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†Cybermap: the Map for Cyberspace

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Map the earth and the moon, why not cyberspace

With the increasing boom in the Internet, there is a virtual space termed cyberspace, parallel to the geographic world in which we are living. Cartography, as a discipline developed initially for mapping geographic space. It is now challenged to map virtual space. From the point of view of cartography, this paper attempts to define the special mapping of cyberspace by the cybermap. It is the authors' belief that cartographers, with a long standing tradition of mapping geographical space, can make an important contribution to mapping cyberspace. A similar view is held by Plewe (1995, p. 2) who stated that cartographers are unique in their ability to display very complex information in a clear, understandable fashion.

INTRODUCTION

The World Wide Web (WWW) has become increasing popular in recent years. It has been responsible for changing the world and many aspects of our society, and is actually the incarnation of the concept of cyberspace, first coined by William Gibson (1984) in his breakthrough novel Neuromancer. In his well-known fiction, cyberspace is defined as a computer-generated landscape, i.e. the virtual space of a global computer network, linking all people, computers, and sources of various information in the world through which one could navigate. Over the past few years, there have been other names such as the Net, the Web, the Clouds, the Matrix, the Metaverse, the Datasphere, the Electronic Frontier, and the Information Superhighway. But cyberspace seems to be the favourite name amongst them.

The notion of 'map and mapping' plays an important role in our society over the centuries. As stated by Taylor (1997, p.1) in his keynote address at the 18th International Cartographic Conference, "throughout history the map has been important to societies all over the world both as an artefact and as a concept. The terms 'maps' and 'mapping' are used in relation to almost all aspects of societal activities. We map the brain, the future, talk of mental maps, and use maps in an increasing range of socio-economic and scientific activities." Now we claim that map and mapping can also be applicable to cyberspace, a virtual space which has been emerging with Internet technology. In the context of this paper, the notion of cybermap in the information era is addressed.

Over the past few years there has been an increase in available literature on visualisation of the Internet, mainly from the fields within the computer sciences, e.g. on mapping networks (Eick, 1996), geographically mapping the Internet (Harrington, 1996), mapping virtual locations to avoid the lost-in-cyberspace syndrome (Girardin, 1995). However, less work has been done in the field of cartography except by Staple (1996) and Plewe (1995). Geographers have recognised the advent of virtual geography, and have responded to this challenge (e.g. Batty, 1997).

This paper presents a preliminary discussion on mapping cyberspace from a cartographic point of view. Section 2 will presents detailed discussions on what cyberspace is and related views on it. This is followed by how to map cyberspace and what to map in it. A functional classification of cybermaps is made before drawing conclusions and pointing out future work in the research field.

WHAT IS CYBERSPACE?

There have been many definitions of what cyberspace is from different points of view. Amongst these, one definition given by Benedikt (1992, p. 122), read as "a globally networked, computer-sustained, computer-accessed, and computer-generated, multidimensional, artificial, or 'virtual' reality". Cyberspace is an ethereal space. Therefore from time to time, we see it is represented graphically as a sea of clouds.

†A clear distinction between "map for cyberspace" and "map in cyberspace" needs to be made. The former is what this paper is concerned with, whilst the latter does not fall in the scope of this paper. Interested readers should consult related literature (e.g. Taylor, 1997; Green, 1997; Toon, 1997)

Cyberspace can be characterised as both small and big. The virtual world is physically small as it exists within computers and networks. With an appropriate computer configuration, however, one can travel the virtual world without country boundaries, although sometimes there is the issue of accessibility (unauthorised access). One can go across a continent in a few seconds. The information one needs is said to be just one more mouse click away (Staple, 1996). This is why cyberspace is described as small. But, on the other hand, it is very big. This has a two-fold meaning, i.e. the amount of information[1] contained in cyberspace is enormous, and the organisation of the information is very complex. Because of the latter, when navigating the virtual world, sometimes it is possible to get lost in cyberspace. It is difficult to know where one is, and how one came to the "land" (a piece of information). The Chinese translation of the WWW, literally 'ten thousand dimensional webs', vividly describes the complexity of cyberspace.

To date, there has not yet been an acceptable model for cyberspace. The Earth is an irregular sphere, and mapping the sphere entails the transformation of this three dimensional body to a two dimensional plane. How about cyberspace? How can virtual space be described? Perhaps it is too early to perceive thoroughly the virtual world, but at least some thoughts exist regarding its perception. Firstly computers and networks which physically construct the virtual world have their geographic locations. One could simply map cyberspace onto real space by mapping the physical location of each piece of information.

Some early thinkers (e.g. Benedikt, 1992) thought of cyberspace as an arbitrary three-dimensional space, in which each piece of information would be assigned an (x, y, z) co-ordinate. But it seems that the growth of cyberspace has not followed this paradigm very closely.

The network viewpoint is to take cyberspace as a network space in which computers or information resources (e.g. homepages) are cabled or wired as a network. At this abstract level, there are two basic objects to be mapped: nodes and links. All nodes and links could be constructed as network or tree structures. The World-Wide Web can be depicted as a graph.

Cyberspace can be defined also as an information space (Staple, 1996). Staple further states (1996, p.2) that, with this definition, it helps to resolve the perennial cartographic dilemma of how to transcribe multidimensional objects onto two-dimensional paper. Thus information has its location (e.g. Domain Name System), category (business, education, science etc.), forms (text, graphics, image and so on), and amount of information. All these could be visualised as a map, from which one may perceive the distribution of information over cyberspace. There is a huge amount of information available in the virtual world, for viewing and downloading.

Traditional Euclidean geometry is no longer applicable to cyberspace. The basic axiom of Euclidean geometry is that a distance from A to B is equal to the distance from B to A. This premise is frequently violated in cyberspace. Distances are not only thought of as lengths of paths on the Earth's surface, but frequently seen as measures of how long it takes from one website to another. Another axiom of Euclidean geometry is the allied triangle inequality, that is, for each triple $\{A,B,C\}$ on the Earth's surface, the sum of the distance from A to B and from B to C is always at least as large as the distance from A to C. Because of the violation of symmetry, this axiom does not hold in cyberspace.

Since physical distance has no meaning, we need to come up with a new way of representing how close or far apart two nodes are. In addition to physical distance, Plewe (1995) defined three other sorts of distances. The first is effective distance, which is a functional definition of distance as expressed, e.g. by time or cost. The second is the psychological distance, a subjective measure of how close to objects one is cognitively. The last distance is integral distance where every link has unit length.

In our view, mapping cyberspace consists of two parts: mapping the physical network and mapping the information. In other words, cyberspace is networked computers and information flows through the network. To understand and perceive the intricacies of cyberspace, specifically, to help us to orientate, navigate and analyse spatial relations of cyberspace, cybermaps have to be produced for various purposes.

HOW TO MAP CYBERSPACE AND WHAT TO MAP?

Having discussed the meanings of cyberspace, it is necessary to take a look at how to map cyberspace and what to map. In the context of this paper, we use a word, "cybermap", to indicate special maps for cyberspace. It can be simply defined as the map for visualising numerous aspects of cyberspace, for instance, physical locations of cyberspace, traffic situation and so on. Numerous cybermaps are being produced in order to understand and perceive cyberspace from different perspectives and for a variety of purposes. In long standing cartographic practice, maps have been considered as communication tools. That is, because of the limitation of the human capability to perceive the objective world, human beings have to depend on certain communication tools to understand the objective world. Cybermaps reflect images of cyberspace from numerous perspectives.

As far as 'how to map' is concerned, this could cover a whole textbook. However, here we will only deal with the visual representation of cyberspace, and put many other cartographic processes such as projection, generalisation and the like aside. Simply speaking, a map is a symbol system of reality, it is also valid for a cybermap. Thus cybermaps can be produced through visual symbols. It is Bertin, a French cartographer, who first summarised the visual variable system which involved seven variables as illustrated in figure 1. All mappable data can be categorised into three kinds, i.e. point, line and polygon data. Cybermaps convey information via their visual variables, for instance, lines to represent routes of information flows with their thickness representing the amount of information; colour to represent different categories of information with value (lightness) to represent the amount of information, etc..

The division of cybermap into a physical part and information part is very similar to that of geographical information into physical information and socio-economic

[1] By 'information', either spatial or non-spatial, in alphanumerical, (carto)graphic, photographic or audial form is meant

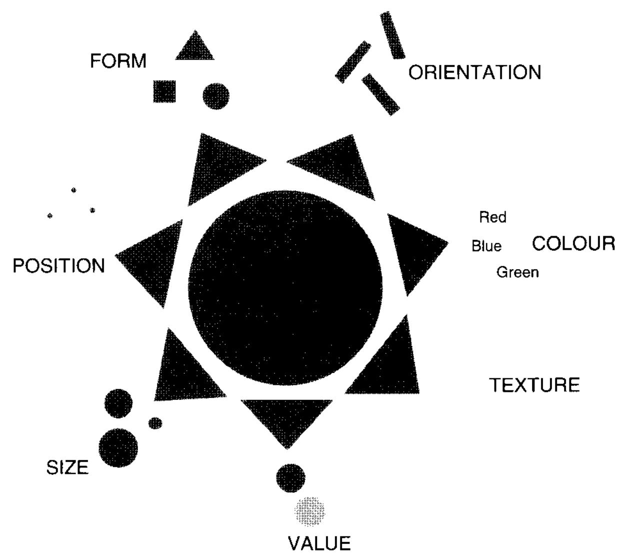

Figure 1. Bertin's system of visual variables (Bos, 1984)

information. Traditionally, topographic maps visualise physical information such as mountains, rivers, buildings etc., whilst thematic maps are more concerned with socio-economic information such as population. In terms of cybermaps, they are more concerned with the information side rather than the physical side. In other words, what the user wants to know is how pieces of information (text, graphics, image and sound etc.) are connected one to another, not the underlying physical structure of the computer and communication systems.

DOMAINS

The Internet addresses have the form name.domain format, e.g. www.esri.com. The last part of the address after the last period is called the 'top-level domain', which can be converted into corresponding geographic locations. In the mean time, the 'top-level domain' indicates the type of group within which the address is located. In general, there are two types of top-level domains: the old-style organisational domains (e.g. .com, .edu, .gov) and the newer geographical domains (e.g. .uk .au).

Figure 2. U.S. domain-name locations (Imperative! 1997)

From a physical point of view, all pieces of information have their own physical location, which can be mapped on so-called domain location maps, as shown in figure 2, where each domain's address (organisational or geographical) is represented by a dot. Domain Name System (DNS) is a distributed database which contains discrete 32 bit numeric addresses for every registered computer in the world, e.g. gauss.geog.fu-berlin.de = 160.45.60.50. There exists some utility to convert the host name to latitude/longitude, e.g. Host Name to Latitude/Longitude Converter (c.f. http://cello.cs.uiuc.edu/cgi-bin/slamm/ip2ll). Once one provides a host name, the converter can calculate the value of latitude and longitude, and plot on a map.

HOSTS

All computers in the Internet are networked, and each of them is referred to a node. The "node" is a more technical synonym for "host". The second meaning of the word "host" has to do with how certain computer systems are set up. Some computers are made to support more than one user at the same time. These multi-user systems are often referred to as host computers. Figure 3 is an example showing the number of hosts per capita in Africa.

HITS

Over the Internet, it is web servers that maintain detailed logs of every request made for information. Here every request is referred to as a hit. The number of hits reflects the frequency of usage of a specific web site. Both the number and distribution of hits can be mapped (figure 4).

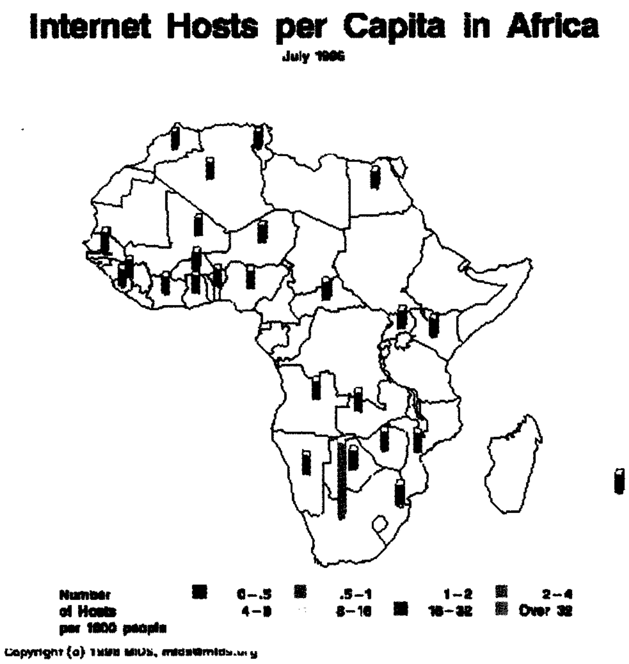

Figure 3. Internet hosts per capita in Africa (MIDS 1997)

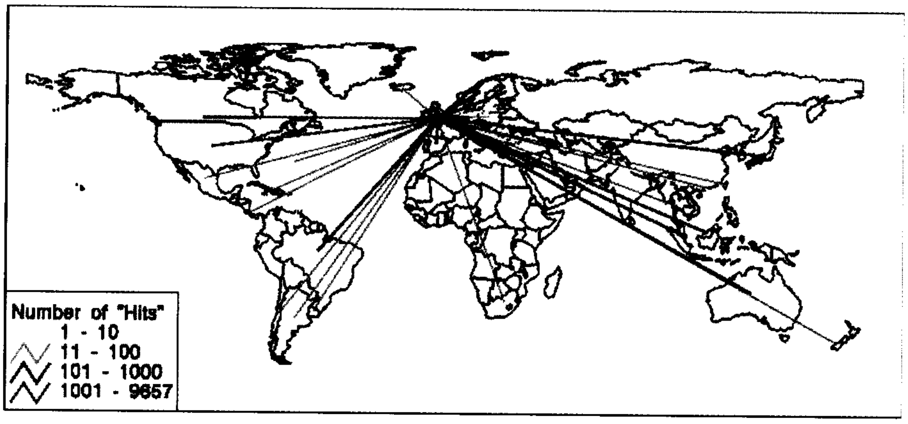

Figure 4. The spatial distribution of "hits" on a certain Web server (Dodge, 1996)

NETWORK

There are not only physical networks in cyberspace; information can also be regarded as a network, because it is structured: from a graph point of view, structure can be mapped as network. Figure 5 shows can example of network representation of the home pages explored.

Distribution mechanisms can also be regarded as networks; an example is the Mbone. The Mbone is the Internet's multicast backbone. Multicast is the most efficient way of distributing data from one sender to multiple receivers with minimal packet duplication. The Mbone has been extremely popular for efficient transmission across the Internet of real-time video and audio streams such as conferences, meetings and congressional sessions. The global topology of the Mbone can be mapped in various ways (Munzner et al., 1996).

INFORMATION

The World-Wide Web has created an exciting universe of information by linking numerous information resources residing in computers dispersed over the world, and making them easily accessible. In this sense, cyberspace is an information space. It enables us to explore the universe of distributed information resources from our desktop computers. The above figure 5 can also be regarded as a cybermap from information point of view where each node is a home page.

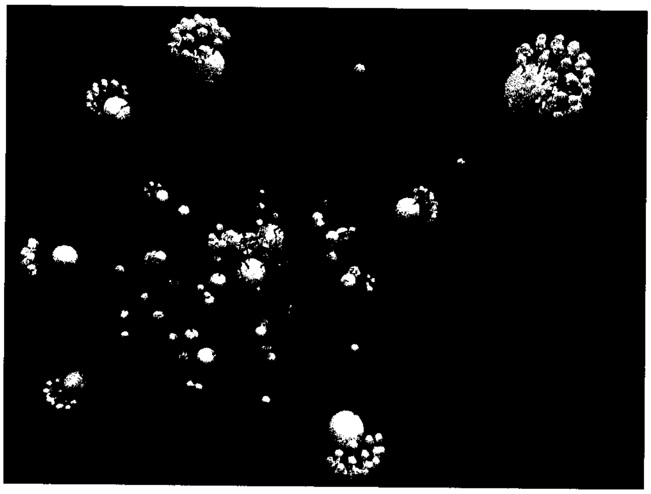

Figure 5. Network representation of cyberspace (Wood et al., 1995)

While interacting with information over the Internet, one feels lost at times, confused and overwhelmed. How can the user know where the source of the relevant information resides, how to get the sources? Once the sources are accessed, how can one get at the relevant information? In short, users can feel lost or become disoriented in the information space. An enhanced version of NCSA Mosaic allows the user to view the cyberspace depicted as a visual "tree" structure (Gershon et al., 1995).

A similar issue has been addressed by Ormeling (1993) in the context of atlas information systems. That is, the geographical data presented in an electronic atlas has to be structured in order to avoid getting lost in it. There are different scenarios to do so. One possible and efficient way is to create a network, or more generally, a graph structure about information or physical locations. Wherever one travels to, the graph network shows the current location by highlighting a certain node. From this point of view, then, cybermaps could be subdivided not only into physical maps and information maps, but the information maps could be subdivided into internal (within a package) and external maps (refering to relations between computers)

In the abstract diagram of figure 6, the circle might be a university node, and rectangular blocks might be faculty or department nodes. It is actually an hierarchical structure of information space, which is much like the London underground route map.

In the previous discussion, Bertin's system of visual variables was described as fundamental for mapping. This system is not only applicable for mapping but also for the interpretation of map information. In this respect, the perception properties (Bertin, 1983) of these visual variables can be considered basic guidelines. For instance, the variable 'size' is often used for representation of value changes but 'colour' is not. As many cybermaps are produced by non-cartographic professionals, it is unavoidable that some low quality maps are created. In figure 4 for instance, we would suggest the use of line width to represent the number of hits.

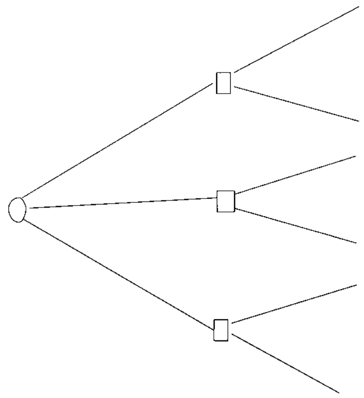

Figure 6. An abstract network of information space

Different from the conventional paper map, cybermaps are more oriented to computer environments. It has been shown that an increasing number of cybermaps are produced with new animated cartography (Ormeling, 1995). In other words, a range of multimedia is widely used in producing cybermaps. However, the basic functions of cybermaps, compared to traditional maps, remain unchanged.

FUNCTIONAL CLASSIFICATION OF CYBERMAPS

In this section, we will endeavour to make a systematic classification of all cybermaps. Dodge (1997) made a classification which covers geographical metaphors, conceptual maps, topology maps, landuse maps and landscape views, virtual cities and navigational tools. From the functional point of view, all cybermaps can be classified into three functional categories: navigation, cyberspatial analysis, and persuasion.

NAVIGATION

One of the useful functions of conventional maps is providing help for orientation and route finding. It is also true for cybermaps. As mentioned previously, one of the problematic issues in surfing the cyberspace is getting lost in it. Navigation here has a two-fold meaning. On the one hand it refers to the geographic world, as it will make users realise where a host is in the geographic world; On the other hand, it refers to cyberspace, where one is travelling in hierarchically organised information.

Now that cyberspace can be viewed as a network, it can be mapped with a relationships map. For this kind of map, the relationships would refer to all hosts that are linked, i.e. the linkages between client and server. This type of map is very similar, in form, to the London underground map where all stops are connected by straight lines (actually distorting the shape).

CYBERSPATIAL ANALYSIS

There are many aspects in which cyberspace is similar to geographic space. For instance, traffic flows (http://www.telegeography.com/Resources/tgmap.html #Flows) are one kind of map in this category. The map is composed of nodes and of lines connecting nodes. The nodes are positioned spatially, and the lines linking the nodes encode relationships, with line colour and line thickness representing the strength of the relationship.

In many respects, maps for cyberspatial analysis are similar to network maps. But a big difference is that the former look more like map with precise spatial locations, while the latter are lacking precise locations, and are more similar to a node and link diagram. Based on this observation, the world physical network map falls into the category of maps for cyberspatial analysis.

As the Internet is expanding increasingly, congestion of traffic flows in space are becoming a major concern. Web explorers are always suffering from the slow speed of surfing. Some places can be overloaded because of too many hits, and sometimes may even become inaccessible (rejected). If all transportation conditions could be mapped visually, this would be useful for traffic analysis and planning. So far, there have been some Internet traffic analysis maps report in the form of weather maps (http://www2.mids.org/weather/index.html), from which one can get to know how busy traffic is in some specific region (figure 7).

PERSUASION

The last function of cybermaps is for the purpose of persuasion. MIDS Inc. maintains a lot of maps about the current situation of the Internet development all over the

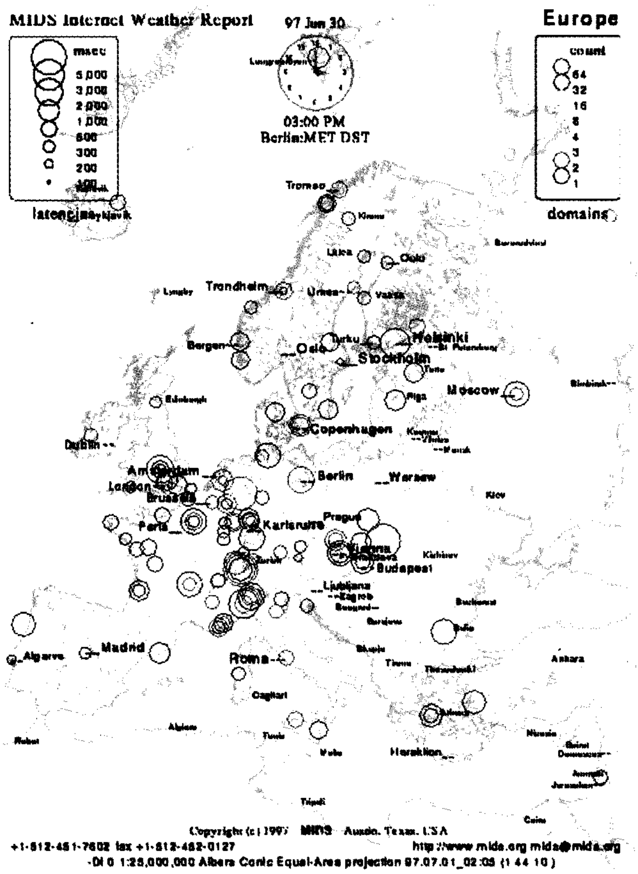

Figure 7. An Internet weather forecast map (MIDS, 1997)

world. The above figure 3 is an example in this respect, showing the Internet development in terms of the number of hosts in Africa.

DISCUSSION AND CONCLUSION

From the above discussion, it has been shown that there are various aspects of cyberspace to be mapped. Cartographic principles as well as animated cartographic principles are fundamental for mapping cyberspace. Thus, the features of cybermaps can be summarised as three points: interaction, exploration and multimedia.

It should be noted that cyberspace is not only exclusively Internet, but can refer to other telecommunication such as telephone, TV as well (Arrowsmith and Wilson, 1997). The same sort of cyberspace is available for them. There is little doubt that in future our television sets may be part of cyberspace. Although what is discussed in the paper is mainly oriented to the Internet, the same principles are also applicable to other types of cyberspace.

Cyberspace is a system with "unimaginable complexity". We are in a similar position to our ancient cartographers, where they lived on a flat earth or an irregular globe. Before fully understanding the nature of cyberspace, we have started mapping it, and thereby, because of our bias or lack of knowledge distortion will have been caused. Therefore properly modelling cyberspace is a critical condition to be met before it can be mapped.

As pointed out at the beginning of this paper, little work in mapping cyberspace has been undertaken by cartographers. We take this opportunity, therefore, to call on cartographers to contribute our long standing experience in mapping and to challenge mapping cyberspace.

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