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Information Cartography: Visualizations of Internet Spatiality and Information Flows

ABSTRACT: This research seeks to connect the visual process of cartography to the lived spaces of the Internet, a frontier whose maps are rarely used by most users. While many maps exist *on* the Internet, maps *of* the Internet are more difficult to locate; thus, this project asks what such a visual representation might look like and how it might serve the purpose of representing the inequalities present in the transmission of information on a global scale. Drawing from several Internet maps with differing approaches to information visualization, this paper analyzes the problems facing the mapping of information flows and how Internet cartography can address these problems through visualizing information not as raw data, but as a lived, social space experienced in a situated and embodied way.

KEYWORDS: Internet, Mapping, Information Visualization, Data Flows

INTRODUCTION

The term "cyberspace" has evoked the process of navigating and embodying the spatiality of the Internet since the word was coined by William Gibson in his cyberpunk fiction. In spatial terms, cyberspace has also been understood as an emerging "frontier space" which users are able to freely construct to fit their particular needs. It is a space of exploration, of possibility, and social connection on a global scale. While most Internet users identify with the notion of "navigating" this space, the process by which this navigation occurs bares little resemblance to the ways we chart and move through material space. In the physical world, we have historically navigated and understood the world around us by charting it with maps. In fact, maps have even defined physical space at points (see, for example, Hartley's (1988) discussion of the symbolic ownership of an

area by an empire through designating it on a map). Conversely, users navigate the Internet typically using a web browser, search engines, and hyperlinks. One link leads to another as the user wanders the Internet in a Situationist-style *dérive* with no clearly charted route or destination. Such a process of navigation is attributed to the confusing layout of the massive tangle of links on the Internet (attributed to another metaphor of the "Web"). The aim of this study is to identify the possible uses of Internet maps, what such visual representations might look like, and how they might serve the purpose of representing the inequalities present in the transmission of information on a global scale. Drawing from several Internet maps with differing approaches to information visualization, this paper analyzes the problems facing the mapping of information flows and how Internet cartography can address these problems through visualizing information not as raw data, but as a lived, social space experienced in a situated and embodied way. Ultimately, I demonstrate that the creation of an Internet map must always account for the visual and data limitations of maps in general (as Monmonier's studies argue, all maps "lie"). As we seek to theorize what a useful user map might look like, we must address how users engage cyberspace on multiple levels and in diverse ways to create visualizations suited to their specific goals.

THE SPACE OF CYBERSPACE

In her study of embodiment in mediated spaces (and technology as prosthesis), Stone (1994) argued that, "what was being sent back and forth over the wires wasn't just information, it was *bodies*" (p. 176, emphasis original). While it may seem commonsense to argue for the Internet as an embodied space, many cyberpunk writers, cyborg artists, and technology theorists have argued that the body is obsolete in the digital age (such as

Moravec's *Mind Children*, STELARC's homepage that welcomes visitors with a banner that reads "THE BODY IS OBSOLETE", and Arthur and Marilouise Kroker's thought that we are transcending the body through digital technologies). The assumption that there can be a cyberspace without bodies overlooks a central component of the production of space. Space, as Lefebvre (1991) argued, is not simply a container that we place objects and people into. Instead it is coproduced with bodies and objects. He writes, "Each living body *is* space and *has* space: it produces itself in space and it also produces that space" (170). Space is dependent upon bodies and bodies upon space. If users understand a sense of movement through the Internet, then they are experiencing the embodied space of cyberspace. Movement and navigation requires space and conceived space requires bodies.

The Internet is not an easily charted territory the way that a material environment can be. The objects that make up this landscape not only function in extremely diverse ways (from HTML, Flash, and VRML webpages, to videos, images, music, currency, data of all types, the list is seemingly endless), but these objects are in constant motion. As Dodge and Kitchin (2001) write:

> 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 […], 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. (p. 2-3)

Echoing this notion that Internet space is constantly in movement, Jahshan (2007) cites Lévy's notion that the form and content of cyberspace is "still partially undetermined" and that "the mobile maps of these fluctuating spaces belong to *terra incognita*, adding, with Massumi, that even if cybernauts were able to achieve the immobility required to get more precise bearings, the virtual landscape itself would continue to flow, to swirl, and to transform the gazer" (p. 26). Jahshan compares Lévy's concept of social mapping of the Internet to Massumi's topology of cyberspace. He writes that Massumi's

> new concept of mapping, better adapted to the new virtual spaces [is] based on a topographical vision of cyberspace. Defining topology as 'the science of self-varying deformation,' he concedes that since a topological unity is multiple (because in constant deformation), it is theoretically impossible to actually diagram and follow every step in a topographical transformation. (p. 26)

Lévy's cartography, on the other hand, "short of being a topographical attempt, is content to map a 'space of knowledge,' a sort of 'anthropological cartography'" (p. 26).

These notions offer interesting insights into the subject's conception of lived space in the Internet and how such a space is mapped. One problem confronted when creating a usable map of the Internet is the issue of directionality. Unless charting the global connections or material infrastructure of the Internet onto a geographic map, compass points do not have bearings in cyberspace. Instead, we encounter the space through our direction of purpose or through social proprioception. The first option is encountered through individual wanderings through the Internet, in which direction is continually changing based on the user's movements and moment-by-moment objectives. Writing about this sort of wandering, Sobchack (2004) writes, "When I was a child, I always thought north was the way I was facing. Sure then in my purposeful direction,

there was a compelling logic to this phenomenological assumption. Bringing into convergence flesh and sign, north conflated in my child's consciousness the design of my body and the design of an atlas page" (p. 13). Sobchack's childhood assumption that north was the direction aligned with the first-person point of view mirrors the phenomenology of Internet wandering. North is associated with the privileged perspective of the individual and serves a creation of Internet space that, rather than being developed out of the social, remains locked into the "personal" computer. In contrast to the privileging of the individual construction of Internet spatiality, theorists like Castells (2000) argue that the mapping of these networked societies - which is always more of a process than a place - is dependent not on geographic locale but on digital connectivity. While proximity is no longer a prerequisite for social interaction according to Castells, with the move of the Internet onto mobile devices that can log on and place the user at specific GPS coordinates, proximity is being reasserted into the online interactions that people engage in (such as utilizing an iPhone application that can tell the user "who's here" within a specific radius). The utilization of the Internet on mobile devices takes the user's proprioceptive engagement with cyberspace beyond the individual's "direction of purpose" on the screen and places it onto a physical landscape that is coproduced with social interaction. While these mobile devices that connect to the Internet can be plotted geographically with GPS coordinates, they are always in movement (in contrast to the personal home computer) and any attempt to "ground" them with a cartographic representation will be immediately out of date. As Jahshan writes, "Most of the maps [of the Internet] are time-bound, i.e., they are either historical, depicting some network state dating a few years back or, on the contrary, so 'current' that they are only valid the moment they are produced. What is more serious is that when they are printed they are already outdated." He continues by noting, "The issue of forecasting is also problematic:

how can one accurately predict network movements? […] The very changeability of networked technologies renders the above mapping attempts at best a precarious endeavor" (p. 24). While it is a reasonable expectation that the Internet is growing all the time (thus is hard to chart), the form it takes is also changing all the time. The Internet today looks very different than it did even 5 years ago. So, given the ever-changing landscape that refuses to be grounded through cartographic techniques, why would we attempt to map the Internet at all? What use could an Internet map actually serve and could an Internet map actually become a useful tool for the Internet user?

INFORMATION VISUALIZATION AND EVERYDAY INTERNET USE

Many Internet users turn to the search engine to guide their journey through cyberspace, entering a query and letting the text-based results direct them to relevant webpages. However, such interactions with the Web offer only a glimpse into the scale of this dynamic space. Addressing the scale and potential of the Internet and communicating that to the everyday user is where the field of information visualization is useful. As Card, et al (1999) writes, "Current methods of access leave much to be desired and do not adequately exploit this immense resource. Information visualization could play a substantial, even enabling, role here in helping users find information faster, understand the structure of the space, find patches of interesting information for greater examination, or make the space more learnable" (465). Information visualizations offer a view into a structure that cannot be easily understood outside of some form of graphic representation (either because the structure is far too complex to be represented in textual form or because the structure's scale cannot be sufficiently represented in other ways). As Dodge and Kitchin (2001) explain, "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" (p. 2). Since Internet space is fluid and changing, any sort of visualization would have to address this characteristic. We have often used metaphors as a starting point to understanding our interactions with the Internet, visualizations have often employed these metaphors to help us navigate through this space. Card, et al (1999) points out that the User Interface Research Group at Xerox PARC classified these metaphors into four categories: "(1) the digital library metaphor, (2) electronic mail metaphor, (3) the electronic marketplace metaphor, and (4) the digital worlds metaphor" (465). Just as these metaphors address the ways we interact with the Internet, they have also influenced the ways we think about and thus behave in online space. Even using the term "desktop" to describe the screen affects the look of that GUI and also how we interact with it (including having a trashcan icon and engaging it by dragging a file to be thrown away). Thus, visualizations can not only meet the current understandings of how we perceive cyberspace, but also teach us how to think about cyberspace.

An important point that Dodge and Kitchin (2001) bring up is that such visualizations, while being useful in helping us understand the Internet, must also never attempt to be exhaustive. The nature of mapping visualizations is that they must always be selective in the scope and purpose of the information they display. They write:

> 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? (p. 4)

Thus, when approaching how we can create a map of the Internet, it is illusory to think that a single map can meet the needs of users and adequately represent the nature of the Internet. A map must address a specific aim and purpose rather that attempting to be exhaustive. This notion is skillfully argued by Monmonier (1996) in his book, *How to Lie With Maps*. As his title suggests, a map (as a singular representation) traditionally presented a limited point of view dedicated to its particular purpose. He writes,

> A good map tells a multitude of little white lies; it suppresses truth to help the user see what needs to be seen. Reality is three-dimensional, rich in detail, and far too factual to allow a complete yet uncluttered two-dimensional graphic scale model. Indeed, a map that did not generalize would be useless. But the value of a map depends on how well its generalized geometry and generalized content reflect a chosen aspect of reality (p. 25).

He goes on to note that the medium on which a map is presented in conjunction with the limitations of the human eye will always restrict the amount of data that can be presented on a map without causing so much distortion to lead to illegibility. Similarly, the limits on what a map conveys is often not simply an issue of the technological or physical limitations, but rather a choice on the part of the cartographer. Harpold (1999) writes, '[D]etails are commonly eliminated, falsified, or distorted so as to improve a map's efficacy toward a particular end, resulting in the misrepresentation or exclusion of information which may serve other ends or reveal inconsistencies' (para. 11). These ends

are often politically and ideologically motivated. Since mapping the Internet often deals with flows of information and retrievable data, it is assumed that charting representations of these flows and statistics are objective rather than subjective. However, as Monmonier and Harpold point out (in conjunction with the cultural geographers such as Soja, Wood and Fels, Harley, Edney, and Pinder), maps are never objective and grounded signifiers of an ontological reality. Instead they are perspectives that are always situated.

ATTEMPTS AT INTERNET MAPPING

As has been argued up to this point of my study, mapping the Internet faces many challenges. From its constantly moving and flexible nature to the limitations of information visualization to exhaustively display such complex data, the Internet has resisted being mapped in a way that has connects users in an embodied way with the processes of navigation they engage everyday. While these kinds of maps (that engage users in an embodied, everyday way) have not been as thoroughly successful, many maps (for different purposes) have used information visualization techniques to display some compelling representations of the Internet that reveal many important characteristics of the Internet. By studying the styles of information visualization in the following maps, we can gain some understanding of the complexities facing Internet mapping and potential approaches for creating a navigable map for users to engage on a daily basis.

Maps have been connected to the Internet since its inception. The ARPANET served as the basic structural foundation for the Internet as we know it today, initially linking UCLA to Stanford in 1969. The following maps (Figure 1 and Figure 2) show this first node and the subsequent growth of ARPANET to include several other nodes across the United States:

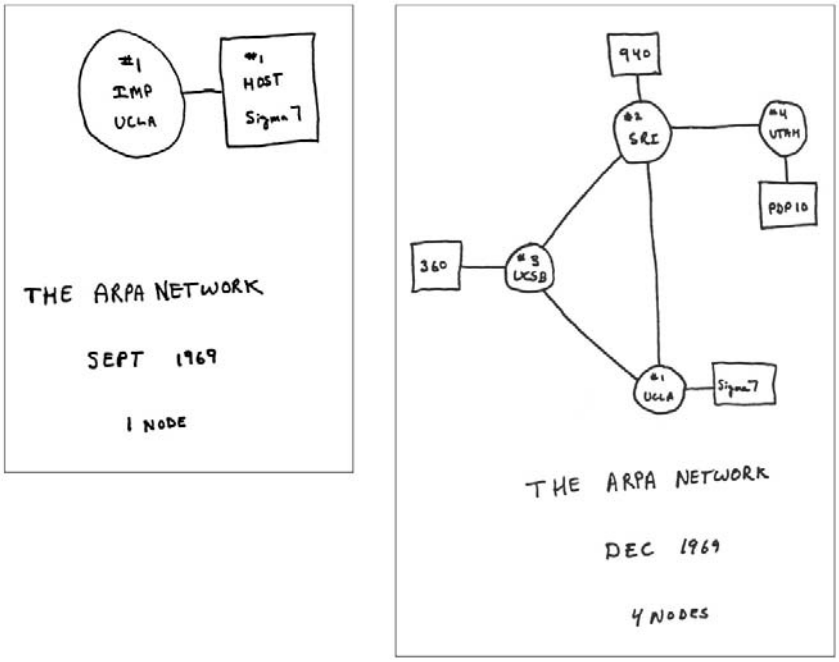

Figure 1: The first maps of ARPANET. Accessed from http://personalpages.manchester.ac.uk/staff/m.dodge/cybergeography/atlas/historical.html

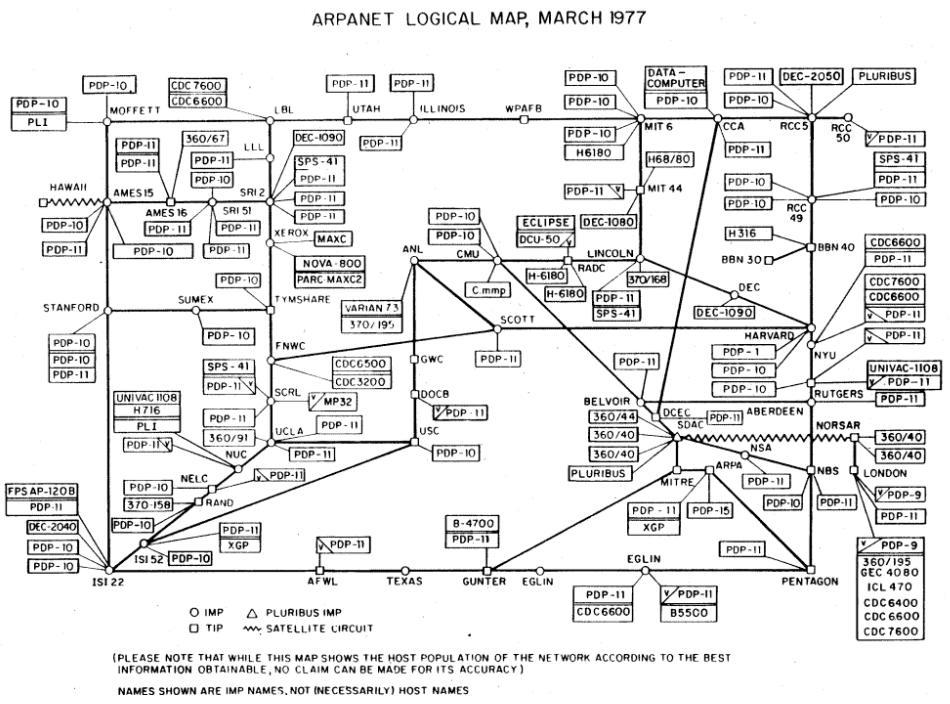

Figure 2: A 1977 map of ARPANET showing its growth across the United States. Accessed from http://personalpages.manchester.ac.uk/staff/m.dodge/cybergeography/atlas/historical.html

These geographically specific nodes of the Internet can reveal the pervasiveness of Internet use and access worldwide. A similar approach to this type of mapping was implemented by Matthew Zook in his 2007 Google Earth overlay (Figure 3), showing the global connections between Internet hosts and the locations and size of domain names registered in each country.

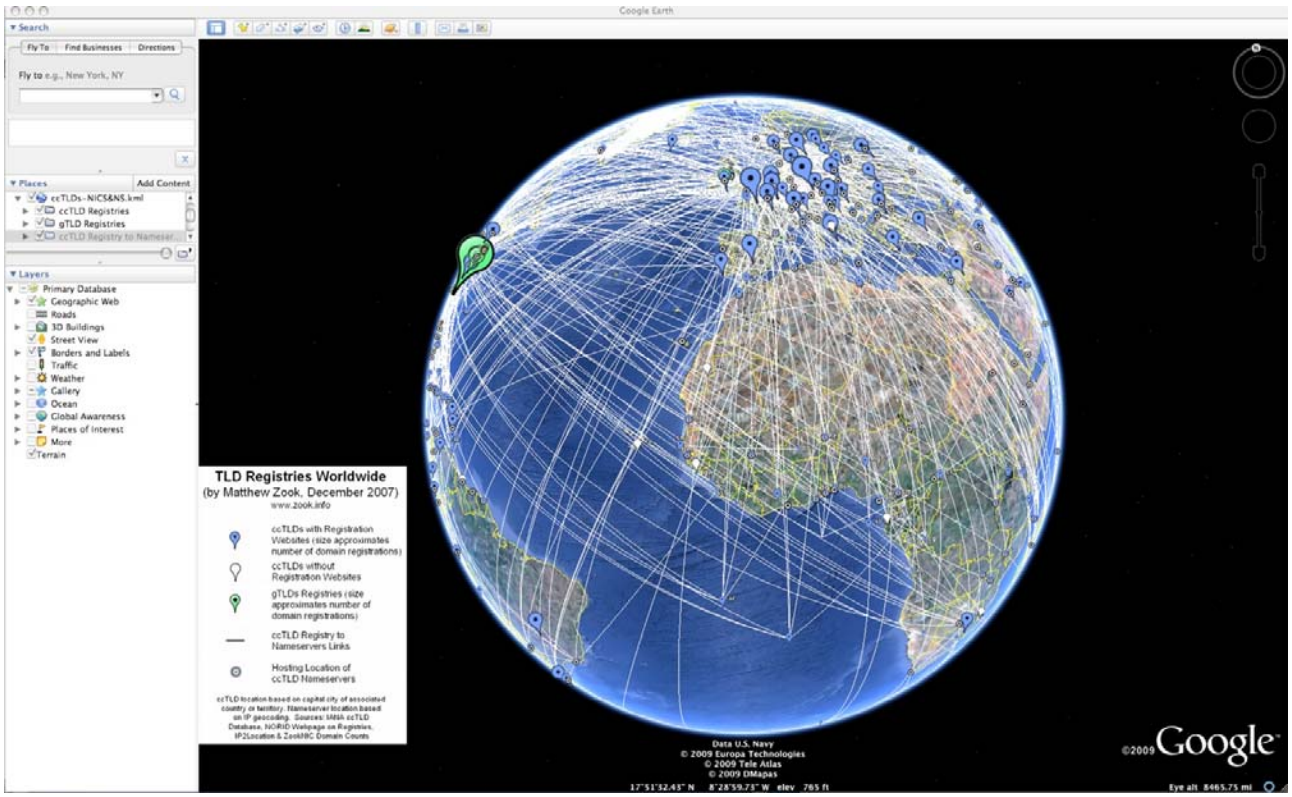

Figure 3: Matthew Zook's Google Earth overlay showing global Internet connectivity. Google Earth screen capture used by permission.

What Zook's Internet map demonstrates, in an interactive 3D map, is the global unevenness of information flows. Maps of these lived information flows — as they are associated with geographic locales — demonstrate in a profound way the inequality of information transmission on the global scale. Thus, visual representations of the Internet and the transmission of information serve the larger purpose of signifying the need to address issues of the digital divide between those who have access and those who do not in the Information Age. While the Internet may be a "lived space" for many in developed

countries, maps like Zook's Google Earth overlay show that the large majority of people on the planet are not inhabitants of this cyberspace. According to the March 2009 statistics published by internetworldstats.com, only 23.8% of the world's population are Internet users. As visualized in Zook's Internet map, only 5.6% of the people in Africa are Internet users.

Part of the problem of access is the distribution of Internet infrastructure. Since this structure is more stable than the content of the Internet, it is more easily mapped, as demonstrated by the maps produced by Alcatel Submarine Systems (Figure 4), a major manufacturer of telecommunications systems. These maps chart the cables that connect users worldwide to the Internet and reveal that the inequality in information distribution online is directly (and obviously) connected to the distribution of infrastructure.

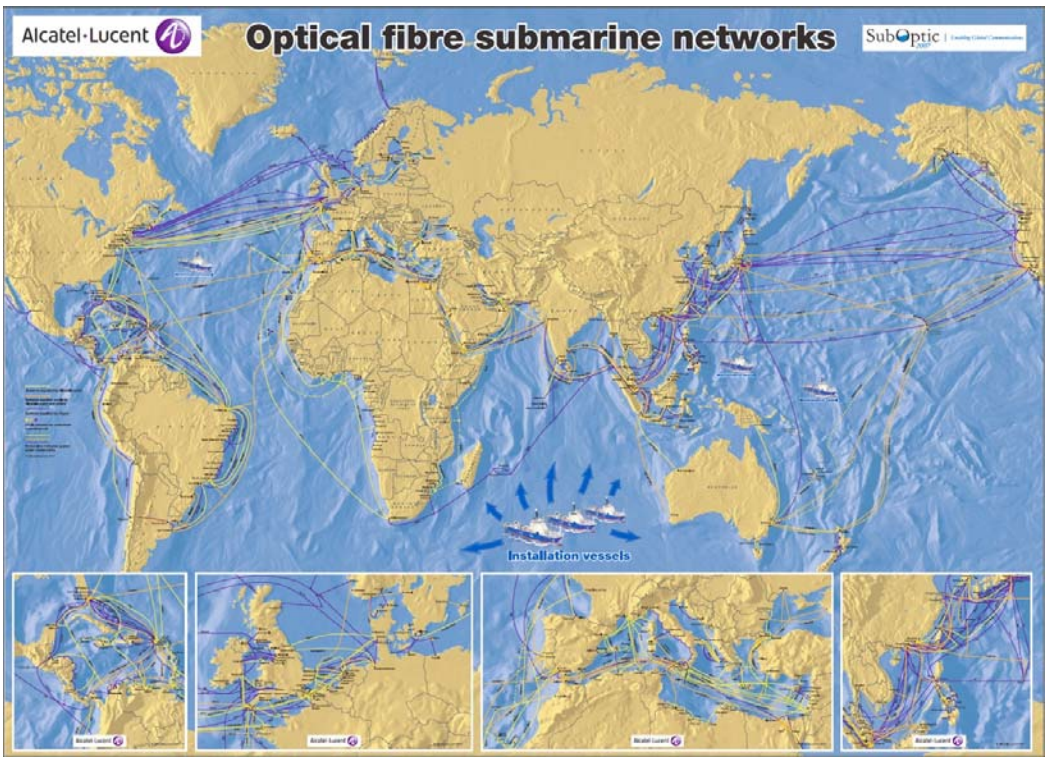

Figure 4: A 2007 map of the global Internet infrastructure. Accessed from http://www1.alcatel-lucent.com/submarine/refs/World_Map_2007_LR.pdf

A similar geographic visualization was created in 1996 by Stephen G. Eick and his colleagues at Bell Labs (Figure 5) showing the flow of Internet traffic in a two-hour period.

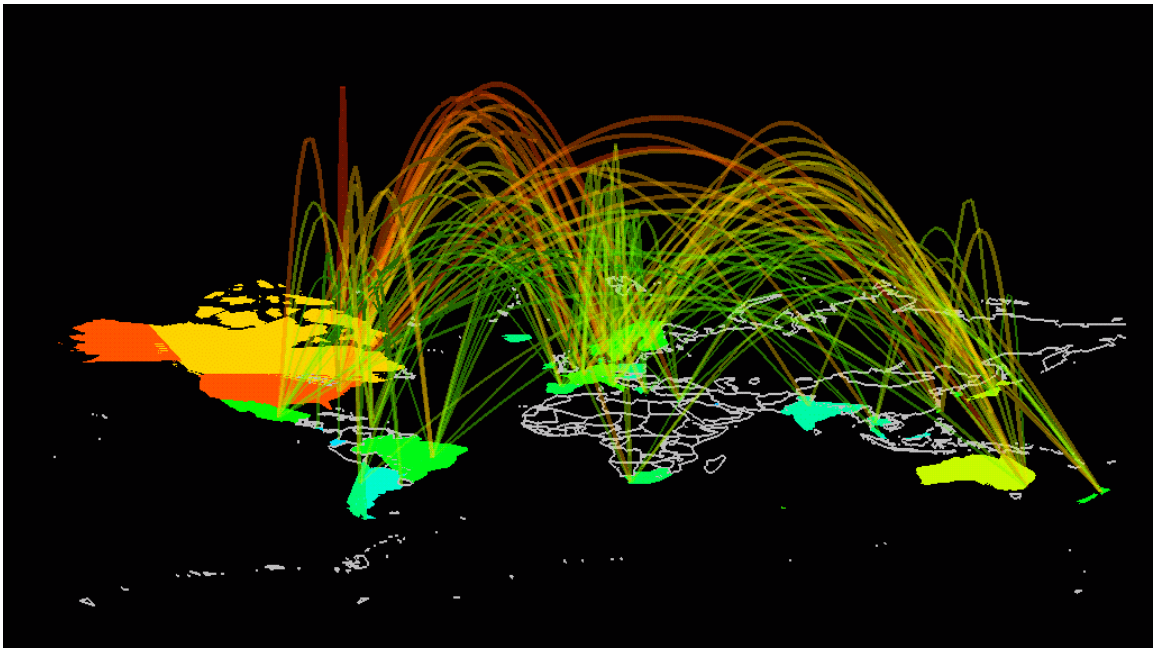

Figure 5: "Arc map" showing worldwide Internet traffic during a two-hour period. Accessed from: http://personalpages.manchester.ac.uk/staff/m.dodge/cybergeography/atlas/geographic.html

Harpold (1999) persuasively critiques visualizations like the Arc map, noting that (along the lines of the cultural geographers) such maps seems to simply present objective data in visual form. Such mapped data is often misunderstood as existing outside the realm of critique. He writes:

> …these and similar cartographic representations of the Internet [are interrogated] as a first step in a critique of the complicity of techniques of scientific visualization with the contrasting invisibility of political and economic formations. I propose that these depictions of network activity are embedded in unacknowledged and pernicious metageographies--sign systems that organize geographical knowledge into visual schemes that seem straightforward (how else to illustrate global Internet traffic if not on images of... the globe?), but which

depend on historically- and politically-inflected misrepresentation of underlying material conditions.

By noting that the Arc map's use of light and dark, presence and absence, on or off, the visualization has significant political messages. He argues, "Viewed with an eye to their unacknowledged political valences, these images of the wired world (that is, of the mostly unwired world) draw, I will argue, on visual discourses of identity and negated identity that echo those of the European maps of colonized and colonizable space of nearly a century ago" (para. 7). This resonates with Edney's (1990) concern that, "Imperialism and mapmaking intersect in the most basic manner. Both are fundamentally concerned with territory and knowledge….Maps came to define the empire itself, to give it territorial integrity and its basic existence. The empire exists because it can be mapped, the meaning of empire is inscribed into each map" (p. 1-2).

Internet maps that connect information flows and infrastructure to a geographic visualization are only a small portion of the maps that have been created of cyberspace. Others have sought to chart out the interconnected nature of the Internet in more abstract visualizations. Drawing from the approach that Castells encourages — that mapping cyberspace is more about social connections than about geographic space — these maps seek to chart the ways information links across the Internet. For example, the 2000 map created by Hal Burch and Bill Cheswick (Figure 6) creates a fractal map of the core of the Internet, charting over 100,000 ISPs and color-coding them.

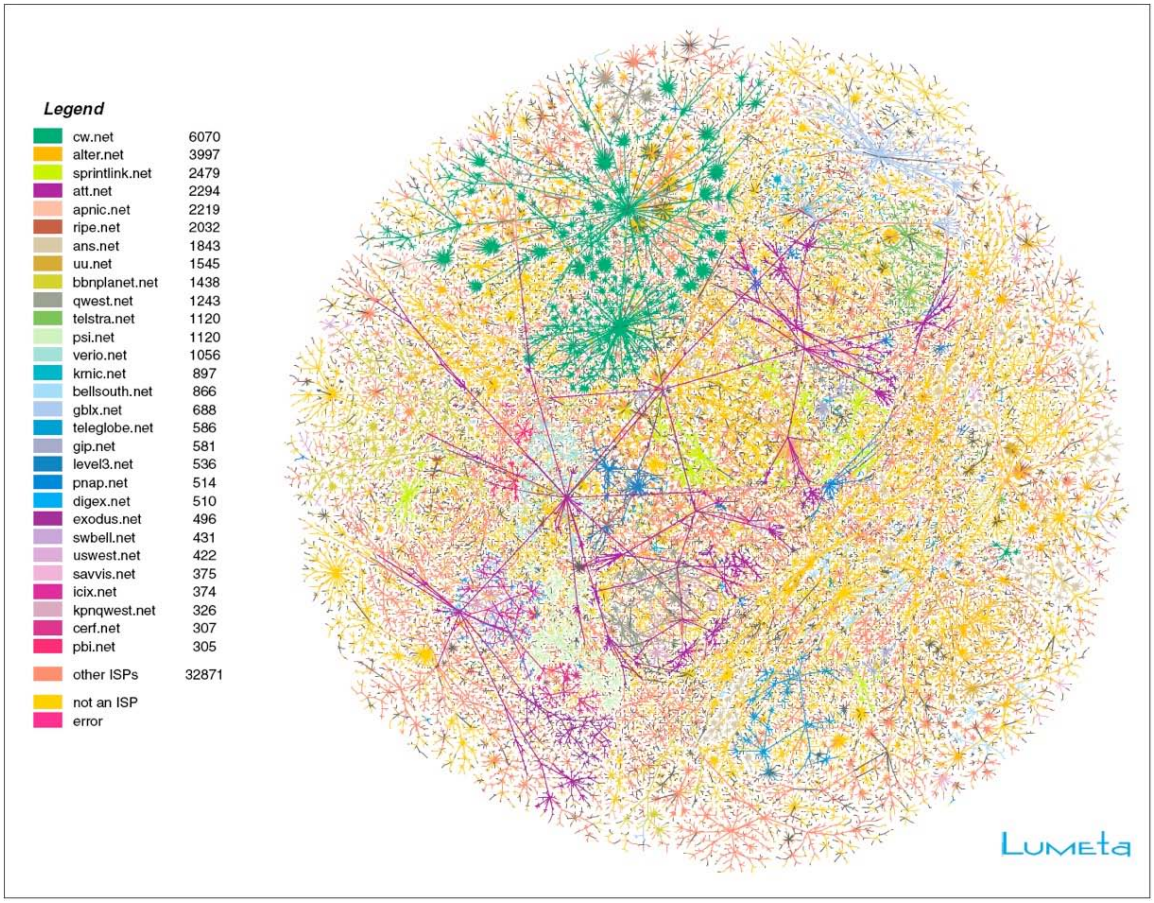

Figure 6: Hal Burch and Bill Cheswick's 2000 map of the "core of the Internet" charting over 100,000 color-coded ISPs. Screen capture from Dodge and Kitchin (2001: p. 43).

One final example of an attempt at Internet mapping is the 1999 charting of the interconnected websites owned by the international publishing firm, Verlagsgruppe Georg von Holtzbrinck (Figure 7). The map seeks to show how the sites are connected, who runs them, and what content they hold. This visualization is color-coded and arranged to prevent overlap and visual distortion, with lines connecting the sites and a thumbnail screen capture inside the circles representing the site.

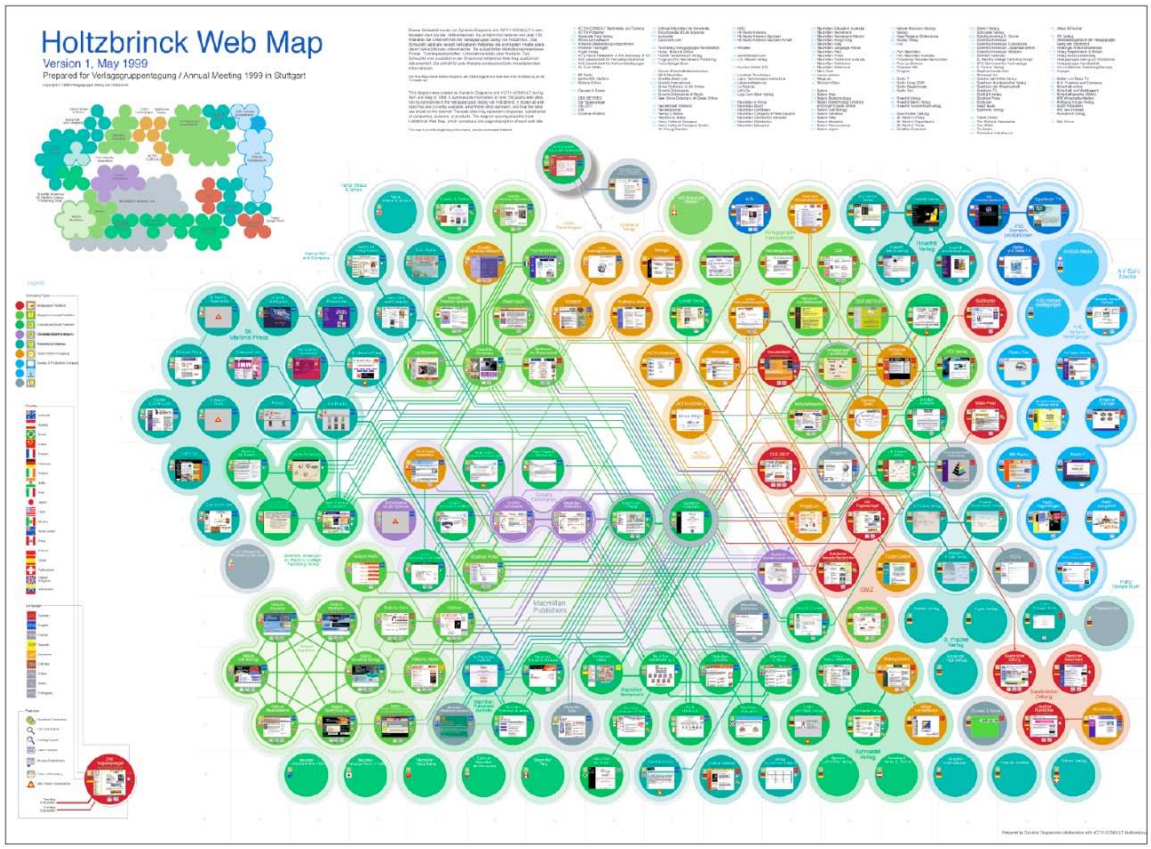

Figure 7: The 1999 map charting all public websites owned by Verlagsgruppe Georg von Holtzbrinck. Screen capture from Dodge and Kitchin (2001: p. 95).

MAPPING THE INTERNET FOR USER NAVIGATION

While most of these maps can offer very useful insights into the scale, interconnectedness, or political ideologies that surround the Internet, none of them address the issue of the user's process of everyday navigation through cyberspace. Instead, as previously mentioned, most users simply chart their course utilizing search engines or links that are not organized visually in a way that can help to make sense of the scale, content, or interconnected nature of the sites we encounter. Most of the Internet maps discussed in this study tend to emphasize the data rather than the user's connection to that data (and how we as Internet users can connect to and interact with it). There is no entry point for embodied interaction that resembles the user's process of navigation.

Certain digital media have used maps for user navigation in ways that can offer some insight into approaches for charting usable Internet maps. From the 1995 Eastgate Systems map of the electronic literature *Patchwork Girl* by Shelly Jackson to the in-world map in VRML social networks like Second Life, mapping connections across thematic content and social networks has benefited users of large digital spaces. As previously mentioned, usable maps must be understood to address particular needs and objectives rather than seeking to be exhaustive. A map demonstrating the interconnectedness of a network of friends across online social networks would serve to visually render these connections in the social space of the Internet. As it is currently laid out on the homepage for sites like Facebook, the flat HTML layout of the page does little to visualize this social network as a lived space and active environment. New, usable approaches would better serve the already prevalent notion that the social network is a lived space, embodied and produced by its users. For the likes of Phillip Rosedale, the founder of Second Life, our interactions with cyberspace will continue to turn away from 2D representations and take advantage of the graphics and broadband capabilities of our current systems, moving toward lived-in, 3D environments in which people from around the globe can interact and alter virtual objects in a more dynamic way. As these spaces offer users a visual representation of the material space they navigate on a daily basis, perhaps the maps of these spaces will also take advantage of the sense of depth and movement that 3D offers and is ultimately the very nature of the Internet.

With the surge of interest in physical computing and locative media, it is apparent that users of digital technologies such as the Internet are keenly invested in knowing where they are in relationship to other people, other objects, and other websites. By creating maps that help the user locate him or herself in the vast space of cyberspace through a map that is not only navigable, but engages the metaphors of computing that

connect to the visualizations they encounter (moving beyond the metaphor of the desktop to visualize cyberspace's connection to our material space) and also addresses the ever-changing landscape of the Internet, users will gain a deeper understanding of cyberspace and their place within it. While these maps might end up looking very different from one another (as they are tailored to their specific purposes), I strongly believe that they will engage the graphic capabilities of our computing systems to function as a natural extension of our material space. The virtuality of the Internet no longer exists as a reality separate from our physical realities. Instead, the two are so intimately related that any new map interface would need to work in collaboration with this understanding. If we begin to think of the map as a way to understand and navigate the Internet, our interactions with the web browser will look completely different in the near future.

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