these issues and work towards appropriate solutions. Fortunately, the pace of internet growth will ensure that this occurs sooner than latter.

REFERENCES

1. *Network Wizards, (1999),* Internet Domain Survey, *www.nw.com*.

2. McRae, H., (1999), Shake Out for the Upswing, *Net Profit: Electronic Business Demystified, Issue No. 27.*

3. Thrower, N., (1972), Maps and Civilization: Cartography in Culture and Society, *The University of Chicago Press.*

4. Barker, J., (1998), The Web's New Shape, *Inside Multimedia, Issue No. 179.*

5. Jupiter Communications, (1999), AdSpend, *www.jup.com*.

6. Brockman J., (1996), DIGERATI: Encounters with the Cyber Elite, *Orion Business Books.*

7. Pindyck, R., Rubinfeld, D., (1998), Microeconomics, *4th Edition, Prentice Hall International.*

8. Stoll, C., (1995), Silicon Snake Oil: Second Thoughts on the Information Highway, *Anchor Books.*

9. Plewe, B. (1997), GIS Online: Information Retrieval, Mapping, and the Internet, *On Word Press.*

Building an Atlas of Cyberspace

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What is Cyberspace and can cartographers map it? Cyberspace is the multifaceted digital space in and of computer networks. At the very heart of Cyberspace, and its golden children, the Internet and the Web, are a rich and deep foundation of spatial metaphors, both literary and visual (Adams 1997, Graham 1998). Given how deeply ingrained spatial metaphors are throughout the emerging Cyberspace, it would seem that cartographers have much to contribute in mapping out this new geography and advancing our understanding of it. Scholars in a number of disciplines have done valuable work critically examining Cyberspace through the lens of geographic space at varying scales; for example, urban planning (Graham & Marvin 1996), architecture (Mitchell 1995, Anders 1998), urban sociology (Castells 1996), and geography (Kitchin 1998, Crang et al. 1999). The field of information visualisation has emerged in the 1990s from computer science and computer graphics, and has contributed significantly to mapping Cyberspace (Card et al. 1999). Also, we should also not overlook the expertise in the graphic design community in charting Cyberspace (Jacobson 1999).

There is no one single map of Cyberspace that can show everything, just as there is no one map of the geography of a country like Britain. Instead, we compile atlases to show the complex and many fold geographies of a country. A comprehensive atlas of Britain covers all aspects - the landscape, the soil, the buildings, the roads, the people, disease, crime, wealth and poverty, rivers and rainfall. In just the same manner, an atlas of Cyberspace will contain many different kinds of maps, mapping the myriad distinct virtual spaces of Cyberspace (e.g. telephone & fax, email, web, chat rooms, multi-user games, intranets, and electronic financial flows). There are also different dimensions of the spaces to be mapped and understood (infrastructure, protocols, content and traffic). As yet, you can not buy an atlas of Cyberspace in the shops, but over the past couple of years I have attempted to construct one by combining the best maps of Cyberspace from many diverse sources. Appropriately enough the current version is available on the Web at *<http://www.cybergeography.org/atlas/>*. In the rest of this article I present five exemplars from the Atlas showing how different aspects of Cyberspace are being mapped and the diversity of cartographic forms being employed.

It is important to realise the Cyberspace is not new, it builds on decades of technological evolution in computing and telecommunications. While maps of Cyberspace have been drawn since its earliest times, for example there are the black and white line drawn maps of topological structure of ARPANET, the cold war forefather of today's Internet (figure 1). The maps were drawn for the engineers who built and managed the network and they are strictly utilitarian and functional, simply showing the nodes of the network - the advanced research labs of universities and corporations doing defence related research - and the links between them on an outline of the Continental USA. Figure 1 shows an example from October 1980, but a whole series were produced through the 1970s and 1980s from which one can trace the growth and eventual decline of the ARPANET. This map is particularly interesting for me, as it shows the satellite linkage from the US to London, installed in 1973, which connected to UCL where I now work. This wavy line on the map is significant as it

represents the first wiring of the UK into the Net.

Maps like these, from the early days of wide-area networking and internetworking, are in some senses the ancient maps of Cyberspace. They are becoming important as historical documents recording the growth and spread of networks of which there is now little physical trace. For this reason they are frequently employed in books on the history of Net (e.g. Salus 1995, Hafner & Lyons 1996, Abbate 1999), after all what better means of illustrating a network that has disappeared than a map of it. For further examples, see the historical maps section of the *Atlas of Cyberspace* at <*http://www.cybergeography.org/atlas/historical.html*>.

Mapping the infrastructure - the nodes and wires - is a common representation of Cyberspace. Look around the web sites of telecommunications companies and ISPs and you will almost always find some kind of marketing map propounding the power and capacity of their network to potential customers. (Many examples are shown at <*http://www.cybergeography.org/atlas/isp_maps.html*>.) Computer scientists and network researchers who are trying to understand and better engineer the Internet also employ maps in their work. A notable example, which extends cartographic form beyond a conventional planar view of the world, was the work of Tamara Munzner and colleagues, who mapped the nodes and wires of Cyberspace in three-dimensions onto the globe (Munzner et al. 1996).

They mapped the geographic topology of part of the Internet called the MBone, visualising the links between routers as arcs traversing the Earth high in space. The result is a visually striking and powerful image of Cyberspace, in many ways matching people's popular imagination as arcs of light encircling the globe (figure 2). Their maps were created as 3d models in Virtual Reality Modelling Language (VRML) and they are available online allowing the map reader to download them, with an appropriately configured Web browser, and explore them from any position or angle.

(See <*http://oceana.nlanr.net/PlanetMulticast/*>)

Other researchers mapping Cyberspace have chosen to lose the familiar, and perhaps constraining, framework of real-world geography, latitude and longitude and country boundaries. Instead, they map Cyberspace onto abstract grids of their own choosing. One of the best recent examples of this approach are the massive and richly

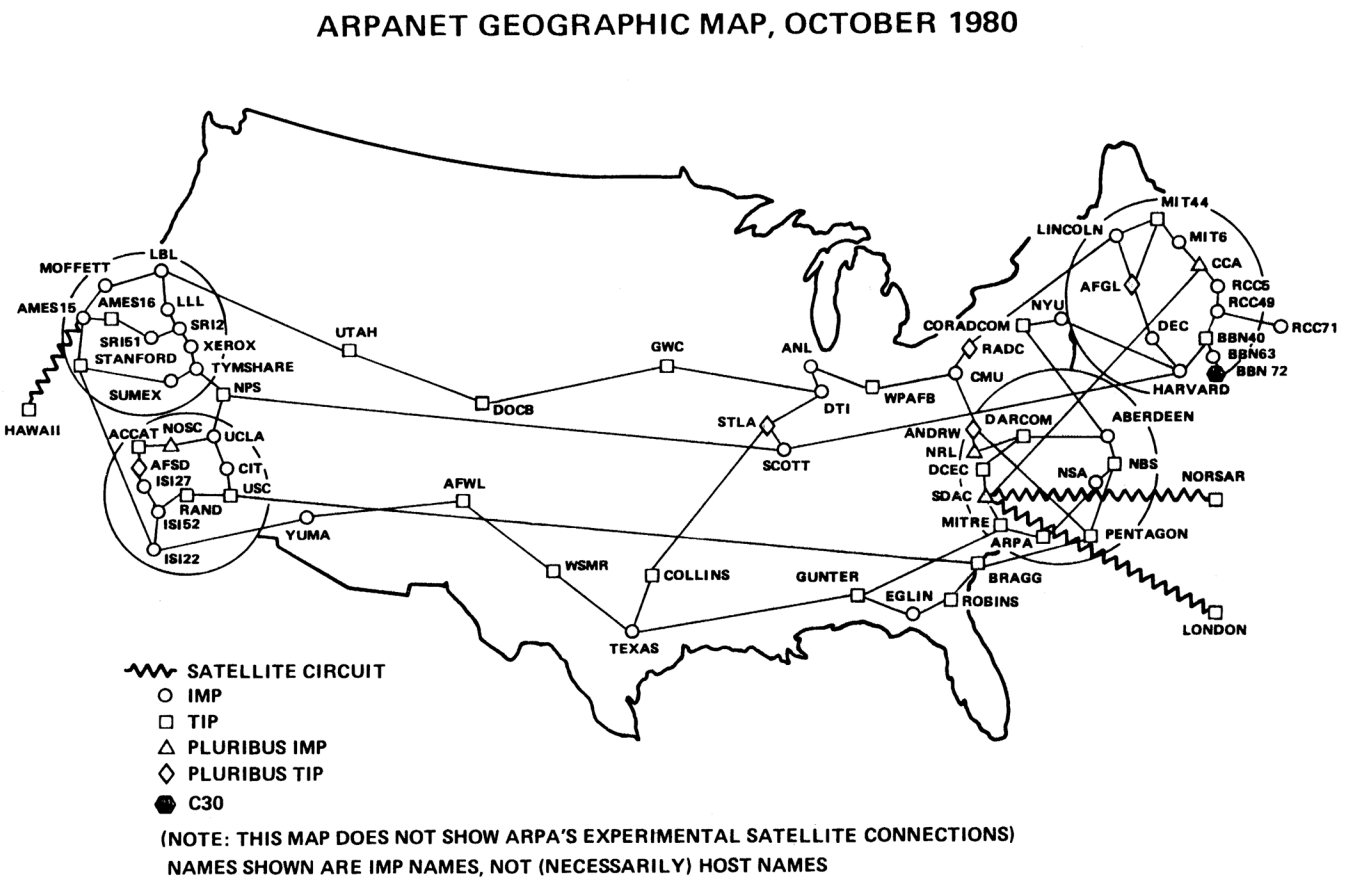

Figure 1: An arc-node style map of ARPANET in October 1980. (Source: CCR 1990, copyright: The Computer Museum, Boston, MA.)

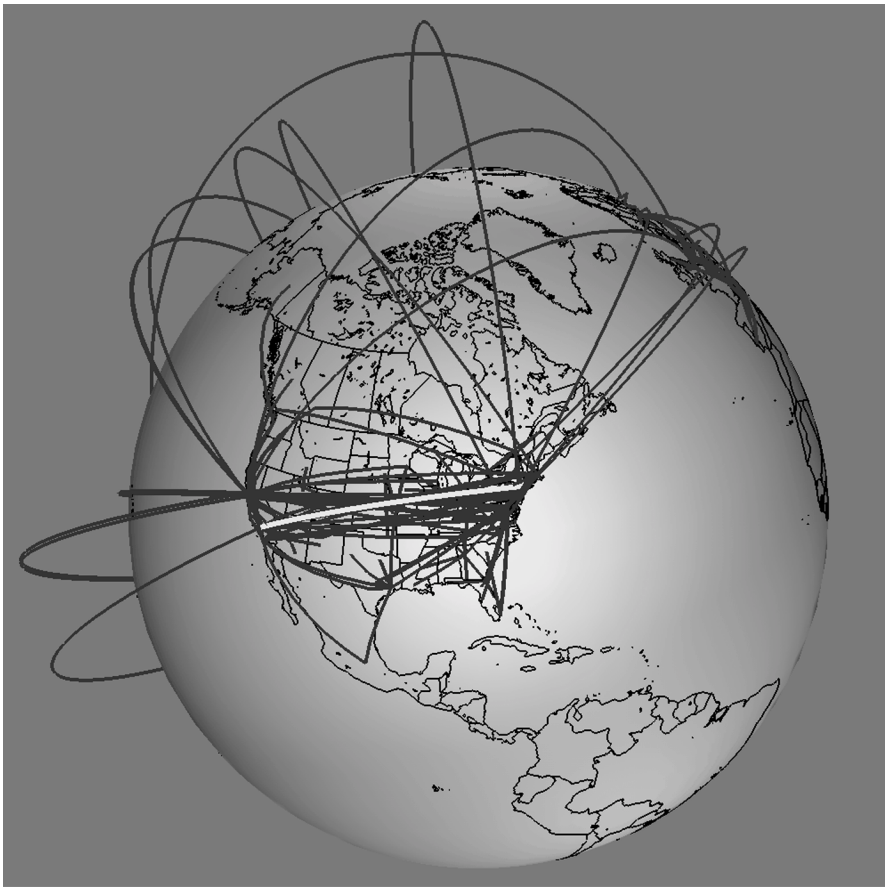

Figure 2: Three-dimensional global MBone map by Tamara Munzner, K Claffy, Eric Hoffman and Bill Fenner. (Source: Munzner et al. 1996)

detailed visualisations of the Internet produced by Bill Cheswick, a researcher at Lucent Technologies-Bell Labs and Hal Burch, a graduate student at Carnegie Mellon University (Burch & Cheswick 1999).

Cheswick and Burch use the Internet to measure itself, tracing the routes data packets take to reach several thousand sample nodes which reveals how the many intermediate computers and networks connect together to form the Internet. They map the results as a huge graph containing nearly one hundred thousand edges (figure 3). This maps Cyberspace with the appearance of a human lung from an anatomy book, with its incredibly fine lattice of filaments laid bare for all to see. In addition, the map is an image of considerable fractal beauty.

For many people it is more important to map what is "on top" of the infrastructure, rather than focus on the computers and wires. How can we map the actual information content and human interactions of Cyberspace. The largest information space on the Internet at present is the World Wide Web, comprising upwards of 800 million publicly indexable pages, on over three million servers (Lawrence & Giles 1999), that are all interconnected by hyperlinks to form the eponymous web. Users have difficulty navigating through this vast Web space to find the things that interest them in a timely fashion. What they need, perhaps, is a map of the Web from a distance, floating above it somehow, so they can get a broad view of the information landscape.

An obvious approach is to map the structure of Web pages and the hyperlinks between them as a graph. This has been attempted with little success beyond visualising individual Web sites, because the graphs quickly grow so large and dense as to be impossible to use as navigational maps. In addition, mapping the Web's structure does not really tell us much about the actual content of the pages. An interesting alternative strategy is to map this information content as a landscape using the terrain metaphor from conventional topographic mapping. There are several academic projects and commercial applications which produce information terrains, with the best current example being NewsMaps (http://www.newsmaps.com/). Figure 4 shows an example of a NewsMap map from mid June 1999. It maps the information content of 951 online news reports on the Kosovan war.

NewsMaps uses sophisticated analytical software, developed by Cartia (http://www.cartia.com/), to process and in some senses understand the content of an information space, in this case a large collection of online news reports on the Kosovan war, determining what are the key topics and how they relate to each other. This statistical abstraction of the information is mapped as a continuous terrain, with virtual mountain peaks representing the most popular topics in the news reports. The higher the peak the more significant the topic. Spatial proximity is used to layout topics, so the more related two topics are, the closer together they will be drawn on the map. The maps are interactive and can be explored on the Web, helping people gain an overall sense of the topography of the information space and track down particular news articles or Web pages of interest. The fundamental research into the processing techniques behind NewsMaps was funded by US intelligence agencies to aid them in understanding,

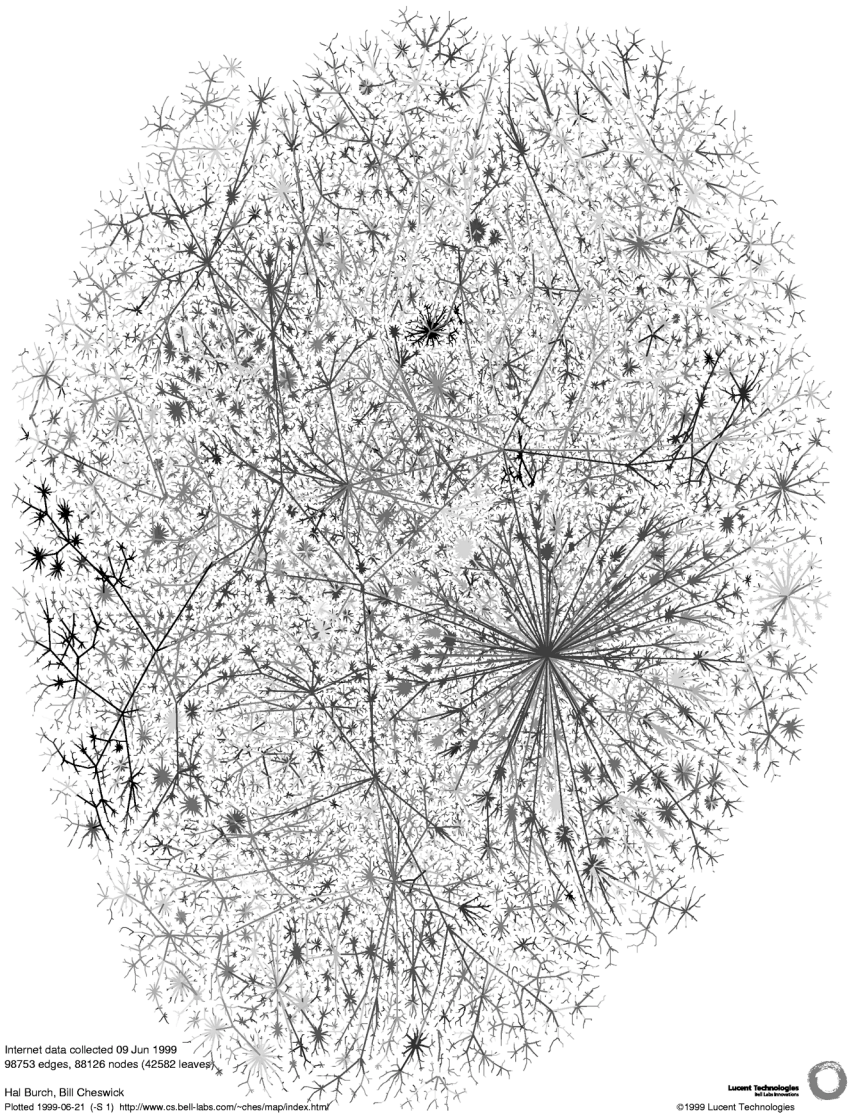

Figure 3: The Internet Mapped as a Graph, by Hal Burch and Bill Cheswick, 9th June 1999. (Copyright: Lucent Technologies)

through visual mapping, their vast information resources.

People talk to each other in Cyberspace. Some of the most popular activities, beside the rather solitary act of Web browsing, involve real-time conversations (via short typed text messages) between real people. Millions of people meet and talk in all manner of chat channels and rooms. All this raucous chatter is the vibrant social heart of Cyberspace, but how can it be mapped? Researchers, Fernanda Viégas and Judith Donath at MIT's Media Lab, are developing what they term "social visualization" to map these Cyberspace conversations. Figure 5 shows one of their innovative mapping techniques called Chat Circles (Viégas & Donath 1999).

This maps the participants of chat rooms as different coloured circles. The size and brightness of the circles is dependent on how much and how open the people talk. Circles also cluster together to conduct particular conversations, just like the groups that form at a party. Overtime the dynamic of the conversation can be seen as the circles grow and shrink, and drift to different groups. A major aim of their research is to provide a more visually appealing and useable interface to real-time conversations than the austere windows of scrolling text of conventional chat software. This highlights the fact that much of the effort in mapping Cyberspace is really about providing better interfaces to existing online information or activities, which is becoming possible through interactive computer graphics and greater network bandwidths (Holtzman 1997, Johnson 1997).

There are many more example maps we could look at, visualising different aspects of Cyberspace, and using many different graphic styles. Many are experimental, work in progress, only providing a fragmentary, imperfect view of Cyberspace, just like the Mappae Mundi's gave of the ancient world. However, they are still worth examining because they having a powerful impact on how people are conceiving the shape and form of Cyberspace. Like the Mappae Mundi, today's maps of Cyberspace provide a visual structure for thinking about the world, a world that is now virtual.

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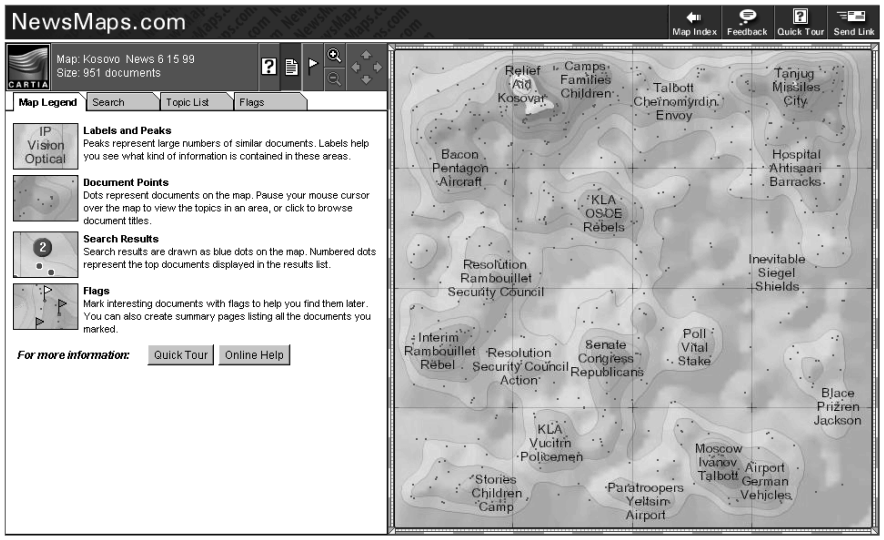

Figure 4: NewsMap information landscape map of Kosovan war news report from June 1999. (Source: http://www.newsmaps.com/)

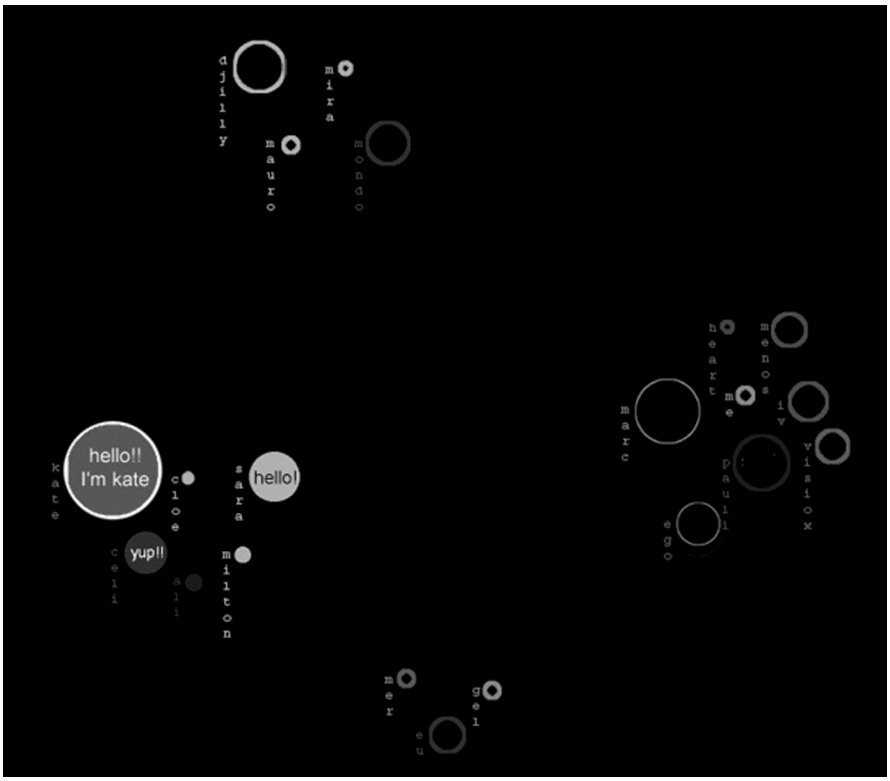

Figure 5: Chat Circles by Fernanda Viégas and Judith Donath. (Source: http://www.media.mit.edu/~fviegas/circles/)

References

Abbate J., 1999, *Inventing the Internet*, (MIT Press: Cambridge, MA.).

Adams P.C., 1997, "Cyberspace and Virtual Places", *Geographical Review*, April 1997, Vol. 87, No. 3, pages 155-171.

Anders P., 1998, *Envisioning Cyberspace: Designing 3D Electronic Space*, (McGraw Hill: New York).

Burch H. & B. Cheswick, 1999, "Mapping the Internet", *Computer*, April 1999.
(Also see their Mapping the Internet project homepage at http://www.cs.bell-labs.com/~ches/map/index.html)

Card S.K., Mackinlay J.D., & Shneiderman B., 1999, *Readings in Information Visualization: Using Vision to Think*, (Morgan Kaufmann Publishers, Inc: San Francisco).

Castells M., 1996, *The Rise of the Network Society*, (Blackwell Publishers Ltd: Oxford).

CCR., (1990), "Selected ARPANET Maps", *Computer Communication Review*, October 1990, Vol. 20, pages 81-110.

Crang M., Crang P., & May J., 1999, *Virtual Geographies: Bodies, Space and Relations*, (Routledge: London).

Graham S. & Marvin S., 1996, *Telecommunications and the city: electronic space, urban places*, (Routledge: London).

Graham S., 1998, "The end of geography or the explosion of place? Conceptualizing space, place and information technology", *Progress in Human Geography*, Vol. 22, No. 2, pages 165-185.

Hafner K. & Lyons M., 1996, *Where Wizards Stay up Late: The Origins* ***of***

the Internet, (Simon & Schuster: New York).

Holtzman S., 1997, *Digital Mosaics: The Aesthetics of Cyberspace*, (Simon & Schuster: New York).

Jacobson R.E., 1999, *Information Design*, (MIT Press: Cambridge, MA.).

Johnson, S., 1997, *Interface Culture: How New Technology Transforms the Way We Create and Communicate*, (Harper San Francisco).

Kitchin R., 1998, *Cyberspace: The World in the Wires*, (John Wiley & Sons: Chichester, England).

Lawrence S. & Giles C.L., 1999, "Accessibility of information on the web", *Nature*, Vol. 400, 8th July 1999, pages 107-109.

Mitchell W.J., 1995, *City of Bits: Space, place and the Infobahn*, (MIT Press: Cambridge, MA.).

Munzner T., Hoffman E., Claffy K., & Fenner B., 1996, "Visualizing the global topology of the MBone", *Proceedings of the 1996 IEEE Symposium on Information Visualization*, 28-29th October 1996, San Francisco.

Salus P.H., 1995, *Casting the Net: From ARPANET to Internet and Beyond*, (Addison-Wesley Publishing Company: Reading, MA.).

Viégas F.B. & Donath J.S., 1999, "Chat Circles", *Proceedings of the Conference on Human Factors in Computing Systems*, 15-20th May 1999, Pittsburgh, USA.
(Also see the Chat Circles homepage at http://www.media.mit.edu/~fviegas/circles/)

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