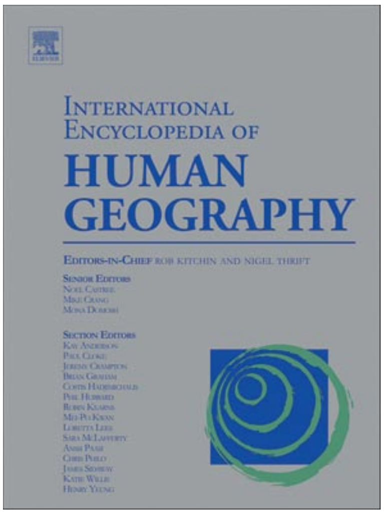

Zook M, Dodge M. 2009. Mapping, Cyberspace. In Kitchin R, Thrift N (eds) International Encyclopedia of Human Geography, Volume 6, pp. 356–367. Oxford: Elsevier.
ISBN: 978-0-08-044911-1

Mapping, Cyberspace

M. Zook, University of Kentucky, Lexington, KY, USA
M. Dodge, University of Manchester, Manchester, UK

Glossary

Cyberspace A term coined by science fiction author William Gibson, now used to refer to the space of interaction and information available through the computer networks, such as the Internet.
Information Space A generic description for all types of electronic communications networks such as peer to peer file exchange, instant messaging, and mobile devices.
Map Mash-Up The practice of dynamically combining two or more Internet-based services into a new map.
Spatialization Map-like interfaces that employ spatial metaphors to represent data that are not necessarily spatial.

Introduction

Over the past 30 years many different mapmakers, from a diverse range of academic, technical, and institutional backgrounds, have mapped various aspects of cyberspace. Cyberspace cartographies are one of the significant areas of creativity in contemporary mapmaking, with a considerable amount of experimentation with visual metaphors, survey methods, data sources, and, above all, novel forms of user interaction with map representations. Indeed, because cyberspace lacks established conventions of representations, it has proven to be a ripe domain for innovation in cartographic theory and practice such as facilitating new types of participatory, bottom-up, mapping activity. At the same time, it offers powerful new means for surveilling and mapping social activity and can increase the capability of government and corporate interests to control what is represented.

Mapping cyberspace can be usefully categorized into three distinct cartographic modes:

- maps in cyberspace;
- maps of cyberspace; and
- maps for cyberspace.

The first mode, maps in cyberspace, involves putting existing forms of geographic cartography online to widen access and add user interactivity. Maps in this mode utilize conventional spatial conceptualizations and are drawn in much the same way as long established paper-based maps. They often, however, depend upon the availability and organization of geospatial data in cyberspace, thereby affecting how the content of these maps is prioritized. The second mode, maps of cyberspace, documents the infrastructures and operations of cyberspace itself, and is, therefore, primarily defined by the subject of the maps rather than the spatial conceptionalization behind the map or the tasks undertaken with them. The resulting maps encompass a multitude of graphic forms, some of which appear quite uncartographic in a normative sense, such as topological network graphs. The last mode, maps for cyberspace, produces maps designed to navigate through the virtual spaces of cyberspace. These maps are mostly created through the spatialization of nongeographic information structures to produce map-like interfaces to support interactive browsing and searching. As such this mode is primarily defined by the task to which the maps are put rather than their subject or spatial conception.

As with all categorization, this threefold classification is a simplification. The boundaries between idealized map modes are not always clear cut and, as noted below, there are cases in which examples can be placed in different classes depending on the context in which they are used. Thus, cyberspace mapping is best viewed as a wide continuum of different representations running from static online cartographic maps of geographic space at one end to immersive spatial interfaces for the navigation of purely virtual space at the other.

Maps in Cyberspace

Mapping in this mode has already produced demonstrable utility and commercial viability in putting 'real-world' cartography online through developments in web mapping portals and Internet-based geographic information system (GIS) services. For example, many popular mapping services allow users to locate addresses or obtain driving directions for trips including options for avoiding road construction or other delays. While most of these are commercially driven, they are generally free to end users and rely on advertising and sponsorship for revenue generation (Figure 1). Because of the continuity with previous forms of mapping, this mode has received much attention from cartography practitioners and academic researchers. This work is mostly of a technical nature, that is, adapting existing practices to the new media and developing appropriate forms of user interactivity.

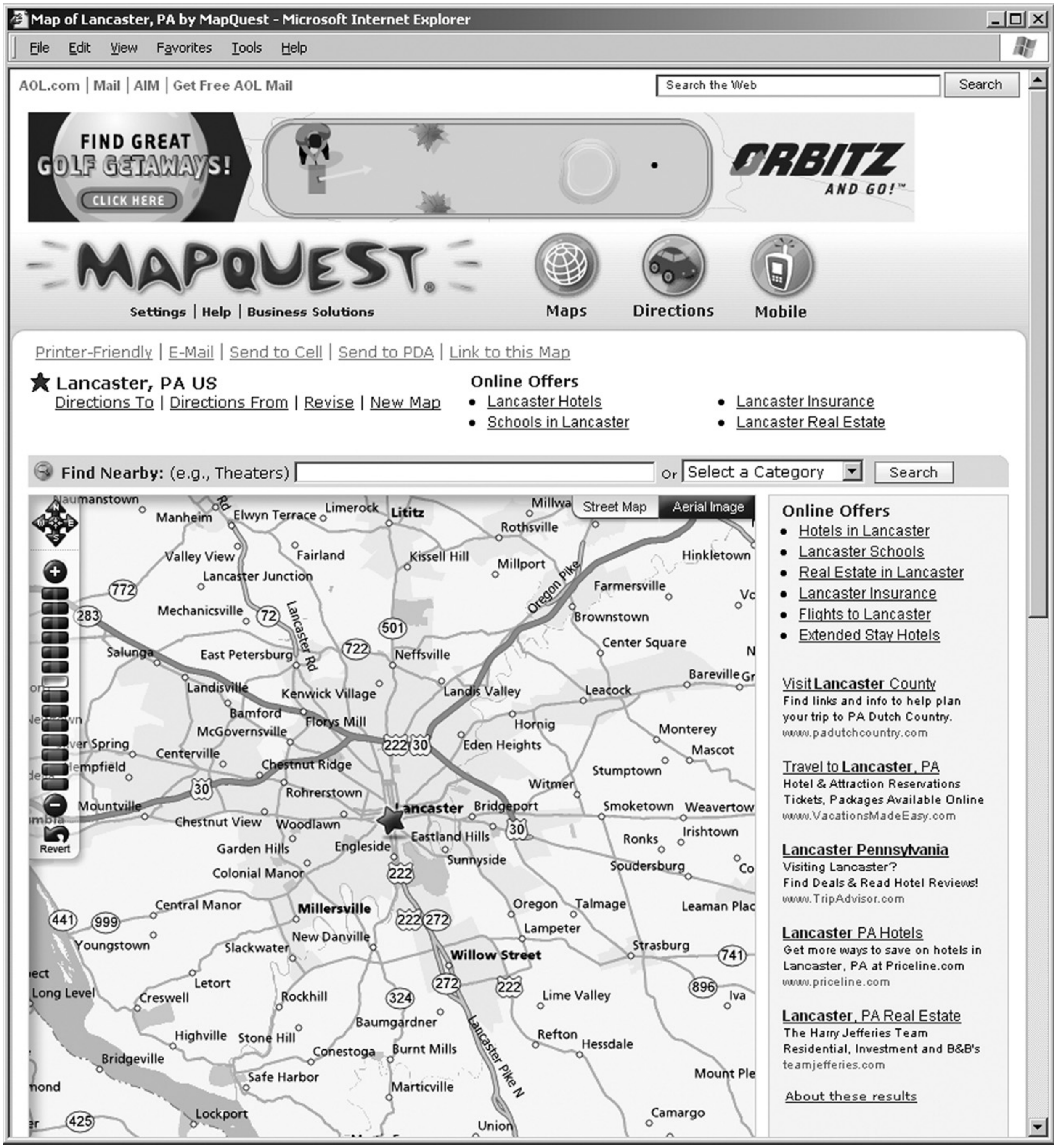

Figure 1 A typical 'maps in cyberspace' example showing a road network representation, generated by the MapQuest service. Source: author screenshot.

In addition to providing driving directions and the ability to find and map nearby facilities, the emergence of virtual globes with aerial and satellite imagery, such as Google Earth and NASA's World Wind, represents a seductive 3-D interface for exploring geographic space ranging from simple search to identifying (and commenting on) points of interest (Figure 2). Thus, maps in cyberspace are creating the means for a more dynamic and interactive mapping that, arguably, transforms people from passive consumers of cartography into much more active map users. Indeed, online mapping services such as Google's 'My Maps' allow Internet users to create their own maps and share them with the entire online community. While potentially empowering for those with access, persistent gap between the 'connected' and those who are offline or unskilled in the use of these

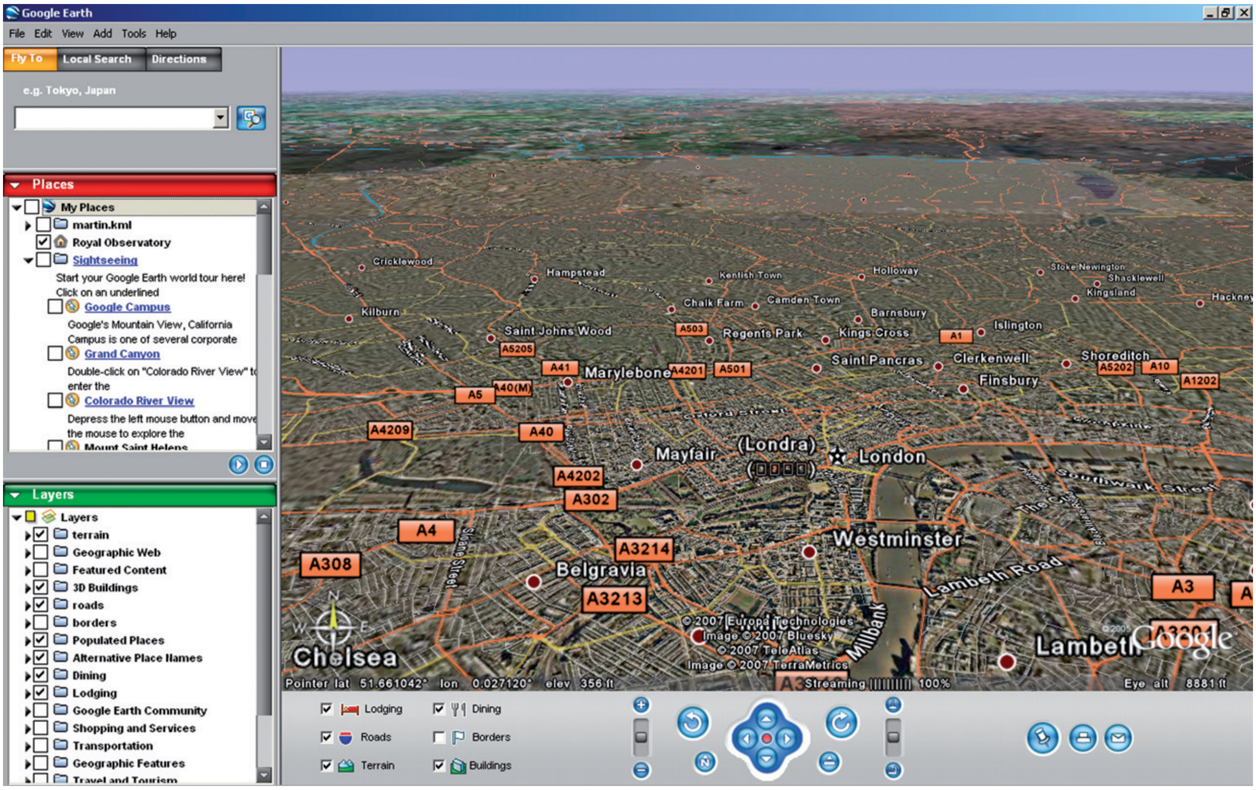

Figure 2 An example of virtual globe display, showing central London seen through Google Earth. Source: author screenshot.

technologies means that active participation in online mapping remains highly differentiated. While this gap is not novel, the replication of the digital divide in the use and annotation of online maps raises questions of whose representations and understandings of place will be mapped and prioritized.

For example, a number of hobbyists and hackers have begun to generate 'map mash-ups', the combination of multiple online data sources into a new integrated service that maps a specific phenomenon. Examples include locating apartment listings from craigslist.org and mapping user reported prices at gasoline stations. Mash-ups illustrate how the combination of digital data available on the Internet with basic mapping software can create new and useful interfaces to the world, albeit the nature of these interfaces is closely tied to who is online and who is not. Moreover, this expanded mapmaking capability is accompanied by a number of related concerns about control over the organization and representation of many maps in cyberspace. For example, databases of businesses and other activities utilized by these maps are often organized at the postal code level to allow for faster processing and map generation. Thus, despite the serious shortcomings of postal codes as areal units, they are becoming a 'naturalized' division used for these maps.

A more serious matter is the way in which the presence and popularity of a business or organization in cyberspace determines the order in which it appears in a map. Google Maps, for instance, uses a hybrid measure of distance that combines physical distance and ranking in cyberspace to determine the order in which businesses appear on maps. Entities with large and highly ranked websites can be prioritized over those with little to no presence in cyberspace even if the latter entities are physically closer to the searched location. Additionally, since maps in cyberspace are largely commercial products, this ranking process (including the possibility of paid placement) is opaque to users. In short, the control over these maps and the algorithms used to generate them is vested in private companies without accountability to the public who uses them.

This privatization of mapping marks a shift in cartographic power away from governments who have long naturalized their agendas via maps designed as instruments of state control. The shift to corporate control of maps, albeit troubling in its own right, challenges the states' ability to shape what appears on maps of their territory. For example, some states such as Greece, Turkey, Pakistan, and South Korea have complained when imagery of sensitive military and government sites has appeared in online mapping services such as Google Earth. While this loosening of state control over mapping is emancipatory, the power to control maps nevertheless remains concentrated. A potential means to place control of maps within the citizenry is web-enabled 'democratic cartography' such as the 'OpenStreetMap' project, that is, a grassroots effort to create an open-source topographic database in the public realm. While much more participatory and less passive than other mapping methodologies it nevertheless presupposes that contributors are on the 'connected' side of the digital divide. Although issues of quality, reliability, and scalability remain, the ability to leverage cyberspace to organize group efforts to create open-source spatial data highlights the potentially revolutionary nature of maps in cyberspace.

Maps of Cyberspace

The maps of cyberspace mode encompass graphic representations that facilitate the spatial understanding of the materiality of cyberspace itself, that is, showing the geographic patterns of network infrastructure, content production, and/or the distribution of users. This narrow focus of subject matter is a key characteristic of maps of cyberspace.

Many of the maps produced in this mode use the semiotics of mainstream cartography, for example, cable routes as colored lines on a geographic base map or thematic mapping that spatially represents statistical data on usage (Figure 3). However, other products of the maps of cyberspace mode go beyond conventional cartographic conceptions and use nongeographic forms of representations, for example, non-Euclidean visualizations of the topological structure of network infrastructures (Figure 4). Such abstract graphs illustrate the relational connectivity between Internet nodes rather than their position in geographic space. In addition, a number of maps of cyberspace also expand beyond the two dimensions of mainstream cartography and utilize 3-D graphics and virtual reality interfaces, for example, visualizing web server traffic as 'skyscrapers' on a virtual globe (Figure 5). While an innovation in cartographic practice these maps often perform poorly in actually conveying useful information.

Few of the makers of maps of cyberspace call themselves cartographers; rather they are a diverse group ranging from individual programmers to governmental agencies. Unsurprisingly, the most prolific group are operators of data networks who make maps of their infrastructure to accomplish particular and immediate goals such as analyzing traffic or projecting growth. Much of this work is never made public. This lack of publicly available maps of cyberspace, tied to the 'invisibility' of telecommunications infrastructure more generally, compels many to become cyberspace mapmakers in order to do their jobs. This scarcity of maps has made individual authorship of maps commonplace, particularly because the cyberspace infrastructures can be used to map themselves in quite innovative ways and at very low costs.

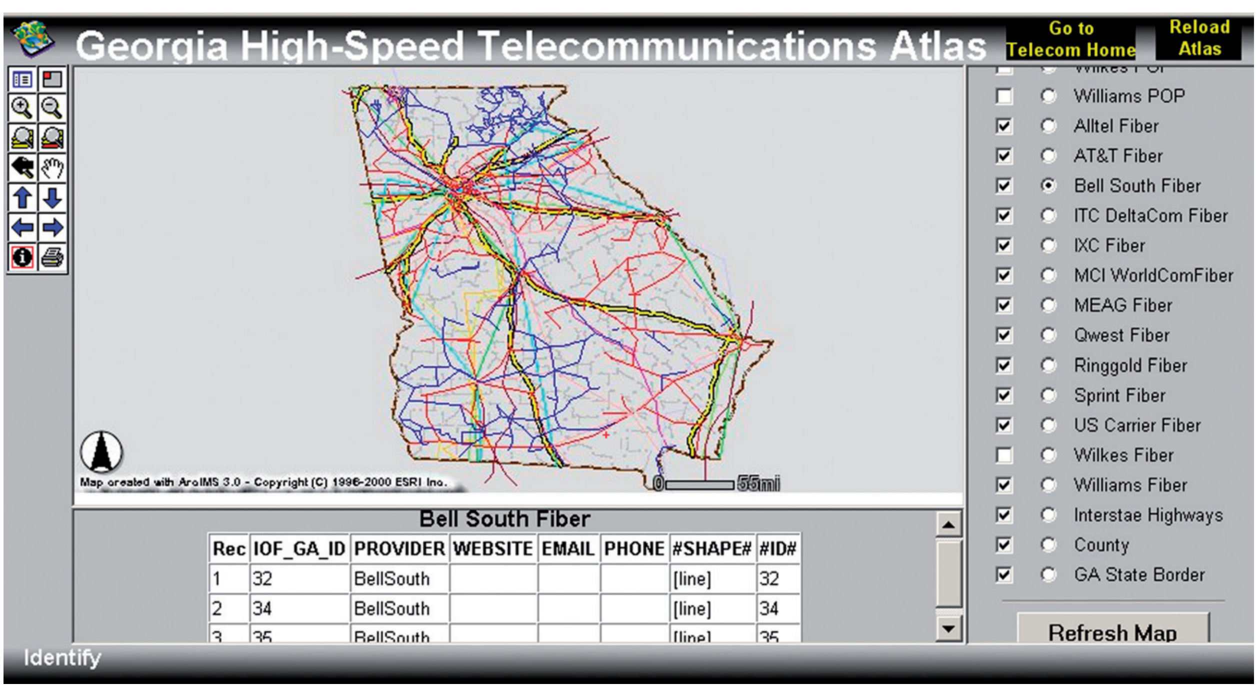

Figure 3 A telecommunications atlas of network infrastructure in Georgia, USA, is a typical example of 'maps of cyberspace' mode. However, it was disseminated using web mapping technology that is characteristic of the 'maps in cyberspace' mode. The atlas was produced by university researchers at Georgia Tech as an information resource for regional economic development. Source: author screenshot; service no longer available.

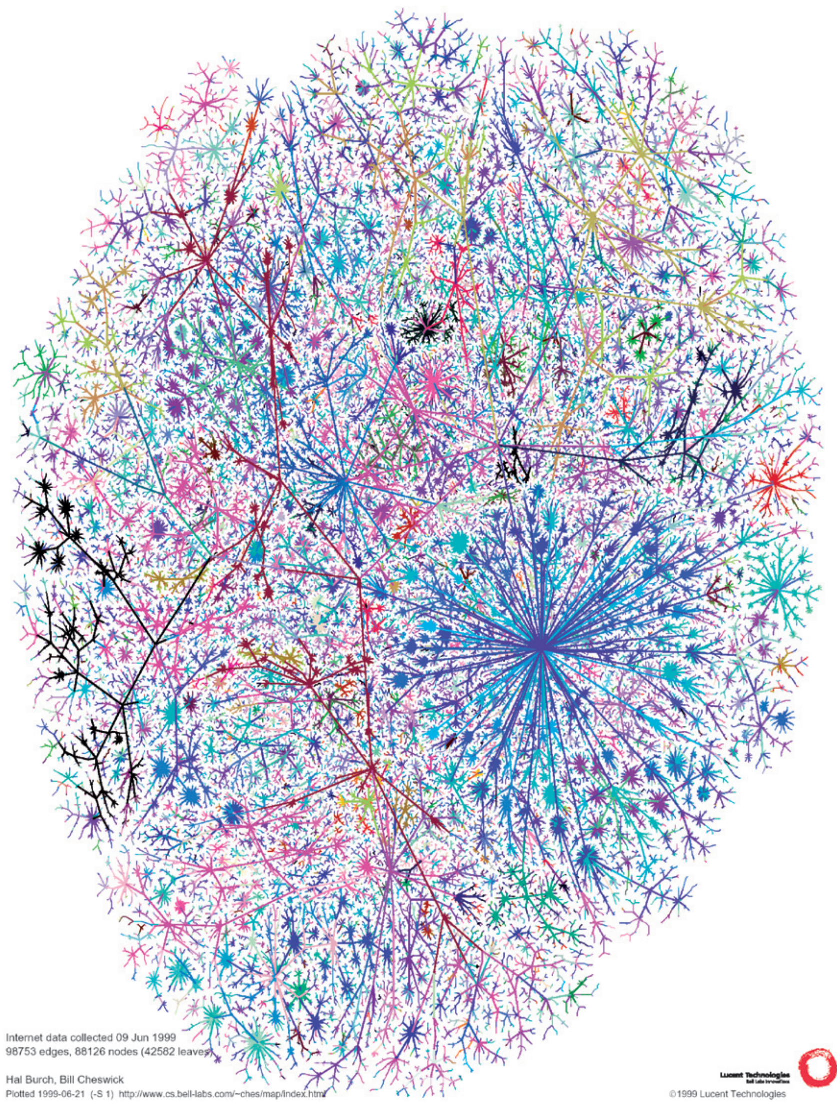

Figure 4 A 'map of cyberspace' example which graphs the core of the Internet 'cloud' in topological terms. The color coding of nodes seeks to highlight zones that share common network addresses and likely corporate ownership. Source: Bill Cheswick, Lucent Technologies, 1999.

This allows novel opportunities for, so-called, super-empowered individuals to chart vast swathes of cyberspace with minimal resources, utilizing software to automate the surveying process and reducing the burden of visualizing large volumes of data.

Given the diversity of producers of maps of cyberspace it is not surprising that they serve multiple normative purposes. These range from documenting cyberspace infrastructure and flow, to cartographic propaganda by companies with vested financial interests in the expansion of cyberspace, to maps used in policy analysis. Infrastructure-based maps of cyberspace can show complex computer networks over several spatial scales, from the street up to the global scale and are used to maintain physical hardware and manage network flows more effectively. The propaganda maps are tied to the market goals and are deployed as persuasive devices to support the rhetoric of expansionism and as a means to exert sovereignty of private capital over public cyberspaces. A cursory examination of most Internet service provider (ISP) websites reveal bright, colorful, and visually arresting maps used to highlight the advantages of the latest communications technology to prospective investors and potential customers (Figure 6). An additional important purpose of maps of cyberspace is academic and policy analysis of the expansion of information flows and cyberspace. Pioneered by geographer Jean Gottmann's work on intercity telephone call patterns in the 1960s, much of this work focuses on explaining the exponential growth in Internet infrastructures, connectivity, and usage. Visual summary presentation using statistical charts and geographic maps is common.

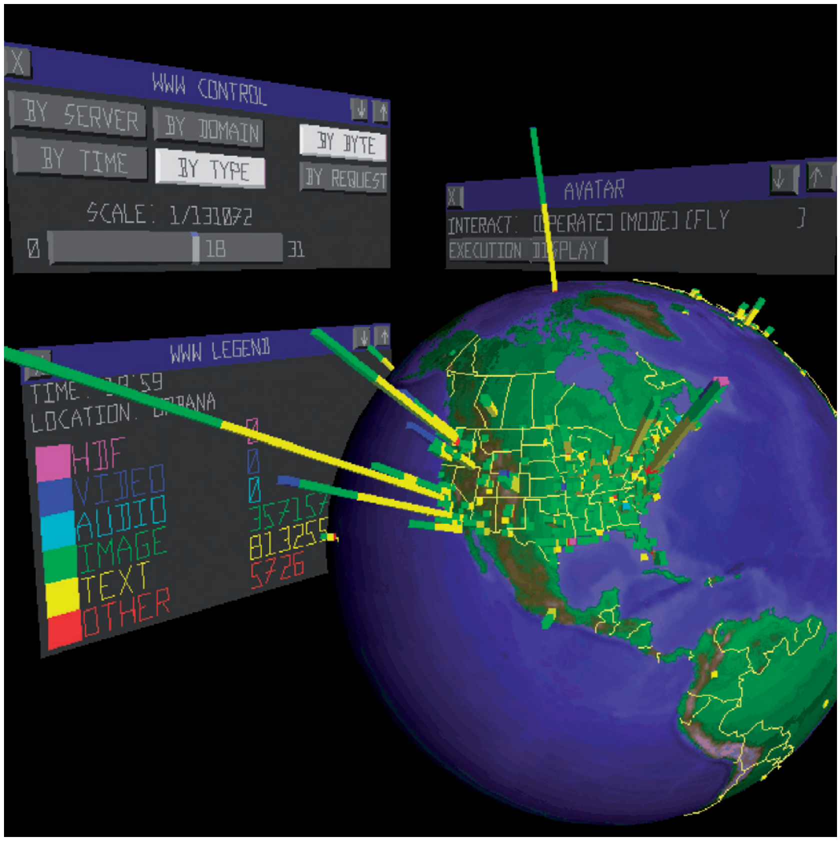

Figure 5 A 'map of cyberspace' showing aggregate traffic on a web server as geocoded bar drawn onto a globe. It could be interrogated within a virtual reality interface. From Lamm, S. E., Reed, D. A. and Scullin, W. H. (1996). Real-time geographic visualization of World Wide Web traffic. *Proceedings of Fifth International World Wide Web Conference*, Paris, France, 6–10 May.

In addition to these three specific purposes, maps of cyberspace taken as a whole have a significant pedagogic utility in challenging the naïve notions that virtual interactions spell the death of distance or render geographic location meaningless. Maps of cyberspace reveal the complex intersections between virtual space and geographic space at various scales. A number of these maps can provide insights into who owns and controls the supporting infrastructure, how and from where content is being produced, and how the uneven diffusion of infrastructure affects cost, speed, reliability, and ability to connect. These maps illustrate how infrastructure is concentrated at the global scale in certain countries (such as the US, UK, and Scandinavia), at the national scale in certain regions (e.g., Silicon Valley, the west London-M4 corridor, the Helsinki metropolitan area), and even at localized neighborhood clusters within 'high-tech' cities like San Francisco or New York, for example, Matthew Zook's mapping of Internet domain name ownership (Figure 7).

Despite the utility of these efforts, the available maps of cyberspace provide, at best, only a partial view of cyberspace given that data are limited in many areas, for example, information on Internet traffic flows between and within cities is unavailable to researchers. Moreover, mappable information of cyberspace is actually diminishing as the growing diversity, size, and privatization of cyberspace, as well as post 9/11 security concerns are making it harder to survey and represent it legibly.

Maps for Cyberspace

The extent and usage of cyberspace have grown very rapidly in the last decade. With so many distinct virtual spaces and users online, cyberspace has become an enormous and often confusing entity that can be difficult to cognize and navigate. The maps for cyberspace mode focus on helping people understand the structures of online spaces of information and social interaction, rendering them in visual form and enabling people to navigate through them. In other words, maps become interfaces of exploration 'inside the wires', rather than representations of how the 'wires' themselves are arranged and produced. They map immaterial information rather than material infrastructures.

Cyberspace has meaningful informational structures to be surveyed, calculated, and mapped. For example, the

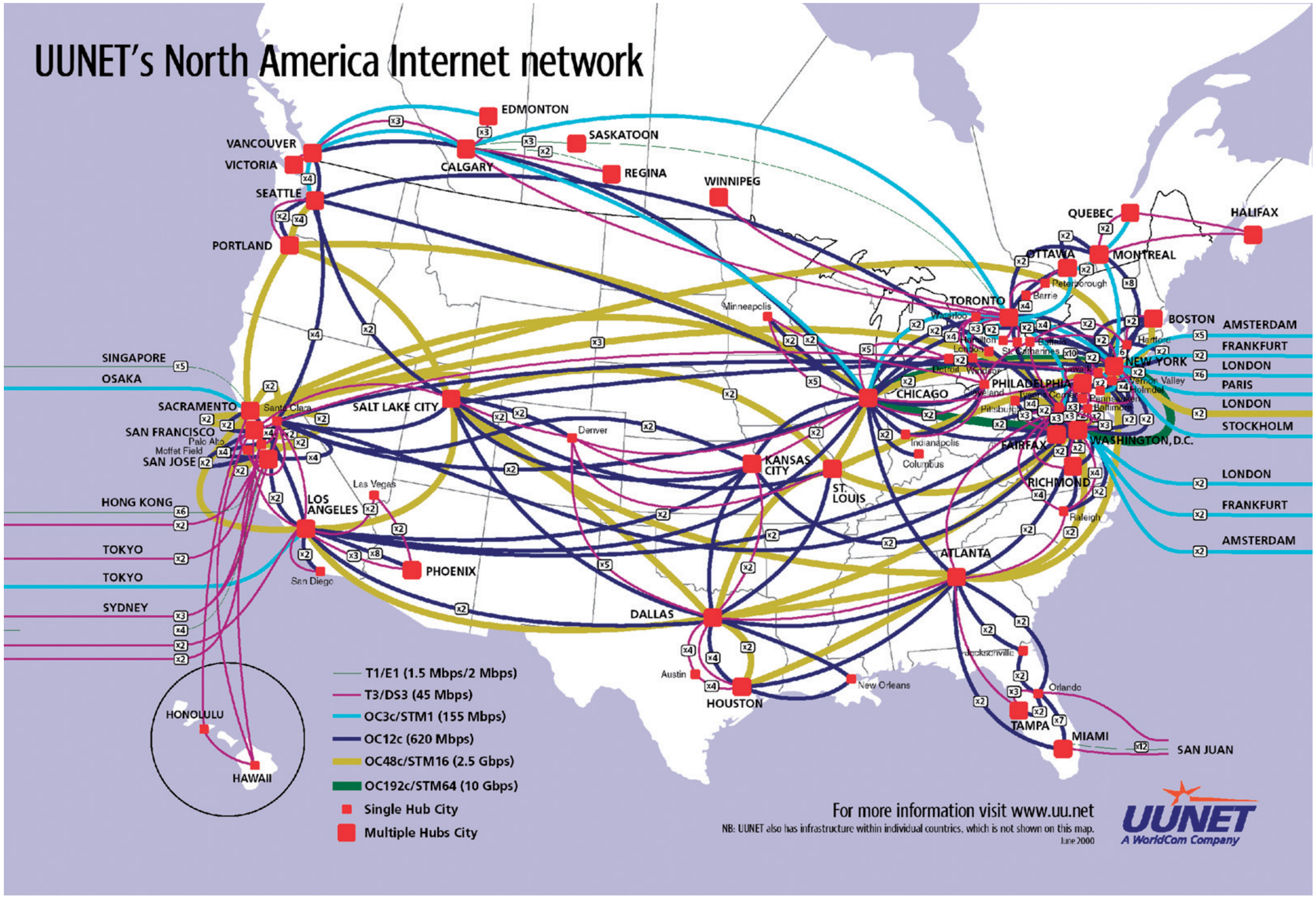

Figure 6 A ‘map of cyberspace’ produced for marketing WorldCom’s UUNET network infrastructure. Source: originally published on corporate website, June 2000. No longer available.

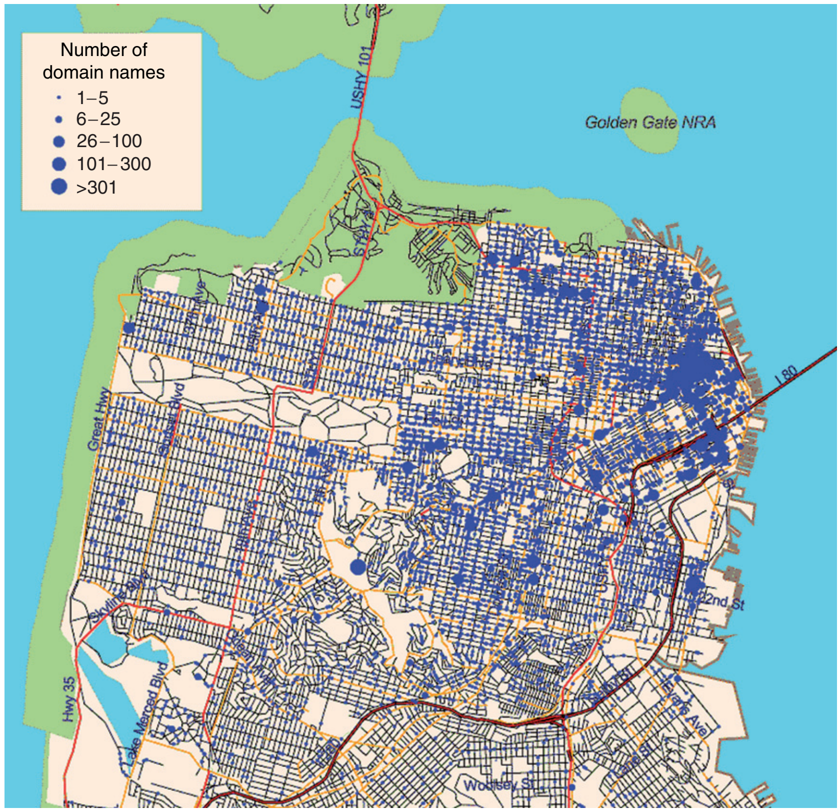

Figure 7 A 'map of cyberspace' representing the number of Internet domain names within San Francisco, based on street address of the registered owners. Source: Matthew Zook.

semantic similarity between content, affinity ties of differing strengths in online social networks, and turn-taking in mediated conversations have all been successfully transformed into map-like representations. Contributions by cartographers or geographers have been minimal, instead a diverse group of mapmakers, including graphic designers, sociologists, information scientists, librarians, and interface engineers (mostly located within academia) have led this work. These efforts, however, have largely failed to produce workable maps suitable for widespread public usage.

Many of these projects, particularly within computer science, emerge from information navigation studies which focus on creating more efficient means of human–computer interaction. Online spaces, such as the web, simply provide a conveniently accessible, large-scale test-bed for this work. Another important focus is the information design community that structures the architecture of the online content such as site maps on websites (Figure 8). Valuable and eclectic contributions have also come from new media artists developing interactive maps as works of art and as virtualized architectural spaces.

Maps for cyberspace have utility since they render intangible virtual media, composed of immaterial software algorithms and database records into visually tangible spaces. Even though one cannot 'touch' hypertext, for example, it is possible to plot its structures on screen to aid user navigation. Depending on their scale and design, information maps can give people a unique cognition of a space otherwise difficult to understand. As such, mapping of information space offers three distinct and interlinked advantages:

- creating a sense of the whole information space;
- supporting ad hoc interactive user exploration; and
- revealing hidden connections between data objects.

In a metaphorical sense, these maps enable users to get a 'bird's eye view' of an information space. Such overview visualization, displayed on a single screen for cognition at a glance, is particularly important given that most online information seeking is via unstructured and poorly formulated browsing and foraging techniques. These maps try to provide an intuitive and meaningful interface to the structures of information space not only in terms of direct relationships between documents (via citations or hyperlinks, for example) but also in terms of shared themes, semantic connections, and common usage within the document's content. These structures and relationships are usually completely hidden in the presentation of conventional interfaces, like web browsers. Yet this is often where one finds insight and answers, in the

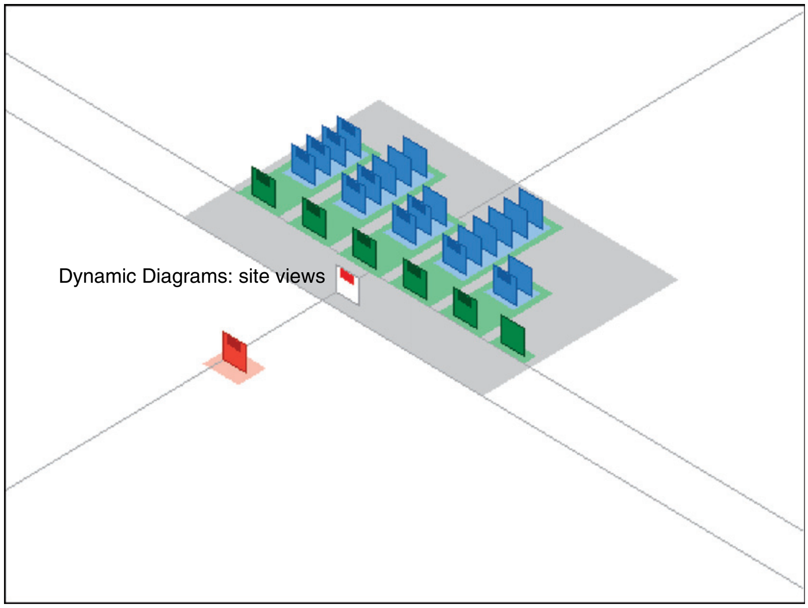

Figure 8 A 'map for cyberspace' system developed by Dynamic Diagrams provided as an interactive spatialization to aid website navigation. Source: author screenshot.

visual–cognitive assimilation of how the mosaic of available information fits together. The effective power of maps for cyberspace comes from showing these relationships to users to enable them to make better navigational decisions.

Developments in the field of information visualization in the last decade have proved particularly fertile through processes of spatialization. These are map-like interfaces that employ explicit spatial metaphors to represent data that are not spatial. Spatialization renders large amounts of abstract data (usually textual corpus) into a more comprehensible, compact visual form by generating meaningful synthetic spatial structure (such as distance on the map display scaled according to a metric of lexical similarity between data items) and applying cartographic design concepts from topographic mapping and thematic cartography. Some of the most cartographic looking examples have used the conventions of hill shading and terrain contouring to create browseable virtual landscapes (Figure 9). There is scope for greater involvement of cartographers in information visualization to develop improved spatializations. In turn, developments in spatialization driven by computing and information science specialities are feeding back into mainstream mapping practice, pushing the boundaries of cartographic theory.

Despite these potential advantages, creating workable spatializations faces significant epistemological challenges. This is particularly the case because cyberspace's many information spaces overlap, but often in *ad hoc* and unplanned ways, giving rise to complex, nonhierarchical and dynamic structures that are not easily surveyed or visualized. Moreover, cyberspace is not a homogenous or static phenomenon, but a myriad of rapidly evolving digital databases, communications channels, and media platforms, with distinct forms of virtual interaction. These are inherently transient landscapes where changes are 'hidden' until one encounters them. Change can happen instantaneously, for example, deleting a web page leaves behind no trace (unless archived elsewhere). The lack of reciprocity in relations means an information node can vanish without notice or notification to any other party.

These issues of information mutability and transience are likely to grow, and become obfuscated by the increasing use of encryption and *ad hoc* distributed architectures (e.g., peer-to-peer file sharing, mobile devices, and Wi-Fi networks) making information mapping even harder. The task of generating even a basic index of parts of cyberspace continues to tax the largest corporations and government agencies. Web search engines, for example, struggle to keep pace with the growth and mutability of just this one part of cyberspace. In contrast to maps of geographic space which may remain valid for decades (e.g., topographic maps), the shelf life for many cyberspace maps is short. To combat this, maps for cyberspace could be structured to dynamically represent virtual space in real time, much like a radar map for tracking weather patterns.

A final challenge for spatializing cyberspace relates to the nature of the space where space-time laws of physics have little meaning. This is because information spaces are purely relational and are solely the productions of their designers and users and only have attributes of geographic (Euclidean) space if explicitly programmed. Thus, many information spaces violate two principal assumptions of

Figure 9 A 'map for cyberspace' called NewsMaps that produced an information landscape to visualize and navigate new stories. Source: author screenshot; service no longer available.

modern (Western) cartography. The first of these are the Cartesian properties of space as continuous, ordered, and reciprocal; there are no sudden gaps in the landscape, 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. Yet parts of cyberspace are discontinuous, lacking linear organization and in some cases elements can have multiple locations. 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 there are virtual spaces, such as created in hypertext, where in a literal and functional sense the map 'is' the territory. Cartesian logic collapses and there is no reality independent of the representation. This can be experienced in the experimental 3-D fly-through spatializations of hypertext, such as Apple's HotSauce navigation map-interface (Figure 10).

A last important point to consider is the ethics of maps for cyberspace when they are used to visualize the patterns of online social interaction between people (such as conversations and activities in virtual worlds) in order to gain insight into user behavior. These visualizations are double-edged in that they may help inform the social life of an online community, but simultaneously they represent a type of cartographic surveillance which highlights interactions previously hidden in unused log files and databases. In ethical terms the act of mapping itself may constitute an invasion of privacy and infringement of personal rights, particularly if the appeal of some online social spaces is their sense of anonymity. For example, the public release by America Online (AOL) in August 2006 of user searches showed how revealing seemingly innocent online interactions could be and how easily individuals could be identified. Thus, in some senses, these maps can shift the information spaces they chart from what their users consider semiprivate spaces to public spaces, thus changing the nature of the space itself.

Conclusion

Cyberspace mapping continues to rapidly develop, with visualization encompassing all types of information space. As wireless access diffuses and mobile devices become more sophisticated, the line dividing Internet space versus other information space is growing more indistinct. Moreover, as these electronic spaces are incorporated into our daily lived routines, we are increasingly navigating through hybrid spaces in which the physical and digital meld together.

All three modes of cyberspace mapping discussed create innovative forms of representation and have

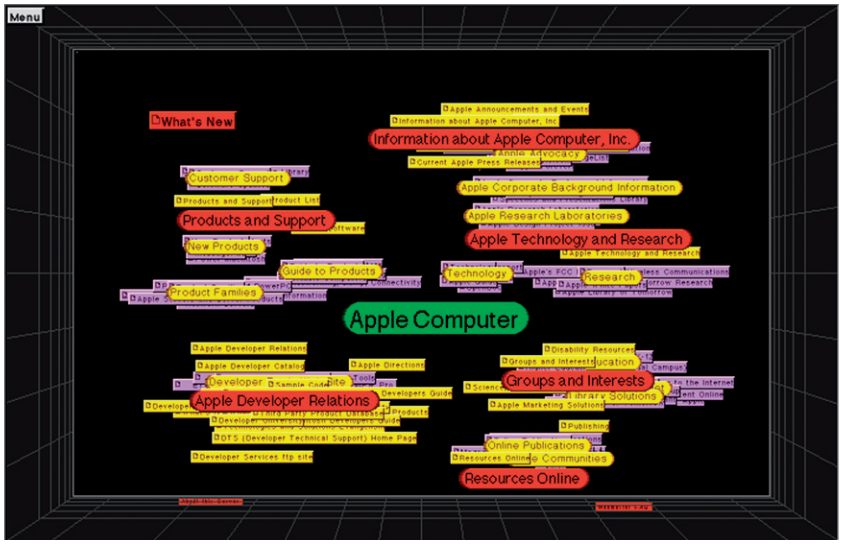

Figure 10 A 'map for cyberspace' called HotSauce that presented websites to users via a fly-through interface. Source: author screenshot.

expanded the frontiers of cartography in terms of what is mappable and how users interact with maps. Alongside these achievements there remain age old questions of the power and the politics of maps. While cyberspace is in some ways democratizing mapmaking, it has simultaneously provided governments and corporations with new opportunities for mapping and control. Maps continue to be effective governmentality tools when the cartographic gaze is harnessed by the state to discipline people and by corporations to market to them. For example, web browsing leaves detailed digital data trails that reveal everywhere a user has 'been' and what they read online. The resulting data, which generally reside with private companies, can be mined and visualized. The ways such trails and traces are used to build data profiles are particularly threatening because they open many new axes of discrimination for powerful public and private interests. Thus, while mapping cyberspace has opened new opportunities for spatial understanding, it also brings up larger questions of power and control. Who is making and using the maps? How is use of these maps monitored? How does the use of the map change the maps and mapmaking?

See also: Critical Cartography; Cyberspace/Cyberculture; GIS, Public Participation; Internet-Based Measurement; Internet/Web Mapping; Map Hacking; Map Types; Mapping, Topographic.

Further Reading

Card, S. K., Mackinlay, J. D. and Shneiderman, B. (1999). *Readings in information visualization: Using vision to think*. San Francisco: Morgan Kaufmann Publishers.

Castells, M. (2001). *The internet galaxy*. Oxford: Oxford University Press.

Crampton, J. W. (2003). *The political mapping of cyberspace*. Edinburgh: Edinburgh University Press.

Dodge, M. and Kitchin, R. (2000). *Mapping cyberspace*. London: Routledge.

Dodge, M. and Kitchin, R. (2001). *Atlas of cyberspace*. London: Addison-Wesley.

Fabrikant, S. I. and Buttenfield, B. P. (2001). Formalizing semantic spaces for information access. *Annals of the Association of American Geographers* 91(2), 263–280.

Geowanking, Discussion of innovation geospatial technologies and open source mapmaking. http://lists.burri.to/mailman/listinfo/geowanking (accessed on 17 July 2007).

Gibson, R. and Erle, S. (2006). *Google map hacks*. Sebastopol, CA: O'Reilly.

Gottmann, J. (1961). *Megalopolis: The urbanized northeastern seaboard of the United States*. New York: Twentieth Century Fund.

Harpold, T. (1999). Dark continents: Critique of internet metageographies. *Postmodern Culture* 9(2), January 1999.

Kahn, P. (2000). *Mapping websites: Designing digital media*. London: Rotovision.

Kraak, M. J. and Brown, A. (2001). *Web cartography*. London: Taylor and Francis.

Lamm, S. E., Reed, D. A. and Scullin, W. H. (1996). Real-time geographic visualization of World Wide Web traffic. *Proceedings of Fifth International World Wide Web Conference*, Paris, France, 6–10 May.

Peterson, M. P. (2003). *Maps and the internet*. Amsterdam: Elsevier Science.

Pickles, J. (2004). *A history of spaces*. London: Routledge.

Wise, J. A. (1999). The ecological approach to text visualization. *Journal of the American Society for Information Science* 50(13), 1224–1233.

Zook, M. A. (2005). *The geography of the internet industry*. Oxford: Blackwell.

Relevant Websites

http://www.cybergeography.org/atlas
Atlas of Cyberspaces (maintained by Martin Dodge).

http://www.caida.org
Cooperative Association for Internet Data Analysis.

http://www.housingmaps.com
Example of Map Mash-up (Apartment listings).
http://www.mywikimap.com
Example of Map Mash-up (Gasoline prices).
http://bbs.keyhole.com
Google Earth Community Bulletin Board.
http://bbs.keyhole.com
MapQuest, an AOL company.
http://worldwind.arc.nasa.gov
National Aeronatics and Space Administration, Learning Technologies, World Wind 1.4.
http://www.openstreetmap.org
OpenStreetMap Project.
http://www.telegeography.com
TeleGeography Research, A Research Division of PriMetrica, Inc, Products and Services, Maps.
http://www.visualcomplexity.com
Visual Complexity Gallery of Internet Network and WWW Spatialization.