*. Critics point out that the ontology of GIS sees the geographical world as being subdivided into spatial

units that can be represented as sharply defined, contiguous, non-overlapping polygons. Captured or processed data become the reduced, sole signifier of such units—towns, neighbourhoods, census tracts—and at the same time their representation and simulation. The signs become coded as the signified, and place is reduced to a geometric object (Shields 1995). But place is not some unitary Euclidean phenomenon—some well-circumscribed spatial unit that can be represented unproblematically as a shape on a computer screen. Rather, as critical theorists point out, it is a dynamic, relational phenomenon made of multiple, superimposed space-times, which jostle and compete through the subjectivities, discourses, and representations of the social world. As Massey (1993: p. 66) puts it, places need to be defined in dynamic and relational rather than static and geometric terms; as ‘articulated moments in networks of social relations’ rather than as ‘areas with boundaries around’. Stressing the constant ‘becoming’ of places, Thrift (1996: p. 1485) writes: ‘There is ... no big picture of the modern city, but only a set of constantly evolving sketches’. Nothing could be further from the ontology of the Cartesian grid. The above-mentioned Varenus initiative on place and identity addresses some of these issues.

According to the critics, similar problems hold for other aspects of geographical space that geographical information technologies also reduce to geometric configurations (primarily, points, polygons, networks, and bounded regions), as only these can satisfactorily be represented through the (digital) Cartesian gaze (Virilio 1991). These artefacts provide rigid categorizations through which meanings about the geographical world are constructed and communicated: one space becomes ‘urban’ and ‘housing’, the next ‘green belt’ or ‘environmentally-sensitive area’, the other an ‘area of social deprivation’, and so on. These definitions then go on to influence social action, spatial practices, and, in turn, the on-going production of space. Ontology thus shapes representation and linguistic construction in what Bibby and Campbell (1998) call a process of ‘representational stabilization’—the production of taken-for-granted boundaries and differentiated categorizations about spaces, characteristics, and boundaries across the Euclidean plane that go on to shape the application and impacts of GIS in practice. For example, the use of geodemographic databases to support GIS-based informal redlining by banks, insurance firms, or retailers, may aggravate spatial discrimination which then further undermines the socio-economic fortunes of an area, leading recursively to further redlining and an accelerating slide down the spiral of decay. As Bibby and Campbell (1998: p. 9) suggest, the ways in which socio-spatial entities are configured or represented in terms of geometrical boundaries and polygons allows them to be reduced to essential, ‘ordinary things’. This closes meaning, ‘reifies spatial definitions’, and generates a spurious integrity for categorizations and generalizations about the social world (Shields 1995). Moreover, as Pickles (1995b) and Curry (1994) have argued, GIS researchers have all too often understood the dynamics of this process of representation and meaning creation as a purely technical one, expecting that the honing of algorithms and the availability of faster computers will eventually lead to the perfect GIS-based representational tool. This is what Pickles (1991: 80) has called a ‘mythos of liberating technology’.

These are indeed serious issues that have not gone unnoticed by the GIS community. Since the days of the Friday Harbor meeting and Initiative 19 an increasing number of GIS researchers and practitioners have critically reflected upon and analysed the fundamental epistemological principles and geographical conceptualizations that provide the essential underpinning to their work. Crisp polygons are no

longer seen as unproblematic representations of places and phenomena (Burrough and Frank 1995). Socio-economic units of data collection or administration are no longer understood as inert geometrical configurations. The multiple levels of meaning of the phrase 'GIS and society', from the most mundane and practical to the ontological, are being examined (Nyerges 1991, Couclelis 1999). Finally, as mentioned earlier, a large part of the purpose of the Varenius theme of Cognitive Models of Geographical Space is to take a close critical look at the discrepancies between human and mechanical representations of geographical concepts.

However, changes in the meanings of geographical concepts do not only—or even primarily—occur through societal re-interpretations and re-constructions. Geographical concepts also change because the corresponding entities and structures change in the empirical world around us. For example, the meaning of distance is profoundly affected by the socio-economic, institutional, and technological developments of the information age (Virilio 1995, Couclelis 1996a, Cairncross 1997). These not only make physical travel faster, easier, and more of an integral part of everyday life than at any time before; they also, in a sense, annihilate distance by rendering instantly accessible, from any suitably equipped location, information originating at places that may be arbitrarily remote in geographical space. The shifting emphasis from distance to connection as the key explanatory variable of socio-economic structures in geographical space reflects contemporary trends towards a 'network society' (Castells 1996). The term implies that the relational interweaving of connections and disconnections within and between places, based largely on information technologies (IT), telecommunications, and fast transport grids, is reaching unprecedented depth and intensity (Amin and Graham 1997, 1999, Castells 1996). Physical proximity no longer signifies meaningful connection, as is usually implied by the 'first law of geography'—namely, that nearby things tend to be more connected. Far-distant nodes, spaces, and places (airports, sea ports, elite spaces, corporate locations, back offices, financial trading areas, Internet sites, 'cyberspaces', and media flows) can be drawn together into intimate exchange with each other across the planet, while being relationally severed from physically adjacent barrios, ghettos, back-countries, and other marginalized areas (Boyer 1996, Graham 1998). Instantaneous, trans-global switchings of billions of dollars between financial centers, as well as international airline flight paths, pass over, through, within and between places where mobility and access of every kind are highly limited and circumscribed.

The Varenius Initiative on Measuring and Representing Accessibility in the Information Age is designed explicitly to address issues arising from the changing meanings of distance, connection, and access in contemporary society, as spelled out in the call for papers. In contrast to the place and identity initiative, which takes a broad theoretical perspective on the changing significance of that other fundamental geographical concept, place, the accessibility initiative focuses on the more technical and measurable aspects of such changes. As in the case of place and identity and Initiative 19, there was a precursor NCGIA-sponsored meeting to the accessibility initiative that was held in Baltimore, MD in September 1996. The meeting, entitled 'Spatial Technologies, Geographic Information, and the City', identified accessibility as a pivotal concept in understanding the far-reaching changes in urban organization and society brought about by the information age (Couclelis 1996b). Some of the questions addressed by the accessibility initiative are as follows:

- What are the information age counterparts to the accessibility and potential surfaces developed for interaction in physical space?

- What space–time topologies need to be developed to accommodate both the physical and virtual worlds?
- How do emerging conceptions of virtual space map onto traditional conceptions of geographical space and how do we handle their interfaces analytically?
- How can interactions and accessibility gradients within these new hybrid spaces (and space–times) be represented and visualized within GIS?
- How useful are traditional spatial interaction and urban computable general equilibrium models for the analysis of the new forms of accessibility? How should they be altered?
- What are the technical and societal impediments to network access in different social domains, particularly for geographical information?
- What representations can highlight patterns of lack of access independently of the lack of interaction?

5. The practice of GIS, societal context, and representations of the world

Next to the more theoretical investigations, an extensive body of research has examined the adoption and utilization of geographical information technologies. Questions examined include the human, organizational, and institutional aspects of GIS implementation (Crowell 1991, Azad 1993, Azad and Wiggins 1993, Budic 1993, Budic and Godschalk 1994, Pinto and Azad 1994); the assessment of the institutional and societal value of geographical information and geographical information technologies (Dickinson and Calkins 1988, Dickinson 1989, Donelan 1993, Epstein and Duchesneau 1990, Gillespie 1991, 1992, Steeger 1991, Smith and Tomlinson 1992, Donelan 1993, Lopez 1996a, b); the evaluation of GIS adoption and management by organizations (Obermeyer 1990, Onsrud and Pinto 1993, Pinto 1994, Campbell 1994, Budic 1994, Obermeyer and Pinto 1994); the diffusion of geographical information innovations (Onsrud and Pinto 1991, Masser and Onsrud 1993, Grimshaw 1994); the sharing of geographical information among organizations (Onsrud and Rushton 1995); and the design of new kinds of geographical information systems based on social and cultural goals (Chrisman 1987). Much less has been documented about the extensive growth in the development and diffusion of GIS by military and espionage institutions (but see Cullis 1995).

While this body of research is documenting the diffusion of current GIS technology and its utility for agencies and institutions, it has paid only a limited degree of attention to examining the societal context influencing the nature of GIS practices, or to the broader societal implications. Nicholas Chrisman, together with Francis Harvey, has explored the question of the nature of the practices that result from GIS adoption (Harvey 1997, Harvey and Chrisman 1998). Rather than focusing on GIS as a fixed set of technical tools with presumably beneficial impacts from appropriate adoption, they argue that the practice of GIS depends not only on the technology used but also on the cultural and institutional context within which it is implemented. Drawing on comparative case study analysis of GIS use in different national cultures, and in different institutional contexts in the US, and on the writings of Bruno Latour (1987) about the practice of science, they argue that the technology (both GIS and geographical databases) and the context co-evolve. Thus, rather than conceiving of GIS as a fixed entity diffusing through social institutions, it is conceived of as an evolutionary practice; an emergent property of the interdependence between technology and societal context.

Other researchers have focused on the societal implications stemming from the kinds of representations of the world that current geographical information technologies privilege (Sheppard 1995). They observe that whereas GIS may be beneficial for public and private agencies and institutions, it remains vital to interrogate the impact of GIS practices on the remainder of society. In this view, even democratic political processes do not mean that state agencies are accountable to, or act in the interest of, all social groups; and neither do market processes guarantee that profit-seeking firms promote general economic and social welfare. (The term 'state agency' is used here to denote the variety of public and quasi-public agencies, at levels ranging from local municipalities to supra-national institutions, whose activities are linked to government.) The databases and analytical capacities that state agencies derive from using GIS have two kinds of potentially negative consequences. On the one hand, GIS enhances the capacity of state agencies to increase their surveillance of society, with negative consequences for those social groups whose interests conflict with those of state agencies and their representatives (Gandy 1989, Pickles 1991, Smith 1992, Clarke 1994, Clark 1998). On the other hand, in conflicts between state agencies and civic society over land use and other location issues, privileged access to GIS and spatial databases can enhance the power of those agencies and thus reduce the effectiveness of democratic processes to influence state policy (Archer and Crosswell 1989, Edney 1991, Yapa 1991, Lake 1993, Aitken and Michel 1995, Miller 1995). Similarly, analysis of the use of GIS by private firms for geodemographic marketing has shown that sub-populations and neighbourhoods are characterized by consumer profiles that homogenize the treatment of those groups and places, in terms of both the products marketed to them and the putative impact of targeted marketing on consumer habits and neighbourhood characteristics (Goss 1995a, b, Curry 1997a, b). Provocative hypotheses about the concrete impact of such processes on the homogeneity of and differences between neighbourhoods and their residents, stemming from these observations, remain to be investigated.

The tendency privileging access to GIS in public and private institutions, relative to their availability to the general public and to civic and grassroots organizations, is opposed by a counter-tendency towards smaller and cheaper systems that can be installed and used by the general public. This counter-tendency has the capacity to enhance the power of the organizations and movements of civic society in democratic processes, and thereby increase their potential influence over public agencies and private institutions (Dangermond 1988, Yapa 1989, Edney 1991, Ferber 1992, Barndt and Craig 1994, Van Der Meulen and Lively 1994, Schmitt 1997, Craig and Elwood 1998, Elwood and Leitner 1998, Shiffer 1998). In this context it has been noted, for example, that GIS is being used more frequently by Indian tribes (Marozas 1993, Bird 1995, Brown *et al.* 1995, Jarvis and Spearman 1995, Kemp and Brooke 1995, Nietschmann 1995). In addition, the US Department of Housing and Urban Development (HUD) is subsidizing and promoting the adoption of GIS by neighbourhood groups (Kingsley *et al.* 1997, US HUD 1997). The adoption of GIS by such organizations raises further questions about social consequences, however. There are numerous institutional and political barriers to the successful use of GIS by community and grassroots groups (Yapa 1991, Hutchinson and Toledano 1993, Barndt 1998, Clark 1998, Harris and Weiner 1998). Elwood and Leitner (1998) show that community organizations have very different capacities to take advantage of GIS technology, depending on their awareness of technology; their financial resources; the networks of which they are a part; the availability of appropriate

expertise; and their ability to integrate GIS use into organizational practices. In addition, community and grassroots organizations are also not an automatic panacea for deleterious state and private sector actions. Elwood and Leitner (1998) find that neighbourhood organizations seem willing to employ GIS for surveillance purposes, recreating at a local scale some of the negative consequences of GIS use. Community and neighbourhood organizations are engaged in their own power struggles, within the organization, with other such organizations, and with more formal agencies and institutions, and the outcomes of those struggles do not necessarily benefit all those who such organizations purport to represent.

Negative social consequences may also emerge from inequalities in access to spatial data. Data are the raw material to which intellect may be applied in order to create and to learn, from which answers may be sought, and from which new intellectual works may arise. Without access to data, geographical information technologies cannot be applied to the exploration of real-world physical or social phenomena. In the past, government has maintained a heavy role in collecting geographical digital data and characteristics of locations. It also has organized massive amounts of other government-collected information through geographical indicators. The dominance of government in the collection of geographical data gives rise to the concern that the state might unintentionally or purposely control the ability of citizens to ask questions. If data do not exist or access to collected data is denied, unlimited access to hardware, software, and expertise will be of little benefit to a citizen inquirer. The potential trend towards diminishment or loss of the current US public commons in geographical information is an important aspect of these issues. Government agencies at all levels in the US are moving towards contracting with private firms for the collection and maintenance of geographical databases whenever possible rather than using government personnel. As a result, in many instances, private ownership interests are now attached to many of the geographical data sets and products used by government agencies in their decision-making. Such databases become far less available for general use by citizens. Corporate firms with vested interests in large accumulations of factual information are pressing for new laws that would grant them ownership interests in compilations of information that are far more extensive than provided under traditional copyright law concepts (e.g. House of Representatives Bill 2652, 1998, 105th US Congress). As businesses and other societal institutions move to offering data and information primarily in digital formats, the concept of fair use is dwindling and may be eliminated altogether.

It would be a mistake to rely primarily on the marketplace to define the relationships between public access and private rights in geographical data sets in future digital library environments, and yet the prevailing response of the research community to date when confronted with these issues has been to claim that 'the marketplace will take care of it'. The research and scientific community is only just beginning to recognize the potential ramifications that loss of the public commons in geographical data might have and has yet to begin concerted research to explore this arena. 'Without equitable access to GIS data and the technology, small users, local governments, nonprofit community agencies, and non-mainstream groups are significantly disadvantaged in their capacity to engage in the decision-making process' (Harris *et al.* 1995: p. 203).

The use of GIS requires heavy dependence on secondary data sources. Means and methods for maintaining and extending access to secondary sources is a major challenge for the research community. Similarly, exploration of approaches and

methods for collecting and merging local data and local knowledge with other forms of knowledge within geographical information processing and analysis environments remains a substantial research challenge.

5.1. *Legal and ethical aspects of GIS in societal context*

Several areas of law are substantially influencing the development of geographical information systems and, in turn, controversies over geographical information and technologies are helping to form information policies and laws at local to national levels. In 1994, the National Center for Geographical Information and Analysis began a research initiative on Law, Information Policy, and Spatial Databases. The overall goals of this initiative were to advance scientific understanding of the law and information policy within spatial database environments; raise the quality and content of the debate about law and GIS by identifying issues in concrete terms with a high degree of specificity; report observations of the law in action in order to explore the impact of spatial databases on public information policy and law, and, conversely, report observations of the law's acceptance of GIS uses and practices; identify emerging problems at the interface of law, information policy, and spatial databases in order to address those problems prospectively, with particular focus on legal issues relevant to the National Spatial Data Infrastructure; and divulge, test, and contribute knowledge useful in the improvement of public policy and formulation of law with respect to the use of spatial databases and related technologies.

Progress has been made by researchers in both the US and Europe in pursuit of all of these goals over the past several years. However, the exploration of any one issue and its resolution in a particular context typically gives rise to numerous additional knowledge gaps and unanswered questions. For instance, even if a workable legal and institutional model is developed and implemented for balancing personal privacy protection and public access interests in spatial data in a single state or jurisdiction, differences in laws and social conditions may make the model inappropriate for application in other jurisdictions. Advancements in technology may also make a workable model today inappropriate tomorrow. Although the challenges are daunting, the academic research community fulfils an extremely important societal role by continually questioning the logic and validity of arguments presented by the various parties in information policy debates. It often falls to the research community to document through observations the truth or falsity of claims and to collect evidence on the actual ramifications of following one information policy or legal approach over another. The research community is particularly suited to this task since the work of individual researchers is subjected to peer review, and full disclosure of research methods and data is the expected norm. In addition, academic researchers often have the ability to identify affected interests not represented in social policy debates and find ways of exposing, articulating, and interjecting the interests of those who may be disfranchised.

Focus areas for investigation of the law and information policy in action have included intellectual property rights in spatial databases (Lopez 1993, Onsrud and Lopez 1998), access rights of citizens to publicly held information (Lawrence 1990, 1993, Rhind 1992, Lopez 1994, Perritt 1995a, Onsrud *et al.* 1996, Onsrud 1998), privacy rights and principles (Onsrud *et al.* 1994), liability in the use and distribution of geographical information system data and products (Anderson and Stewart 1995, Johnson and Danby 1995, Perritt 1995b, Onsrud 1999), and ethical issues in the use of geographical information (Onsrud 1995).

The breadth and extent of the legal, ethical, and policy issues that geographical information technologies and data sets give rise to is enormous. The challenge for the research community is to continually revisit the issues in order to critique existing social and institutional models, and develop new models that may better satisfy and benefit diverse stakeholders in society.

5.2. *Incorporating alternative representations into current GIS practices*

A further group of researchers has begun to raise the question of whether the GIS systems and databases developed are appropriate for neighbourhood and community organizations. In this view, their development as useful tools for public agencies and private firms does not guarantee that they are the appropriate technology for other potential users. Sheppard (1995) has argued that different social groups employ different 'ways of knowing' (different ways of reasoning about and making sense of the world) which need not be consistent with those underlying conventional databases and GIS software. He suggests that an important area of research is to determine the degree to which this is the case, and its implications. Dan Weiner, Trevor Harris, and co-researchers note, for example, that much of the local knowledge about the history of land ownership in South Africa is not recorded in standard property files, but resides in the oral histories of local peasants who have been progressively denied access to land that they once had a right to. Through development of the Kiepersol GIS, they have innovatively combined conventional GIS mapping routines with overlays containing this local knowledge. This knowledge is in a form quite different from that of conventional databases: it is qualitative, taking the form of narratives rather than statistics, and is partial in its coverage and even contested by different informants. Yet they have demonstrated that it can be combined visually with conventional data, providing a different perspective on land ownership rights than would otherwise be available (Harris *et al.* 1995, Weiner *et al.* 1995).

In a similar vein, Yapa (1998) has argued that use of a conventional layer-based GIS to analyse poverty results in a particular spatial representation, a mapping of poverty that treats poverty as located in the actions of poor people, rather than in broader societal causes that marginalize certain social groups. He advocates object-oriented GIS as an alternative that generates a more systemic representation of the causes of poverty. A more sceptical assessment of the possibilities of extending the kinds of representation possible with GIS is provided by Robert Rundstrom's analysis of American Indian conceptions of space and place, and their compatibility with GIS (Rundstrom 1991, 1995). He argues that Indian understandings of space are deeply rooted in local context, and cannot be abstracted into the kinds of general principles about topology and geographical data that lie at the root of GIS software and databases. This incompatibility raises significant questions, he suggests, about the ability of even Indian organizations to employ GIS in ways that are consistent with the views and understandings of Indian cultures.

The difficulties associated with incorporating local knowledge into GIS have been highlighted in research using GIS for the assessment of environmental justice, and risk assessment more generally. On the one hand, careful application of GIS to publicly available Toxic Release Inventory (TRI) and census data has been able to detail the closeness of different social groups to places releasing toxic chemicals. Work carried out at a variety of scales and resolutions, using different measures of proximity, and different definitions of the risk of exposure, have shown the complexity

of the relationship between the location of noxious facilities and that of low income, minority, and dependent populations. In some cases clear inequities to the disadvantage of such groups are documented; in other cases, higher income populations are closer to TRI sites (McMaster 1990, Burke 1993, Glickman 1994, Bowen *et al.* 1995, Sui and Giardino 1995, Cutter *et al.* 1996, Chakraborty and Armstrong 1997, McMaster *et al.* 1997, Nyerges *et al.* 1997b, Scott *et al.* 1997, Scott and Cutter 1997). On the other hand, the causal processes behind such patterns cannot be inferred from GIS analysis. Patterns do not reveal process, and understanding process requires detailed and intensive examination of the local historical and geographical context (Bryant 1995, Pulido 1996, Pulido *et al.* 1996, Sheppard *et al.* 1998).

Making such GIS capacity available to local neighbourhood or environmental groups concerned with state proposals to locate a garbage transfer site or an incinerator in their neighbourhood, with developing a good neighbour agreement with a local firm, or with generally documenting and improving the local physical environment, exposes limitations to conventional use of GIS in novel contexts. First, many of the environmental problems of local concern are not documented in the standard databases used for nation-, state-, or city-wide GIS analysis; local-scale data collection creates the possibility of a much more comprehensive analysis of local public health risks in the environment than is possible in larger-scale analyses. Second, local knowledge about environmental problems may be anecdotal and in narrative form, requiring careful further investigation and novel methods of analysis that may or may not be compatible with those available in GIS. Third, local priorities for environmental improvement may again challenge the capacity of GIS as the appropriate technology for addressing them. Finally, provision of GIS to neighbourhood organizations is fraught with the kinds of difficulties of implementation, and unforeseen local social impacts, described above. In response to these problems, neighbourhood involvement in the development and completion of environmental inventories, in the implementation and design of databases, and in discussions about the appropriateness of GIS-based analyses for addressing neighbourhood concerns is important. More generally, this addresses the question of developing public participation GIS.

5.3. *Public participation GIS*

During the specialist meeting for NCGIA's Research Initiative 19 on GIS and Society the question of 'what could GIS be?' was continually raised in the context of GIS that would be more responsive to the needs of broader segments of society and in different ways. At the meeting a small working group developed an initial set of criteria for what was then called GIS2. The criteria developed by this group included the following:

1. A GIS2 would increase emphasis on the role of participants in creation and evaluation of data.
2. A GIS2 would accommodate an equitable representation of diverse views, preserving contradictions, inconsistencies, and disputes against premature resolution.
3. System outputs would be redefined to reflect the standards and goals of the participants.
4. A GIS2 would be capable of managing and integrating all data components and participant contributions from one interface. Components would include

e-mail, the Web, access to data archives, presentation of parallel texts and counter texts in diverse media, real-time data analysis, standard base maps and data sets, sketch map capabilities, and field note capabilities.

5. A GIS2 would preserve and represent the history of its own development and be more capable of handling time components than existing GIS.

This initial formulation of GIS2 thus envisioned new technological capabilities that could have a much greater ability than current ones in enabling the process of communication. Technologies and processes to be embedded in this new geographical information systems environment would allow diverse members of communities to explore and interact with each other in manners allowing them to improve their own community conditions and relationships. This new information systems environment would allow enhanced participation by all groups or individuals with interests in the outcomes of disputes.

Because the term GIS2 appeared to imply a straightforward extension of existing current geographical information systems (i.e. GIS1), a term that would describe a systems environment more focused on communication, process, and participation among many interested parties was sought to describe this new domain of research and development. No shorthand title is sufficient to describe the complete body of concepts that individuals wanted to embed in this new way of looking at geographical information technologies and their relationships to individuals and communities, but the ensuing discussions in search of an appropriate term raised a series of interesting issues.

In preparation for a follow-up workshop at the University of Maine to further develop and explore the concept of GIS2 (NCGIA 1996), one of the many terms suggested to better describe the set of concepts being pursued was 'Public Participation GIS'. Xavier Lopez suggested the term because a well-developed literature already existed relating to public participation in decision making in the planning community, and it appeared that a merging of the concepts embedded within that literature stream with the technical and social concepts being explored in the geographical information science community came close to encompassing the intended research domain.

One critique of the term Public Participation GIS (PPGIS) was that public participation seems to imply the development of concepts and systems directed primarily at meeting the needs of and enabling grass roots, community, and marginalized groups. An alternative suggested was to pursue concepts and capabilities that would serve the interests of all of those interested in the outcomes of publicly debated decisions, including not only grassroots and community groups but also government and commercial sector groups. In response to this concern, the term 'Public Forum GIS' was proposed. Although this term might suggest openness and opportunity for all interests to be heard, it seems to imply that final decision-making is primarily and foremost in the control of government decision-makers and thus the term suggested a less active role for others. PPGIS is a more active term. In addition, public participation as conventionally understood within the planning community does indeed imply identification of all interested groups, and involves invitations to all such groups to participate in consensus building processes. If the term PPGIS implies to some people a greater focus on meeting the specific needs of marginalized groups this meaning was acceptable as well, because the academic community is in a far better position than the marketplace or government to focus

on developing tools, techniques, and processes for these groups. Thus the ambiguity in the term PPGIS was deemed desirable.

A focus on communities and the integration of diverse interests in communities seems a more accurate description to some people of the concepts to be encompassed by the research domain and therefore the term 'Community-Integrated GIS', or 'Community-Integrative GIS' was preferred by these people. For others, the term 'Participatory GIS' was more appropriate. Regardless, the title for the domain of interest is far less important than the concepts and ideas within it, to which a large number of people with diverse perspectives and backgrounds are being drawn.

In summary, PPGIS research seeks an adaptable suite of analytic tools, communication technologies, and participatory processes that will expand the roles of communities in defining questions in which location or geography have a bearing on the issues addressed; increase public participation in data creation and evaluation; increase opportunities for community self-exploration and self-improvement; increase the breadth and depth of participation in decisions of broad public interest; and enable wider public acceptance of the results of decision making in which place or space play a significant role (Schroeder 1997). An extensive literature on PPGIS is now beginning to emerge. Recent examples include articles in the *Proceedings of the 1997 ACSM/ASPRS Annual Convention*, Volume 5 (e.g. Neyrges *et al.* 1997a); the *Proceedings of Auto-Carto 13*; the *Proceedings of the 1997 UCGIS Annual Assembly and Summer Retreat*, <http://www.spatial.maine.edu/ucgis/assembly-schedule.html>; and a special issue of *Cartography and Geographical Information Systems on Public Participation GIS*, Volume 25, No. 2 (Barndt 1998, Obermeyer 1998).

The Varenius initiative on Empowerment, Marginalization, and Public Participation GIS addresses a broad range of issues related to the relevance of GIS representations for community organizations and public participation GIS, as spelled out in the call for papers:

- The implications of map-based representations of information for community groups;
- The nature of GIS knowledge distortion from grassroots perspectives;
- The value and impact of increasingly sophisticated analyses for understanding key issues and marginalizing certain groups;
- The ways in which socially differentiated communities and their local knowledge are or might be represented within GIS, and the impacts on communities of differential access to hardware, software, data, and expertise in GIS production and use;
- The educational, social, political, and economic reasons for lack of access, and exemplary ways communities have used to overcome these barriers;
- The implications of conflicting knowledge and multiple realities for spatial decision making;
- GIS as local surveillance;
- Current attempts to use GIS to empower communities for spatial decision making;
- Changes in local politics and power relationships resulting from the use of GIS in spatial decision making;
- Successful implementations of a public participatory GIS;
- What community groups need in the way of information, and the role GIS plays or could play in meeting this need;

- The economic impact of government pricing policies on small and large businesses.

6. A roadmap for future research

Looking forward, a variety of potential avenues for future research on the geographies of the information society can be discerned. The questions raised in the context of the individual Apex initiatives, and the recommendations for research agendas arising from those meetings, will help assess the influence of these initiatives over the broader research scene for the next three to five years. A parallel agenda-setting effort is reflected in a white paper on 'GIS and society' by the University Consortium for Geographical Information Science (UCGIS 1998), with specific recommendations about research which are worth noting here briefly. The UCGIS recommends that attention given to the impact of GIS on society be counterbalanced by attention to the impact of society on the evolution of geographical information technologies; that attention to the determinants and consequences of GIS in public agencies and institutions be balanced by the study of their use by private firms and by community and grassroots groups; and that attention to empirical questions regarding the societal determinants and consequences of GIS be counterbalanced by attention to ethical and legal implications (for more details, see <http://www.ucgis.org>).

The Varenus roadmap largely intersects with the UCGIS recommendations but is sketched here more specifically as the logical continuation of the three Apex initiatives. Thus the theoretical perspective on geographical information, information technology, and society, best represented by the place and identity initiative, must eventually lead to the development of case studies investigating the relevance of the theoretical views within concrete places and situations. Second, the attempt to conceptualize accessibility in the information age should be followed by similar investigations of how to measure and represent socially induced changes in other fundamental geographical concepts such as proximity, community, region, and so on. Third, the concerns raised by the current practice of GIS should lead to the study of new tools, new data schemes, and new institutional frameworks for facilitating and safeguarding democratic values at all levels.

6.1. *From theory to case studies: taking the next step*

The evolving relationships between society and GIS can take many forms depending on local context and circumstances, and it seems that at this stage we know less about the actual than we do about the potential consequences. We believe that further progress is best pursued through a series of carefully selected case studies of particular organizational and geographical contexts. Since less is known about GIS in the private sector and in community organizations, case studies of these contexts will be particularly useful both to further develop and also to challenge and improve our understanding of theoretical scenarios.

We need case studies and eventual generalization regarding the widespread and increasingly sophisticated use of geo-demographic analysis. Under what corporate (large or small firms, local or global marketing and production strategies, industry setting), localized or social-context circumstances (entrepreneurship, capital availability, data availability) and under what geographical characteristics (degree of heterogeneity of regions and neighbourhoods) does geodemographic modelling lead to

redlining or other forms of geographical exclusion or, on the other hand, more efficient niche marketing and better, specialized location and investment decisions? What sorts of effects has the widespread use of neighbourhood or block-group-targeted marketing campaigns had on heterogeneity of tastes and households within and across neighbourhoods? What are the implications of widespread use of spatial-interaction and location-allocation models in corporate geography for competition, for public welfare, and for corporate welfare (e.g. how effectively and appropriately have these tools been used)? What public-policy measures (e.g. formal regulation of the dissemination and use of private, household information) would be effective in reducing the negative impacts of geo-demographic analysis and marketing?

Second, we need further case studies of the use of GIS software by neighbourhood organizations in low-income and minority communities, seeking to improve the social and physical environment available to community residents. Its effect on the ability of these organizations to make or negotiate improvements; and its effect on the internal coherence of these organizations and their ability to represent the diversity of views of local residents. Case studies of such organizations beginning to transform the nature of GIS practices through their actions do not yet exist, but as they emerge they will begin to give a better sense of the possibilities and limits of current software, compared to new technologies (see below).

Third, there is still a need for case study analysis of the use of GIS in public agencies. Many such studies are documenting the influence of GIS on the actions of government agencies, and on the capacity of the general public to assert democratic influence over those agencies, and important questions in this area still remain. Of particular interest, however, are studies now beginning to emerge which are showing how the practices of GIS use in such agencies are themselves actively constructing GIS conventions and norms.

Finally, there is a great need for case studies of controversial applications of GIS, paying attention to what can be learned about appropriate ethical principles and legal regulatory mechanisms.

In concert with and drawing on such individual case studies, comparative analysis across case studies will be important to tease out which kinds of contextual conditions affect which kinds of outcomes. This will be as important for the study of how social practices influence the evolution of GIS technologies as it is for the study of the social implications of GIS. Such analysis should compare both case studies of similar organizational contexts in different places, and case studies of different organizational contexts in similar places. A successful outcome of such comparisons would be the development of mid-range generalizations about the relationships between GIS and society, and about ethical and legal principles, which may be capable of further examination through a combination of extensive empirical analyses and new targeted case studies. Progress on these questions will depend crucially on fostering collaborative research networks.

6.2. *Measuring and representing the new geographies*

This research direction would attempt the synthesis of the societal view of geographical concepts taken under the Apex with other Varenus research in the area entitled 'Cognitive Models of Geographical Space', which approaches similar questions from a cognitive perspective. For reasons of research efficiency Varenus took a disjunctive approach to the study of basic geographical concepts, treating them either as cognitive constructs, as in the case of scale, or as evolving

socio-empirical phenomena, as in the case of place and accessibility. The dialectic between the cognitive and the societal must now be played out in a new research arena where these concepts can be defined and represented with the richness appropriate to their dual role: compatible with the cognitive structures of individual GIS users, while at the same time reflective of the contextual and evolving meanings that the information society bestows on them. That fusion is needed for the development of a new generation of geographical information technologies that are advanced and sophisticated enough to play the roles proponents have always hoped for and sceptics have always doubted. The more applied and practical aspects of that ambitious program would be picked up by the third stream of research, continuing the work of the Public Participation GIS initiative.

6.3. *New participatory GIS software: the next generation?*

It is important to develop a parallel area of research into new types of GIS technologies, perhaps more reflective of the flexibility and communicative logic of Java and the Web than the complex logic of expert programs over which users have little influence. To be effective in designing geographical information systems that are appropriate for all areas of society, such developments should combine the practical experiences of new users struggling with currently dominant GISs; the expertise of programmers, graphic artists and communications specialists; and the experience and expertise of individuals skilled in the study of GIS and society. Focused research in this area will increase the possibility of lateral development of new approaches to GIS which can qualitatively enhance their relevance for an equitable and democratic society.

One important aspect, where research is already making advances, is in our ability for (and our software for) simultaneously and interactively showing, manipulating, and commenting on computer-based information. How can these technologies be combined to allow group interaction and analysis via GIS? What are the relevant differences in human perception of geographical relationships and human visualization of computer-generated models, that affect the ability of multiple individuals to interact in this way? Assuming that the technological and dissemination issues are resolved, what are the social, communication, perception, and cognitive barriers to the interactive use of spatial-display and spatial-analytic tools? This research is moving GIS and related technologies away from the norm of being tools for the individual analyst to store and manipulate spatial information, but there are many other aspects of software development, ranging from interface design to Web-based technologies of communication, that are necessary before the GIS2 vision can be approximated.

6.4. *Institutional catalysts for research*

Finally, relevant institutions (UCGIS, software developers, and speciality groups of researchers whose main focus is not GIS) should develop demonstration projects and compilations of the use of GIS in human-geographical research: migration, labour analysis, or central-place modelling. Specifically, demonstrations are needed of innovative uses of data and new data sources, and of new data consortia. These same institutions, along with funding agencies such as NSF and private foundations, need to catalyse the development of GIS software that employs more rigorous approaches to spatial statistics, regionalization schemes, and more probabilistic

approaches to estimates of spatial interaction; new analytic methods; and new, automated modelling tools.

It is to be hoped that this sketch of a roadmap will stimulate the kind of criticism and further debate needed to articulate a sustained, rigorous, and reflective agenda for research into geographies of the information society by both practitioners of geographical information science and their critics.

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