chapter 1

Mapping cyberspace

For thousands of years, people have been creating maps of the world around them – cave paintings, drawings in the sand, maps made of sticks and shells, black-and-white pencil sketches, richly colored manuscripts, three-dimensional models and, more recently, satellite images and computer-generated simulations. Since the Renaissance period, cartographers have collected together paper maps to create atlases. This book is the first comprehensive atlas of cyberspace.

Inherent in the creation of maps is the realization by the cartographer that spatial modes of communication are extremely powerful. Cartography provides a means by which to classify, represent and communicate information about areas that are too large and too complex to be seen directly. Well-designed maps are relatively easy to interpret, and they constitute concentrated databases of information about the location, shape and size of key features of a landscape and the connections between them. More recently, it has been recognized that the process of spatialization – where a spatial, map-like structure is applied to data where no inherent or obvious one exists – can provide an interpretable structure to other types of data. In essence, maps and spatializations exploit the mind's ability to more readily see complex relationships in images, providing a clear understanding of a phenomenon, reducing search time, and revealing relationships that may otherwise not have been noticed. As a consequence, they form an integral part of how we understand and explain the world.

For the past five years, we have been researching and monitoring the latest "spaces" to be mapped, namely cyberspace and its supporting infrastructure. In this book we draw together a selection of the maps and spatializations created by a range of academic and commercial "cartographers", and we examine them and the techniques used in their creation.

These maps and spatializations are extremely important for a number of reasons. First, information and communication technologies and cyberspace are having significant effects on social, cultural, political and economic aspects of everyday life. The exact nature of these effects is contested, but evidence suggests that cyberspace is altering community relations and the bases for personal identity; is changing political and democratic structures; is instigating significant changes in urban and regional economies and patterns of employment; and is globalizing culture and information services. Maps and spatializations can help us to understand these implications by revealing the geographic extent and interrelations of the changes occurring.

Second, the extent and usage of cyberspace has grown very rapidly in the last decade. For example, there were over 1 billion publicly accessible Web pages as of January 2000 (likely to have tripled by January 2001), and the number of other media such as email, mailing lists, chat rooms, and virtual worlds has also grown significantly. Moreover, these media are used by a rapidly expanding population. For example, 377 million people were connected to the Internet by September 2000, an 87 percent increase from September 1999 (based on data from NUA, http://www.nua.ie). With so many media and users online, cyberspace has become an enormous and often confusing entity that can be difficult to monitor and navigate through. Maps and spatializations 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", giving people a unique sense of a space that is difficult to understand from navigation alone. As such, they have significant educational value by making often complex spaces comprehensible.

Third, the creators of these maps and spatializations are making significant contributions to the theory and practice of geographic and informational visualization in two ways. At a basic level, the research underlying the maps and spatializations is pushing the boundaries of visualization aesthetics and how we interact with data. At a more fundamental level, the research is experimenting with new ways to visualize complex data. Whilst some aspects of telecommunications infrastructure and cyberspace are relatively easy to map, such as plotting the networks of service providers onto conventional topographic maps (see chapter 2), other aspects are very difficult. This is because the spatial geometries of cyberspace are very complex, often fast-changing, and socially produced. Cyberspace offers worlds 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 space in cyberspace is purely relational. Cyberspace consists of many different media, all of which are constructions; that is, they are not natural but solely the production of their designers and, in many cases, users. They only adopt the formal qualities of geographic (Euclidean) space if explicitly programed to do so; and, indeed, many media – such as email – have severely limited spatial qualities. The inherent spaces that exist are often purely visual (with objects having no weight or mass) and their spatial fixity is uncertain (with spaces appearing and disappearing in a moment, leaving no trace of their existence). Trying to apply traditional mapping techniques to such spaces is all but impossible, because they often break two of the fundamental conventions that underlie Western cartography: first, that space is continuous and ordered; and second, that the map is not the territory but rather a representation of it. In many cases, such as maps of websites, the site becomes the map; territory and representation become one and the same.

Issues to consider when viewing images

On one level, it is possible to view and enjoy the images we present at face value. However, we think that the images are best viewed and interpreted in the light of several key issues. These issues can be expressed simply as a set of questions:

- Why was the map or spatialization created?
- Does the map or spatialization change the way we think about, and interact with, cyberspace?
- To what extent does the map or spatialization accurately reflect the data?
- Is the map or spatialization interpretable?
- How valid and reliable are the data used to construct the map or spatialization?
- Is the map or spatialization ethical?

These questions, in conjunction with the discussion below, can be used to construct a more nuanced and informed analysis of each image and technique. This type of analysis is important because to date most maps and spatializations have been produced and viewed quite uncritically.

The power of mapping

It has long been recognized that mapping is a process of creating, rather than revealing, knowledge. Throughout the process of creation, a large number of subjective – often unconscious – decisions are made about what to include and what to exclude, how the map will look, and what the map is seeking to communicate. In other words, a map is imbued with the values and judgements of the people who construct it. Moreover, they are undeniably a reflection of the culture and broader historical and political contexts in which their creators live. As such, maps are not objective, neutral artefacts but are constructed in order to provide particular impressions to their readers.

Maps, then, are situated, embodied and selective representations. Commonly, the messages are those of the powerful who pay for the maps to be drawn, and the ideological message is one of their choosing. As Mark Monmonier, in his book *How to Lie with Maps* (University of Chicago Press, 1991), comments:

> In showing how to lie with maps, I want to make readers aware that maps, like speeches and paintings, are authored collections of information and are also subject to distortions arising from ignorance, greed, ideological blindness, or malice.

Spatializations of cyberspace similarly are the products of those who coded their construction algorithms. They are mappings designed for particular purposes. As such, they too are representations of power, and we should be careful to look beyond the data generated to question, in a broad sense, who the spatialization was made for, by whom, why it was produced, and what are the implications of its message and use.

Maps, then, can be a powerful means of communicating selected messages. This power can be illustrated by the extent to which they are being used to market various aspects of cyberspace enterprise. The provision of Internet services and infrastructure is a highly competitive business, dominated by large corporations, many of which operate globally. These corporations, as we illustrate in chapter 2, make significant use of maps in their marketing strategies. Indeed, the Internet marketing map is an important tool used to demonstrate the power of a company's network to potential customers. Considerable effort is invested in producing high-quality maps that present their networks in the best possible light. As such, Internet marketing maps fit into a long tradition of maps used by companies to promote their networks – be they shipping, airlines, or railroads.

When considering maps in the following chapters, one should question why the map has been presented in the way it has, and why it was produced at all.

The agency of mapping

As just noted, all maps are designed to either change or reaffirm the way we think about, and comprehend, the data presented. In many cases, maps or spatializations of cyberspace are designed to change the way we interact with cyberspace. A key question is thus to ask to what extent a mapping is successful in these aims: does a map or spatialization change the way we think about cyberspace, and do those that seek to offer new modes of interaction offer viable spatial interfaces that could replace or supplement current methods of data management and navigation? In other words, do the maps or spatializations achieve their aims, whether that be improving comprehension, providing new means of navigation or interaction, or selling a service?

A further set of questions relates to the effects if these aims are met. For example, in relation to improving interaction, if a method of spatialization qualitatively alters how we interact with media, how does this affect social relations within specific domains? It may well be the case that the process of mapping may actually change what it seeks to augment, altering the very nature of the medium involved.

Representation and distortion

Maps and spatializations are representations. They aim to represent, in a manner that is spatially consistent, some particular phenomenon. An age-old concern in cartography therefore relates to the extent to which maps adequately represent data. Maps necessarily depict a selective distortion of what they seek to portray, because they employ processes of generalization and classification. There are three principal ways in which maps can distort reality, and give rise to false interpretations: presentation; ecological fallacy; and omission. Each is discussed in turn next.

In making decisions about how data might be mapped, the cartographer has to decide how the data will be presented, considering issues such as projection, scale, classification, and graphic styles of symbols, colors, labeling and fonts. Each of these decisions can affect significantly how data is portrayed and thus interpreted. The map style dictates the choice of base data on which the phenomenon data will be plotted, and how the phenomenon data will be manipulated for presentation. Varying the projection of the base data can lead to maps that vary quite significantly in presentation. For example, the Mercator projection distorts factors such as area and shape in order to allow all rhumbs (lines of constant bearing) to appear as straight lines. While a map drawn in this way suggests that Greenland is approximately the same size as Africa, in reality Greenland would fit inside Africa several times.

Data of interest might be displayed individually or aggregated into units. Aggregation can create a whole set of problems. For example, how the aggregation classes are selected can lead to maps that look quite different. Moreover, the same data mapped onto differing sets of spatial units (e.g., wards, districts, counties, states) can produce significantly different spatial patterns. This is known as the Modifiable Areal Unit Problem (MAUP), which consists of two components: a scale problem and a zoning problem. MAUP problems arise because there is an assumption that we can delineate the boundaries between zones in a precise and meaningful manner, so that the area within a zone is uniform in relation to the data. Of course, this is not in fact the case, because natural spatial variation leads to gradual change across space. The difference between reality and the model can then lead to erroneous interpretation. This is known as the "ecological fallacy". Here, the aggregate characteristics of a whole population are inappropriately ascribed to individuals within populations, and the problem is commonly associated with mapping methods used to map the geography of Internet diffusion (see chapter 2).

Ecological fallacies are often the product of having to map data collected at particular territorial scales. Because the data have no subscale variability there is little choice but to map them at the scale collected. Many of the maps of the Internet are constructed using "off-the-shelf" data that are readily available for country-level aggregation. For example, in many studies of Internet diffusion and "digital divides", the same data sources – such as the World Bank, OECD, International Telecommunications Union, CIA world database and Network Wizards Internet data – are used repeatedly. These organizations publish orderly tables of statistics at the national level that can be turned into maps with ease and little thought. If there is no commentary in the analysis warning of the possible dangers of ecological fallacies, then the people who use the research data can easily be misinformed.

In many ways, national-level data collection is a logical unit choice as there is no doubt that individual experiences and institutional decisions are shaped by national-level power structures through government legislation, deregulation and subsidies. In some respects, however, it seems illogical to create maps that demarcate the Internet into the straightjacket of national borders, especially when the data displayed (e.g., infrastructure owned and operated by global corporations) have little relationship to nation-states. The network technologies of cyberspace are forging connections and virtual groups that potentially subvert the primacy of national boundaries. These borders are relatively meaningless to logical connections and data flows that operate on a global scale. The question in these cases is therefore: "How much sense do existing political borders of the material world make when mapping cyberspace?"

The final way that maps can create false impressions is through omission. For example, many maps of infrastructure and cyberspace focus their attention – either deliberately or unconsciously – on the developed world in the West, especially the United States (and the majority of examples in this book are created by researchers and companies located there). This focus all too easily relegates other parts of the world, such as Africa, metaphorically – and sometimes literally – to the edge of the map. Pushing countries to the periphery reinforces, visually at least, the existing world hegemony in relation to the Internet. The lack of representation of the "unwired" masses on many of the maps is a particular concern. In reality, many of these countries are key to the sustenance of the information economy, providing sites of low-paid, low-skilled office work and the manufacture of computer and telecommunication components that are almost exclusively exported. Moreover, many of the most talented people in the field, such as computer programmers, are being drawn to high-tech centers such as Silicon Valley in the United States from countries such as India.

The issues outlined above affect all maps and spatializations, and yet they have been little considered so far in the mapping of infrastructure and cyberspace (although see our book *Mapping Cyberspace* (Routledge, 2000)). Although map makers can draw on solutions from generations of cartographic theory and practice in order to try to produce better representations of the data, much more consideration needs to be given to spatializations of cyberspace. Here, there are no standards by which to judge factors such as accuracy, precision, verisimilitude, mimesis and fallacy. Indeed, when data and mapping become synonymous, how do issues of representation apply? In this latter case, cyberspace may become meaningless outside its own representation. The need for standards to be set and for issues of representation to be addressed is then of paramount importance.

Level of user knowledge

As the work of cognitive cartographers over the past two decades has amply illustrated, whilst maps are effective at condensing and revealing complex relations, they are themselves sophisticated models. It is now widely recognized that maps are not "transparent" but are complex models of spatial information that require individuals to possess specific skills to understand and use them. Using a map means being able to read a map, which requires a distinct set of skills that must be learnt. This implies that a novice will learn little from a professionally produced map unless he or she knows how the map represents an area. This also applies to maps of cyberspace, particularly in the case of three-dimensional interactive spatializations, which may increase confusion and disorientation rather than reduce it.

Care needs to be exercised in relation to the design of maps, so that the target audience can understand and use the information portrayed. As far as we are aware, whilst there has been some work on the legibility and design of visual virtual worlds and hypertext, there has been little or no work on the legibility of maps of infrastructure or spatializations of cyberspace. Many of the maps we present in the following chapters are difficult to interpret without reference to the explanation in the text. The need for such reference points to the fact that the maps hold poor communicative properties, which need to be improved. Having said this, it must be recognized that many of the maps and spatializations have not been produced for a general audience, having been created as tools to aid specialist analysts in their work.

Data quality and availability

Maps and spatializations are only as accurate as the data used to underpin the representation. Therefore a key issue for those seeking to construct maps of infrastructure and spatializations of cyberspace is access to timely, accurate and representative data. Such access has always been a concern of cartographers, particularly since the Renaissance, but it has become a major issue since the widespread adoption of computer-based cartography in the form of geographic information systems in the 1980s. In particular, spatial data users are concerned about issues such as data coverage, completeness, standardization, accuracy and precision. Here, "accuracy" refers to the relationship between a measurement and its reality, and "precision" refers to the degree of detail in the reporting of a measurement. It is generally recognized that all spatial data are of limited accuracy due to inherent error in data generation (e.g., surveying) or source materials.

No standards of accuracy exist for data concerning cyberspace, and what sources there are are limited and fragmented, with no definitive or comprehensive databases. Consequently, maps can be fascinating but at the same time limited in scope, coverage and currency when compared with the wealth of statistics gathered and mapped for geographic space by government agencies such as the USGS, Ordnance Survey, and national census bureaux. This is compounded by the fact that both infrastructure and cyberspace lack central planning and a controlling authority that monitors and gathers statistics on their operation and use. In addition, the provision of both infrastructure and content services has become an intensely competitive and profitable business. As such, corporations are wary of giving away details that may aid competitors or threaten security.

Given the fast-growing and dynamic nature of both infrastructure and cyberspace, the issue of data quality and coverage is of critical importance. We are in little doubt that maps will become increasingly important for understanding the implications of cyberspace and in comprehending and navigating through cyberspace, but without suitable high-quality and up-to-date data to underpin their construction they will be of limited use. A valuable exercise is to apply the following questions to the data used to construct maps of cyberspace (adapted from *The Geographer's Craft Project* by Ken Foote and Donald Huebner):

- What is the age of the dataset?
- Where did the data come from?
- How accurate are positional and attribute features?
- Do the data seem logical and consistent?
- In what format are the data kept?
- How were the data checked?
- Why were the data compiled?
- What is the reliability of the data provider?

<http://www.colorado.edu/geography/gcraft/contents.html>

Ethics

One final issue to consider relates to the ethics and responsibility of researchers producing maps of cyberspace. As sociologist Marc Smith has argued, these new forms of maps and spatializations open up cyberspace 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 media is their anonymity, then users may object to them 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 cyberspace itself. For example, how does the use of Chat Circles (see Pages 174–5) alter the nature of social interaction within chat rooms? Here, it is important to consider the ways and the extent to which maps of cyberspace are "responsible artefacts" (i.e. ones that do not destroy what they seek to represent or enhance).

Structure of the book

Although still a relatively young field of interest, there have been literally thousands of maps and spatializations of cyberspace created to date. In the course of constructing this particular atlas, we have had to make numerous subjective decisions about which examples to include. At times, this has been a difficult process. Our strategy has been twofold: first, to include a very broad range of images and techniques that visualize as many different aspects of cyberspace and its underlying infrastructure as possible; second, to select those techniques that seem particularly innovative, in terms of both methodology and design, and that seem to offer promising avenues for further development. This inevitably means that the atlas is a partial record of attempts to visualize and spatialize cyberspace, yet at the same time it is intended to provide a balanced overview of the field.

In order to provide a coherent structure to the rest of the book, we have divided the remaining text into five chapters. Within each of the first four of these chapters, we provide a summary overview of some of the main arguments about the particular aspect of cyberspace being mapped, and a discussion of the merits, aims and uses of the maps and spatializations presented. The last chapter contains some final thoughts on the subject.

In chapter 2, we focus our attention on the interesting intersection of cyberspace and geographic space. Here, we present maps of the infrastructure that supports cyberspace, the demographics of cyberspace users, and the flow of data traffic across different scales from the local to the global. The examples discussed predominantly map the data from which they are constructed onto familiar geographic frameworks, although a few use a more abstract approach. These maps provide important insights into who owns and controls the supporting infrastructure, who has access to cyberspace, how the system can be surveyed, and how and from where cyberspace is being used. Often they are most useful for public understanding because a familiar template of real-world geography is used.

In chapter 3, we examine some fascinating ways to spatialize the Web in order to create information spaces that are comprehensible and, in some cases, navigable. We present a wide range of spatializations that have employed a variety of graphical techniques and visual metaphors so as to provide striking and powerful images that extend from two-dimensional "maps" to three-dimensional immersive landscapes. These spatializations are important because they provide interpretable images for data that were previously very difficult to understand. For example, topological structure data of traffic in the logs of a large website are almost impossible for humans to interpret, because they are held in large textual tables, tens of thousands of lines long, that provide no tangible referents other than attribute codes but that, once spatialized appropriately, are relatively easy to interpret.

Spatializations that seek to chart aspects of community and conversation are the focus of chapter 4. The primary attraction of cyberspace is its ability to foster communication between people through a variety of asynchronous (participants communicating at different times) and synchronous (participants present at the same time) media such as email, mailing lists, bulletin boards, MUDs (multi-user domains – see chapter 4), and virtual worlds. Here, we document novel ways to spatialize all these media. Although somewhat variable in their success, these spatializations are important because they seek to enrich the mode of interaction, and thus the success and pleasure of communication between users. Whilst none of the spatializations we present has significantly altered how people currently use these media, they hold great potential to do so.

In chapter 5 we turn our attention away from geographic and informational visualization to consider the other ways in which cyberspace has been imagined, described and drawn. Here, we focus mainly on the work of artists, film makers and writers, who have been seeking to answer the question "What does cyberspace look like?". These visualizations are important, because they often provide the inspiration for the designers and creators of maps and spatializations discussed in chapter 4. As we have argued elsewhere, the influence of these artists, film makers and writers should not be underestimated. This is because they provide a popular imaginal sphere in which to question and explore the space–time configuration of cyberspace. Also, they have aesthetic and artistic worth in and of themselves, and as such they represent both the art and the science of mapping cyberspace.

Chapter 6 comprises our final thoughts for the book.

Concluding comment

There are clearly many issues to think about when viewing the maps and spatializations we present. However, although many are imperfect (to varying degrees), they are all fascinating examples of the innovative ways in which cyberspace is being mapped and spatialized. The examples we document are perhaps equivalent in stature to the real-world maps created at the start of the Renaissance period that formed the bedrock of modern cartography. The broad array of maps and spatializations we detail in the following chapters are the beginnings of what we are sure is going to be a vibrant area of research with many practical applications.