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The Role of Maps in Virtual Research Methods

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the map is a help provided to the imagination through the eyes.
Henri Abraham Chatelain, *Atlas Historique* (1705)

Mapping provides a uniquely powerful means to classify, represent and communicate information about places that are too large and too complex to be seen directly. Importantly, the places that maps are able to represent need not be limited to physical, geographical spaces like cities, rivers, mountain ranges and such like: maps can be used to represent online spaces of computer-mediated communication or (Dodge and Kitchin 2001a, 2001b). This chapter makes the case for the use of maps as an addition to existing methods in virtual research.

Maps have long been useful in research into social phenomena. They provide a key technique in human geography of course, but they are also used in other disciplines such as archaeology, history and epidemiology, to store spatial information, to analyse data and generate ideas, to test hypotheses, and to present results in a compelling, visual form (Monmonier 1993). Mapping as a method of inquiry and knowledge creation also plays a role in the natural sciences, in disciplines such as astronomy and particle physics, and in the life sciences, as exemplified by the metaphoric and literal mapping of DNA by the Human Genome Project (Stephen S. Hall 1992).

The ability to create and use maps is one of the most basic means of human communication, at least as old as the invention of language and, arguably, as significant as the discovery of mathematics. The recorded history of cartography clearly demonstrates the practical utility of maps in all aspects of Western society, being most important for organising spatial knowledges, facilitating navigation and controlling territory (Thrower 1996). Some have gone further, to argue that mapping processes are culturally universal, evident across all human societies (for example, Blaut et al. 2003), although the visual forms of the resulting map artefacts are very diverse. At the same time maps are also rhetorically powerful graphic images that frame our understanding of the human and physical world, shaping our mental image of places, constructing our sense of spatiality. So in a very real sense maps make our world.

I begin by defining the nature of the map, discussing the theoretical basis of mapping processes and visualization. This is followed by a consideration of mapping in the context of research into the operation and structures of CMC by social scientists, where I advance reasons why mapping online space is useful but also challenging. I then set out a classification of contemporary mapping, showing how maps are used, before examining in some detail four exemplars. I conclude this chapter with a brief discussion of the limitations of mapping as a research methodology in terms of practical problems, ethics and ideology.

Maps and Visualization

Conventionally, maps are material artefacts that visually represent a geographical landscape using the cartographic norms of a planar view (that is, looking straight down from above) and a uniform reduction in scale. However, it is impossible neatly to define maps according to the type of phenomena mapped or the particular mode of presentation, or their medium of dissemination (Dorling and Fairbairn 1997). Maps have traditionally been used as static storage devices for spatial data and usually printed on paper, but now they are much more likely to be interactive tools displayed on a computer screen. Here I take a very broad definition, given by Harley and Woodward, (1987: xvi), 'maps are graphic representations that facilitate a spatial understanding of things, concepts, conditions, processes, or events in the human world'. We currently live in a map-saturated world, surrounded by both conventional geographic maps and many other map-like spatial images and models (for example, animated satellite images, three-dimensional city models, magnetic resonance imaging (MRI) scans of the brain).

The development and diffusion of information and communication technologies (ICTs) since the early 1980s has profoundly affected the nature of cartographic mapping. Nowadays, the majority of maps are digital and only created 'on-demand' for temporary display on screens. The days of the unwieldy folded map sheet and heavy paper atlases are past, increasingly replaced by geographic information systems (GIS) and spatial databases. The web mapping portal MapQuest.com has already delivered more maps than any other publisher in the history of cartography (Peterson 2001). Cheap, powerful computer graphics on desktop personal computers (PCs) enables much more expressive and interactive digital cartography, such as animated maps, multimedia atlases and so-called geo-visualization. Geovisualization draws on concepts from statistics for exploratory data analysis, envisaging highly interactive environments of linked, multiple representations (maps, two-dimensional charts, three-dimensional plots, tables).

As well as making maps more interactive, ICTs are also helping to give many more people access to cartography as map-makers themselves, be it via the 'map charting' options in spreadsheets to produce simple thematic maps, creating custom maps from an online mapping service, or desktop GIS such as ArcView or MapInfo. As more and more people bypass professional cartographers to make their own maps as and when required, it is likely that the diversity of map forms and usage will expand. Of course, the availability of 'point and click' mapping software is no guarantee that the maps produced will be appropriate and effective. Map-making still takes skill and thought, requiring considerable effort to make *good* maps.

The production of cartographic map artefacts and map-like visual images involves a whole series of mapping processes, from the initial selection of what to measure to the choice of the most appropriate scale of representation and projection, and the best visual symbology to use. The concept of 'map as process' is useful as a research methodology because it encourages particular ways of organized thinking to do with how to generalize reality, how to distil out inherent, meaningful spatial structure from the data, and how to show significant relationships between things in a legible fashion. Mapping provides a means to organize large amounts of, often multidimensional, information about a place in such a fashion as to facilitate human exploration and understanding. Yet, mapping is not just a set of techniques for information 'management', it also encompasses important social processes of knowledge construction. As scholars have come to realize, maps and culture are intimately entwined and inseparable (Harley 1989; Wood 1992). Mapping not only represents reality, but also has an active role in the social construction of that reality. Yet most people are not conscious of this when they use maps. Sparke (1998: 466) calls this the recursive proleptic effect of mapping, 'the way maps contribute to the construction of spaces that later they seem only to represent'. The power of maps comes from the fact that they are both a practical form of information processing and also a compelling form of rhetorical communication.

Mapping works, essentially, by helping people to see the unseen. This is achieved through the act of visualization, premised on the simple notion that humans can reason and learn more effectively in a visual environment than when using textual or numerical description. Maps provide graphical ideation which renders a place, a phenomenon or a process visible, enabling our most powerful information-processing abilities, those of the human eye–brain vision system, to be brought to bear. Visualization is thus a cognitive process of learning through the interaction with visual signs that make up the map and it differs from passive observation in that its purpose is to discover unknowns, rather than to see what is already known. Effective visualization in a research context reveals novel insights that are not apparent with other methods.

The power of mapping as visualization to elucidate meaningful patterns in complex data is well illustrated by some of the 'classics' of the pre-digital era like John Snow's 'cholera map' of 1854, Charles Joseph Minard's 'Napoleon map' of 1869 and Harry Beck's 'Tube diagram' of 1933 (see Tufte 1983; Garland 1994; Brody et al. 2000; Hadlaw 2003). Even though these examples are non-interactive, that is, they are static, two-dimensional images, hand-drawn on paper, they are nonetheless still powerful. They show the potential of visualization to provide new understanding and compelling means of communicating to a wide audience. Through their aesthetic visual form they also demonstrate the extent to which mapping can be a creative process in and of itself. The best visualizations go beyond merely representing to become a kind of cognitive shorthand for the actual places and processes themselves, illustrated well by the way in which Beck's celebrated diagrammatic design of the Underground provides such a powerful spatial template for the 'real' layout of London in the minds of many visitors and residents. The problem is that although Beck's map works well for underground movement, it can be confusing for surface navigation because it famously sacrifices geographic accuracy for topological clarity.

Conventional cartographic mapping is just one type of visualization and many other visualization techniques have been developed for handling large, complex datasets without gross simplification or unfathomable statistical models (for example, volumetric visualization in exploration geology, three-dimensional body imaging in medical diagnostics). Of course, there is a long history of visualization prior to computers and interactive graphics (for useful reviews, see Tufte 1983; Orford, Dorling and Harris 1998; Friendly and Denis 2003), but newer computer-based visualization techniques are particularly useful to researchers confronting poorly structured problems in information-rich environments – like a good deal of quantitative social science research on CMC.

Developments in the field of information visualization since the early 1990s have proved particularly fertile in creating navigable maps of information spaces (Card, Mackinlay and Schneiderman 1999). These maps are non-geographic, instead focusing on visualizing information structure using abstract projections, but interestingly they make explicit use of spatial metaphors (Couclelis 1998). The production of these novel types of maps of information has been termed spatialization (Skupin and Fabrikant 2003) and it often 'borrows' proven design concepts from cartography, for example the use of hill shading and contouring from terrain mapping to represent large text archives (Wise 1999).

Mapping the Spaces of Computer-mediated Communications

It may seem surprising, in the first place, that a worthwhile case can be made to use maps in social science research on CMC. This surprise is based on two false assumptions: first, that CMC has no meaningful spatial structures, is somehow divorced from geographic reality, and is thus 'unmappable'; and second, that maps can represent geographic phenomena only in relation to the surface of the earth. Both these assumptions are incorrect; maps are not just geographic and CMC has meaningful structures to be mapped (such as semantic similarity between content, affinity ties of differing strengths in online social networks, temporal usage patterns). The self-evident answer is that it *is* possible to map CMC – as many researcher have indeed done (see Dodge and Kitchin 2001b) – and several of the best examples are discussed later.

Given that it is possible, why might one actually want to invest time and effort to produce maps of CMC? Mapping is particularly useful for virtual research since so much of the 'terrain' of study, the social phenomena and the online places in which they occur, are composed of immaterial software (in essence they are just lines of code and database records) and are to a large degree invisible. Consequently, this 'terrain' can be hard to comprehend, and maps are an obvious tool to help make the virtual tangible. The processes of mapping can help make the virtual understandable to the researcher.

The extent and usage of CMC has grown very rapidly since the early 1990s. With so many distinct spaces and users online, cyberspace has become an enormous and often confusing entity that can be difficult to monitor and navigate through. Maps can help users, service providers and analysts comprehend the various spaces of online interaction and information, providing understanding and aiding navigation. Depending on their scale, some of the maps provide a powerful 'big picture' view, giving people a unique sense of a space difficult to understand from navigating alone.

Beyond the online spaces themselves, the adoption of CMC is having significant effects on social, cultural, political and economic aspects of everyday life (Dodge and Kitchin 2001a). Maps can help in understanding the implications by revealing the extent and interrelations of the changes occurring. Geographical mapping of the Internet is significant, as it can provide insights into who owns and controls the supporting infrastructure, and how and from where cyberspace is being produced (Dodge and Kitchin 2004). In addition, geographical maps are especially useful for public communications because they use a familiar template of countries and continents.

However, mapping CMC is a challenge. This is particularly the case because CMC is new and rapidly evolving, it is fluid, and it is diverse. It is not a single, homogenous and continuous phenomenon, but a myriad of rapidly evolving digital spaces, channels and media, each providing a distinct form of virtual interaction and communication. Many of the spaces of CMC are overlapping and interconnected, but often in ad hoc and unplanned ways, giving rise to complex rhizomatic structures that cannot easily be surveyed and mapped (Dodge and Kitchin 2001a).

Cyberspace offers places that at first often seem contiguous with geographic space, yet on further inspection it becomes clear that the space-time laws of physics have little meaning online. This is because the spaces of CMC are purely relational. They are not natural, but are solely the productions of their designers and, in many cases, users. They adopt the formal qualities of geographic (Euclidean) space only if explicitly programmed to do so, and indeed many media such as email have severely limited spatial qualities. The inherent spaces that do exist are often purely visual (objects have no weight or mass) and their spatial fixity is uncertain (spaces can appear and disappear in a moment, leaving no trace of their existence). Additionally, many online spaces violate two principal assumptions of modern (Western) cartography making them tough to map using conventional techniques. The first of these is that space is continuous, ordered and reciprocal. There are no sudden gaps or holes in the landscape, everything is somewhere, and the Euclidean notion of distance holds true, that is, the distance from *A* to *B* will be the same as from *B* to *A*. The second assumption is that the map is not the territory but a representation of it, that is, the territory has a separate, ongoing existence and meaning beyond the map. Yet parts of cyberspace are discontinuous, lacking linear organization and in some cases the map and the territory are conflated and cannot be separated (Dodge and Kitchin 2001a).

What are maps of CMC like? The diverse range of maps so far produced makes it hard to generalize. Just as there is not one true geographic map of a given place, so there are no definitive maps of CMC. Devising effective map representations for the structures of CMC when no obvious framework or intuitive metaphor exist has led to considerable creativity, with many visual forms, projection methods and models of interaction tried out. Many of the resulting maps, while novel and interesting, are not workable (that is, they are not effective visualizations). The wide range of CMC mapping is undertaken by a wide range of different map-makers, including designers, sociologists, artists, physicists, information scientists, librarians and interface engineers. Interestingly, almost none have been made by cartographers or geographers (although see the notable contributions discussed by Skupin and Fabrikant 2003).

Map Use in Virtual Research

One way to classify the nature of contemporary mapping is to focus on how maps are actually used to do work, for example in the different stages of an academic research project. MacEachren (1995) provides a useful conceptual device, the 'cartography cube', to do this (Figure 8.1), employing three axes to encapsulate the distinctive characteristics of contemporary map use. The first axis covers the scope of the user audience for the map (running from private maps, used only by their maker, through to published, widely distributed maps for public use); next is the degree to which the map offers interactivity in use (ranging from the low interactivity of traditional paper maps up to highly flexible map displays of GIS); the third axis is the so-called 'data relations' (a continuum running from revealing unknowns patterns to presenting known facts). Particular types of map use can thus be classified and placed within the cartography cube, and four examples are identified – explore, analyse, synthesize and present (Figure 8.1). These run roughly from the lower corner of the cube up to the other and the diagonal line they form can be thought of as marking the distinction between 'maps to foster *private visual thinking* early in the research process and those to facilitate *public visual communication* of research results' (MacEachren 1995: 3, original emphases). Some of the most interesting recent developments in mapping have been in the 'explore' usage – that is, highly interactive private maps for visual thinking,

In the course of a typical academic project, researchers may use maps in a number of different roles, from an initial 'scan' of raw data through to the creation of an 'eye-candy' map for the cover of the final report. In the 'explore' usage, maps

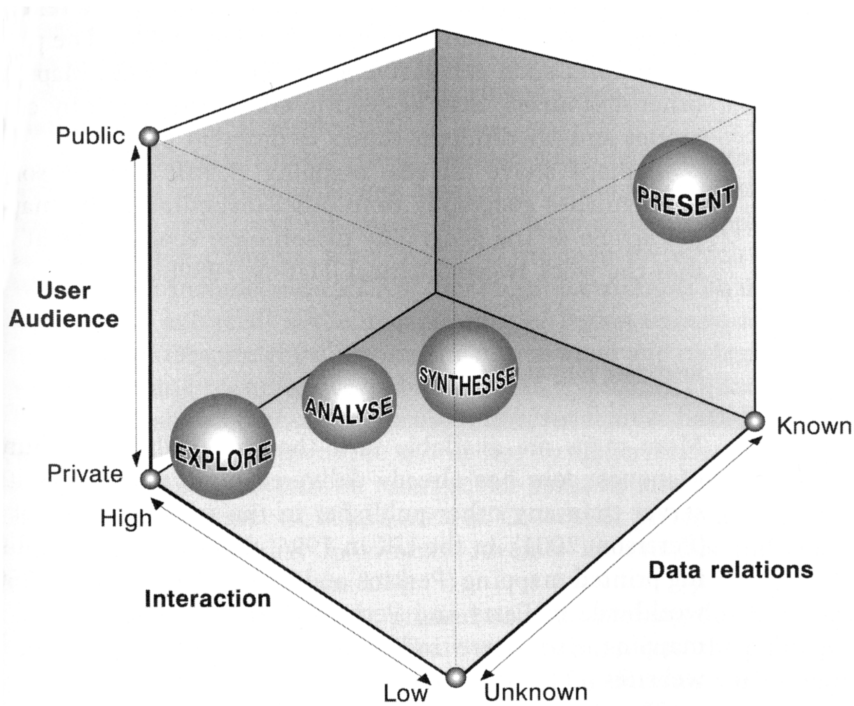

Figure 8.1 Alan MacEachren's 'cartography cube' conceptualisation of map use. This particular version is from Perkins (2003, p. 347). (Courtesy of Chris Perkins, Department of Geography, University of Manchester.)

can answer basic 'what is happening here?' type questions, by giving a visual inventory that can be quickly reviewed for interesting trends and anomalies (seeing the 'holes' in a map can be the best way to spot errors in data collection). The 'analysis' phase of research would use interactive maps to process and classify complex data, breaking it down in the hopes of revealing previously unknown patterns that could not be discerned from looking through the raw data. For example, scrolling through page after page of a web site user log would tell you little, whereas overlaying the pathways of individual user sessions onto a map of the hyperlink structure of content (so-called 'clickstream' visualization) might quickly show consistent patterns of site navigation. The 'synthesis' stage of research often requires evidence to be assembled to support particular hypotheses. Maps are useful tools here for marshalling together diverse data into a single visual explanation. Maps can facilitate visual explanation of observed patterns, for example through testing for the existence of spatial processes such as hierarchical clustering, small world networks, and distance decay functions. John Snow's 'cholera map' is often put forward as a prime example of maps as synthesizing tools (Brody et al. 2000). Towards the end of a research project, it is usually necessary to present results to external audiences and well-designed maps are an exemplary means of public communication. In a compact visual image, a good map can convey a huge amount of data in a legible, aesthetic and comprehensible fashion. Maps are rhetorically powerful ways to dramatize research results (Tufte 1983).

I now consider in detail four examples that illustrate the diversity of map use in research on CMC. The first two examples visualize aspects of the geographic structure of CMC at the level of Internet infrastructure and traffic flows. The last two examples are maps of online activities aimed to help researchers and potentially also users to understand the social structures of CMC spaces.

Envisioning Internet Geographies

The seemingly magical ability to surf around a virtual globe of information, moving from web site to web site at a single click, belies the scale and sophistication of the socio-technical assemblage of protocols, hardware, capital and labour that makes this possible. Despite the virtualized rhetoric, this assemblage remains embedded in real places and maps can help to reveal the intersections between cyberspace and geographic space. In CMC research, I believe that geography is still important, as knowledge of the physical location of virtual phenomena can tell you interesting things (such as which territorial jurisdiction it is in) and can also enable linkage to a large array of existing secondary data (for example socio-economic characteristics from censuses).

The 'where' and 'how' of the physical embeddedness of data networks and information flows are also important because of their uneven geographical distribution and the consequent socio-spatial implications in terms of access and inequalities, as starkly revealed in Figure 8.2. This is a global scale mapping of network infrastructure that contrasts the density of core Internet routers with the distribution of population. The maps are density surfaces, where the land is colour-coded so that higher densities are darker (in the original the colours range from white through to red). The map was produced by physics researchers based at the University of Notre Dame who are exploring the principles behind the topological structures of complex networks like the Internet (Yook, Jeong and Barabási 2002: 13,383).

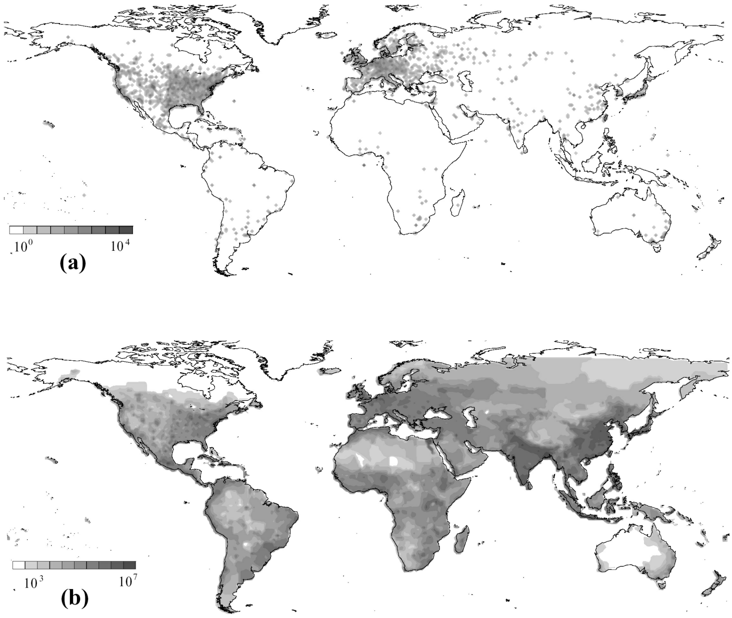

Figure 8.2 An example of how cartography can be used to visualise the uneven global distribution of the Internet: (top) map of the density of routers; (bottom) population density map. (Courtesy of Soon-Hyung Yook, Department of Physics, University of Notre Dame.)

In terms of the cartography cube, these maps are firmly in the 'present' usage category, being high in terms of public communication, high in terms of presenting known patterns and low in terms of interactivity. In design terms they are really quite conventional cartographic maps, using a geographic framework of continental outlines to show univariate data. This type of world map is familiar to most people and can be easily produced using GIS software. It succinctly summarizes a large volume of data in an intuitive manner (imagine the same data presented as numeric values in a spreadsheet) and effectively demonstrates the potential of maps in virtual research for communicating complex patterns to a wide audience.

The Figure 8.2 maps are non-interactive and the data present a static view of the Internet. Yet the Internet is obviously a dynamic environment, with continuously shifting patterns of usage. How can this be mapped? One way is to use software tools for measuring the Internet; these are called traceroutes and allow the active mapping of real-time data routing (Dodge 1999). Designed primarily for network engineers to 'debug' routing problems, they are also useful tools for researchers to probe the inner workings of the Internet. Traceroutes work by reporting the routes that data packets travel through the Internet to reach a given destination and the time taken to travel between each of the nodes along the route. They reveal the hidden complexity of data flows, showing how many nodes are involved (often more than twenty), the seamless crossing of oceans and national borders and the transfers through networks owned and operated by competing companies. They can also detail how geographically illogical some data routing is, following the cheapest paths rather than the shortest.

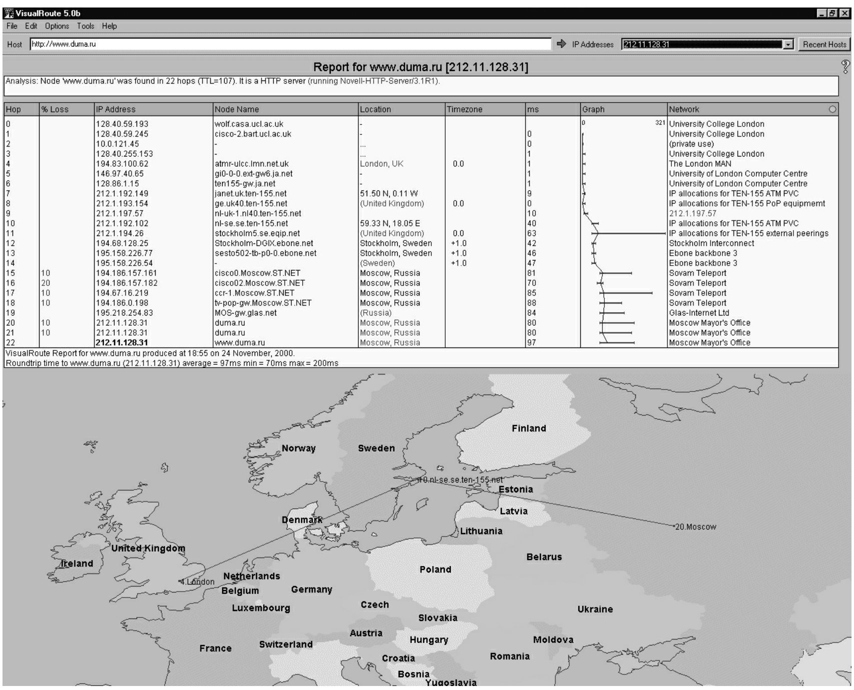

Figure 8.3 An example of geographic mapping of data pathways in real-time through the Internet using the VisualRoute traceroute utility (http://www.visualroute.com).

Figure 8.3 shows a screenshot of one particular traceroute program, called VisualRoute (http://www.visualroute.visualware.com, accessed 3 November 2004), tracing the data pathway from my PC at University College London to the Russian Parliament web site in Moscow (http://www.duma.ru, accessed 3 November 2004). Each line in the traceroute output represents a single 'hop' the data take across the Internet. The approximate locations (where known) of the routers are plotted on a simple map. Referring back to the cartography cube again, traceroutes are a good example of private, interactive mapping, aimed at revealing unknowns by actively 'exploring' routes through the Internet. Even though the map is crude in terms of cartographic design, traceroutes as a dynamic application show the potential for mapping as a research tool in exploratory analysis. Leaving the infrastructure level behind, mapping can expose the nature of online information archives and social interaction by exposing their latent structures in abstract, non-geographic visualization.

Mapping Social Cyberspaces

Understanding the formation of virtual groups and what is necessary for self-sustaining online communities has been a core element of social science research into CMC. A typical problem for researchers is how to gain a sense of the social nature of discussion spaces when conventional interfaces present only a hierarchical listing of text messages. There is growing body of work employing a wide variety of graphical techniques and visual metaphors to 'spatialize' online conversations (for example, M. Smith 1998; Donath, Karahalios and Viegas 1999; Fisher and Lueg 2003). Figure 8.4 shows a screenshot of PeopleGarden, a way of mapping social cyberspace that uses a quite novel visual metaphor (Xiong and Donath 1999).

PeopleGarden is an interactive map that spatializes web-based discussion boards in order to visually summarize overall patterns of social interaction over time. It was created by Rebecca Xiong as part of her graduate research at the Laboratory for Computer Science, MIT and deploys the visual metaphor of a flower to represent each participant, with petals being postings. Collections of flowers form a 'garden' to show the whole discussion space. Xiong says that she chose the flower metaphor because she liked 'the organic nature of a flower, and the suggestion that it changes over time, as users do' (Xiong and Donath 1999: 39). Thus the shapes of the flowers and the spatial structure of the whole 'garden' represent the nature of the online interaction and contrasting conversational styles of the participants. For example, if a PeopleGarden contained only a few small flowers, with sparse, faded petals, one could conclude that the discussion space is relatively lifeless.

The power of social mapping, such as PeopleGarden, is that it shows an overall structure not easily apparent from reading individual message postings. In a

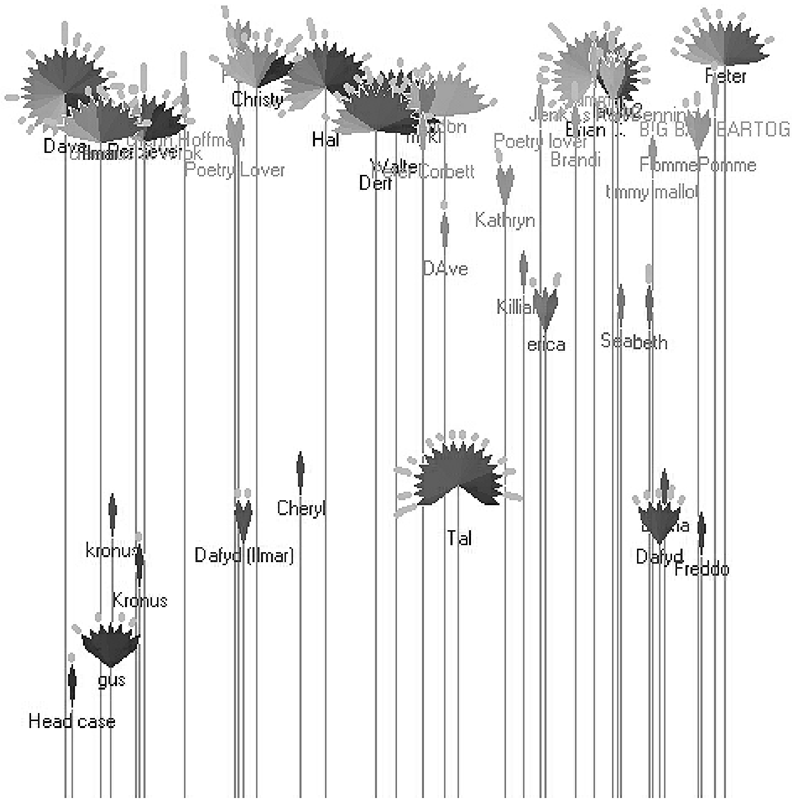

Figure 8.4 A screenshot of PeopleGarden, an interactive mapping tool for online discussion boards developed by Rebecca Xiong.

metaphoric sense these kinds of visualizations provide the missing ‘up button’ on the browser to allow people to get above the online conversations for a synoptic view of the whole. On the cartography cube I would place the use of PeopleGarden and similar examples in the ‘analyse’ sphere as it provides a private map for researchers with a good degree of interactivity for use in revealing unknown data relations.

The final example I want to consider is an interactive tool for researchers to track and examine the activity patterns of users in three-dimensional virtual worlds, being developed by Katy Börner, Shashikant Penumarthy and colleagues at Indiana University (Börner and Penumarthy 2003). These spaces provide collaborative environments in which participants are represented as avatars and can interact with each other in real-time; they are used for games, community building, research and education primarily (see Damer 1998). They are one of the more

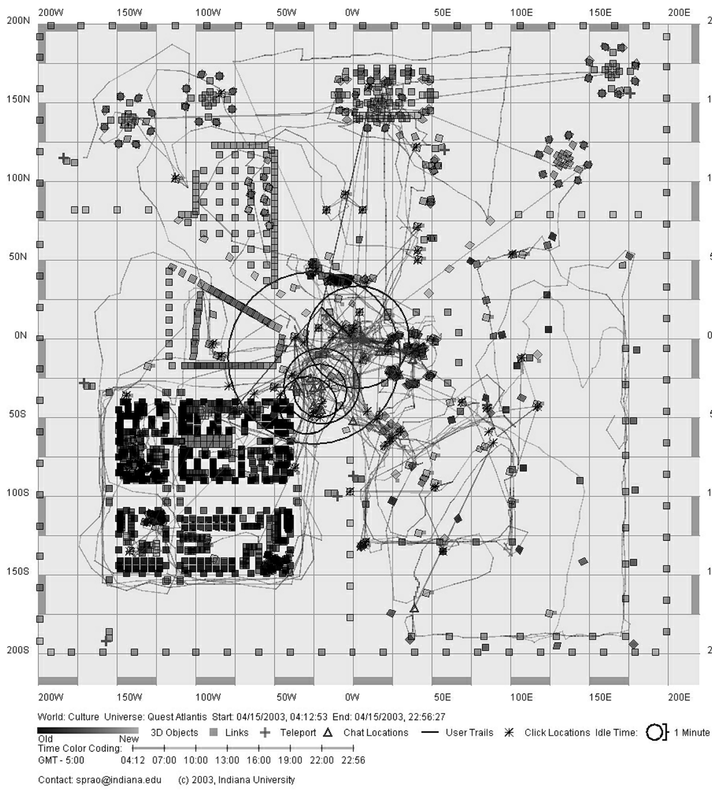

Figure 8.5 A map of all user activity in a three-dimension virtual world called Culture. (Courtesy of Shashikant Penumarthy and Katy Börner, Indiana University.)

interesting and novel CMC spaces for investigation by social scientists because of the navigable nature of their environments, the sense of presence engendered through avatars and the scope for fostering virtual communities (Schroeder 2002; Snowdon, Churchill and Frécon 2003). The administrators of virtual worlds can log all interaction in the world by users (movement, actions, chatting), providing a potentially panoptic source of multidimensional social data.

While there have been a number of attempts to map out virtual worlds, these have mainly focused on 'physical' structures of the environments (Dodge and Kitchin 2001b; Bodum and Kjems 2002), whereas the work of Börner and Penumarthy is novel in its focus on the social and temporal dynamics of the worlds in relation to spatial environment. Figure 8.5 shows a screenshot of their tracking tool visualizing over nineteen hours of activity inside one particular virtual world called Culture (this an educational world, using the Active Worlds system). The map is dominated by the meandering paths of avatars (like pheromone trails), revealing where users went and when, and where they were talking. This degree of time-space tracking can be highly revealing when plotted on a map, but also potentially very invasive, particularly if the users are not made aware that this is occurring.

According to Börner and Penumarthy, the role of their social visualization is to serve three particular groups – end-users gain an overview map to ease navigation and raise awareness of what social activities are occurring, world designers acquire a guide for their work in constructing the environment and researchers can understand socio-temporal patterns, particularly in relation to group formation. According to the cartography cube, I would place the use of this tracking visualization in the 'explore' category for researchers and world designers as it is a private, interactive map revealing unknown patterns. If the tracking map was made available to participants in the virtual world then it would enter the 'synthesizing' category as it is more public and more about reinforcing existing knowledge.

Maps such as PeopleGarden and the virtual worlds tracker can give researchers useful new insights into particular social spaces. Another important question is how far these maps can be used by the participants of the spaces to augment or enhance their CMC experience? Will seeing a social mapping of the community help inform the social life of the community, helping it grow through additional feedback? Or might such maps actually be detrimental to community life?

Conclusion

Virtual research is still often about the exploration of online spaces, seeking to discover structures of information and patterns of social interaction. Maps are useful tools for any explorer (terrestrial or virtual), helping them to find their way and also explaining to others what they found. In essence, maps exploit the mind's ability to see complex relationships more readily in visual images, providing a clearer understanding of phenomena, reducing search time, and showing relationships that may otherwise not have been noticed. As a consequence, they form an integral part of how we understand and explain the world.

Although mapping is a potentially powerful research method for exploration, analysis, synthesis and presentation, it is not without its problems and I want to conclude this chapter by briefly outlining three types of limitations – practical, ethical and political. First, there are many practical issues to be faced and it is important to acknowledge the investment of time and effort necessary to make good maps. Map-making is now much easier to do, but it is not necessarily a quick fix. Like any chosen research technique, the potential of mapping has external practical constraints, including data quality and the level of user knowledge.

There are also issues to consider relating to the ethics and responsibility of researchers producing maps of CMC. The processes of data selection, generalization and classification and the numerous map design decisions mean that one can never remove the subjective element in map-making. As Monmonier (1993) notes:

> any single map is but one of many cartographic views of a variable or a set of data. Because the statistical map is a rhetorical device as well as an analytical tool, ethics require that a single map not impose a deceptively erroneous or carelessly incomplete cartographic view of the data. Scholars must look carefully at their data, experiment with different representations, weigh both the requirements of the analysis and the likely perceptions of the reader, and consider presenting complementary views with multiple maps. (Monmonier 1993: 185)

Further, these new forms of social mapping open up CMC to a new kind of surveillance, revealing interactions that were previously hidden in unused log files and databases. The act of mapping itself may constitute an invasion of privacy. If the appeal of some CMC spaces is their anonymity, then users may object to it being placed under wider scrutiny, even if individuals are unidentifiable. Here, public analysis may well represent an infringement of personal rights, especially if the individuals were not consulted beforehand. In some senses, these maps may work to shift the spaces they map from what their users consider semi-private spaces to public spaces, and thus the maps may actually change the nature of CMC itself. Thus, it is important to consider the ways, and the extent to which, maps of CMC are 'responsible artefacts', that do not destroy what they seek to represent or enhance.

Lastly, it should be recognized that mapping is also cultural process of creating, rather than merely revealing knowledge. All the sophisticated, interactive maps of network infrastructures and online social structures have politics just the same as any other form of cartographic text, and we must be alert to their ideological messages (Harpold 1999; Dodge and Kitchin 2000). Maps of CMC can prove to be very valuable, but at the same time they can never be value free.