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VIRTUAL GEOGRAPHY

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Geography and its study are changing in subtle and dramatic ways in the rapid transition to a digital world. Here we present a preliminary discussion of how this new geography, which we call 'virtual geography', might be classified. Virtual geography is not merely cyberspace *per se* for it comprises many types of place and space in which the digital world finds expression. We define cspace—the space within computers, cyberspace—the use of computers to communicate, and cyberplace—the infrastructure of the digital world, as key components of what Castells[1] refers to as 'real virtuality'. Virtual geography is all this as well as the study of these worlds from traditional geographic perspectives. Like all classifications, the interesting questions lie at the boundaries between classes—between cspace and cyberspace, cyberspace and cyberplace, and between all of these. We illustrate this variety and complexity with examples.

The new virtuality: computers and communications

Powerful ideas have dramatic social impacts that are rarely anticipated. Such ideas are hardly understood for their origins invariably lie in deep theory whose science is esoteric. Computation is one such idea whose impact on contemporary society is so sweeping that all predictions of its power to change the world have been wrong. Even the pioneers who first glimpsed the fact that the computer was a universal machine, failed to see how all pervasive such technologies might become.[2,3] Computers of course are simply the vehicles that are directly associated with computation, and as computation itself is pervasive across all media, traditional bounds posed by the constraints of space and time are fast being changed, in scale and scope, qualitatively as well as quantitatively. In this essay, we will sketch the impact of computation on space and place, on geographies,

on the study of geography, collapsing all these notions into the concept that many facets of geography are becoming virtual.

Digital computation rests on the coming together of two of the most important ideas of the 20th century. The notion that all knowledge might be reduced to a two-valued binary logic—either/or, true/false, on/off, 0/1—was an idea that grew in importance in the early century and was elevated to universal status as a form for dealing with the world by the mathematical genius of those such as Turing and von Neumann. The association between two-valued logic and electric switching circuits held out some promise for the practical implementation of machines for digital computation, but it was the second idea—the discovery that silicon or sand could conduct electricity—that heralded the invention of devices such as the transistor and the integrated circuit, which made the notion of universal computation possible.

At the end of the Second World War, the pioneers argued that no more than a dozen or so digital computers would ever be required for it was impossible to anticipate the process of miniaturization that began from the invention of the transistor, although they might have taken the practicality of the concept of the universal machine more to heart. A quarter of a century later, those in the vanguard of main-frame and mini-computing were equally adamant that there would never be any demand for personal computers.[4] Miniaturization might make them possible but what would people do with them? A failure, once again, to perceive that computers were universal machines. Now that computers have become truly graphic, when their extension to many other forms of media looks eminently possible, and when new worlds based on such computation are being invented, there is the same disbelief. This essay will attempt to suspend it through an account of the way the geographical world is being changed by computation, and by the emergence of virtual worlds which have their own sense of place and space—their own geography.

The idea that a picture might be reduced to binary digits is clear enough today but even as late as 1980, it was still quite alien to computing. It was the personal computer, itself a consequence of exponentially increasing silicon memory, that opened up the world of computation to those who wanted to have fun, to a generation of hackers whose interest was in making computers do incredible things especially through games that still represent the cutting edge of graphics and multimedia. It was graphics that made computers friendly and it was games that propelled them into the public consciousness.[5] From games have come the most amazing graphics interfaces where we sit at screens, point and click, draw and type, cut and paste. And from graphics interfaces has come the retreat into virtual realities where entire environments are being constituted within the machine. In a sense, most *graphical* computation is now geo-*graphical*. The geography might be the geography of the screen but it is more likely to be linked to the geography of the real world. Games are often manifestly geographical in that they either attempt to constitute a fictional reality or even portray a real reality, but in either event the portrayal is virtual.[6] Practical applications for more prosaic purposes such as work often attempt to put the geography of the real world into the computer and analyze, model and predict it; the classic example in contemporary geography being geographic information systems or GIS. Putting real geography and inventing fictional geography inside the computer is thus our first benchmark for a virtual geography.

Our second benchmark involves that other remarkable convergence of 20th century technologies between computers and communications. Until some 2 or 3 years ago, most

of the world's direct experience with computers was through single personal computers, but suddenly everyone is connected and computing is across networks. Not so remarkably perhaps for from the dawn of digital computing, there was always a sense of remote interaction. In the beginning, it was by taking computer applications from the place where they were prepared to the place where the computer was located but gradually, networks were established to link users to remote computers. By the mid-1970s, most large computer installations had users connected to them in the form of some star network. Personal computers blew the network idea apart in that computers were brought directly to users but a good idea will never die entirely and the networking of machines continued less visibly but inexorably. Electronic mail formed the first application of virtual communications across academic networks such as BITNET. But advances in communications protocols, data compression, and network technology itself meant that by the early 1990s, personal computers could be connected to one another across telephone lines, heralding in the era of the Internet and the World Wide Web.

The deregulation of communications systems and the exponential growth in bandwidth have made universal network computing not only a possibility but something that is as dramatically different and all pervasive as the personal computer of a generation ago. Computing itself is drifting to the net, while computers are being used more and more as devices for actually communicating as well as computing, for accessing data, services, information of many kinds, as well as for talking, browsing, and for all types of communication that traditionally have taken place face-to-face. The convergence, however, has only just begun. Television, cameras, video recorders and players, diaries, telephones, faxes are all being collapsed into various types of digital box, which are consistent with one another as anything that can be pictured or written becomes digital.[7] Wires are disappearing as the wireless revolution takes off after a century of ingestion. Eventually computers will be everywhere—in paper, in clothes, in highways, in the very fabric of material society itself as entire cities become computable.[8]

This is generating an entirely new dimension to geography.[9] Real geographies are being changed through virtual communications while virtual geographies are being invented over the net that have little or no resemblance to the geography of reality. In fact, although real and fictional worlds were first developed inside the computer, these worlds are themselves emerging from the net itself. This is William Gibson's[10] science fiction of the near future: Cyberspace —'... a graphic representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the non-space of the mind, clusters and constellations of data. Like city lights receding'—Virtual Geography.

Classifying virtual geography

At the outset, we should define reality and its variants: fiction, abstraction, and virtuality. Reality once extracted from context exists at different levels of abstraction, as indeed does fiction, which we consider to be 'imagined reality'. The central distinction we pose is between reality and fiction, which once embedded within computers and across networks we define as 'virtual reality'. This is a broad definition for it suggests that all computation is virtual, ethereal,[11] but it says nothing about the way in which computation itself is redefining material reality, which is very much part of virtual geography. However, we will begin by defining clear differences between geography inside computers and geogra-

phy inside computer networks, which are both distinct from the geography of computers and the geography of networks. On top of this, there is a new geography of everywhere that is being created by the very acts of embodying computation within networks and within the material infrastructure of society itself; we will return to this by way of our conclusion. Computation is thus two-way traffic in that it is largely abstract and ethereal but it is also changing the material reality which is the subject of that abstraction in the first place. As Bailey[12] so perceptively envisaged in the title to his article: 'First we reshape our computers, then our computers reshape us'.

We must also attempt to define or at least situate geography. Geography is about place, but once abstracted, places are conceptualized as spaces, as relations between them, as activities and processes in space, which break up into those that determine the physical form of the world—geomorphology, those that determine the natural form—biogeography and the environment, and those that determine the man-made form—social, economic, urban–human geography. There is a countless spin on such definitions, with little agreement as might be expected in a vibrant yet small discipline. The field is strong and its intellectual following convincing: our's is a working definition. Virtual geography then is the study of place as ethereal space and its processes inside computers, and the ways in which this space inside computers is changing material place outside computers. Around this Janus-like face of virtual geography lies the study of the geography of computers and networks from a traditional, non-ethereal standpoint.

Our typology of virtual geography is preliminary and like all initial self-conscious forays, it is overcomplex. We have arranged the framework on two levels: first at a macro level, the level of geography itself, perhaps reflecting the material world, which is based on the distinction between space and place, while second, at a lesser perhaps micro or ethereal level, we can define how real and imagined place/space is influencing individual and collective human behaviour. Above all this at a meta level, the geography of computers and communications attempts to explain the macro and the micro.[13] The macro is our starting point and we define four foci involving place and space:

place/space: the original domain of geography abstracting place into space using traditional methods;
cspace: abstractions of space into c(omputer)space, inside computers and their networks;
cyberspace: new spaces that emerge from cspace through using computers to communicate; and
cyberplace: the impact of the infrastructure of cyberspace on the infrastructure of traditional place.

Before we elaborate these distinctions, we must emphasize that the introduction of new terms such as cspace is meant to separate the uses of computers for games, design, various types of science, word processing and so on from the use of computers for communications, which is the traditional theme of cyberspace. In the same fashion, distinguishing new computer spaces that comprise cyberspace from the impact of cyberspace on traditional places, legitimates its extension as cyberplace. We chart these distinctions in *Figure 1* where we show how these spaces have evolved from one another. Our chart makes a clear distinction between place and space where these varieties of geography are situated and this is arrayed against the geography of single and related places and spaces as nodes and nets.

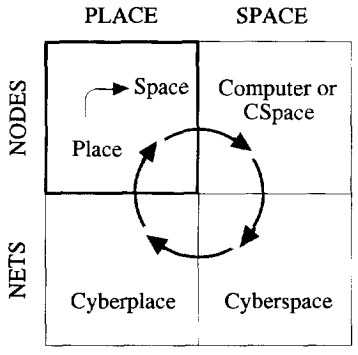

Figure 1. Virtual geography as place and space in nodes and nets.

The first uses of computers for geography generated cspace, but it was not until the convergence of computers with communications over the last decade that the burgeoning use of networks for human interaction and the delivery of services generated new geographical spaces within the ether, which are now popularly called cyberspace after Gibson.[14] The effect of these on the way we organize our infrastructure and our geography of real places has been happening ever since computers were invented but this is gathering pace as cyberspace begins to change the role of real places, as the new material infrastructure of telecommunications and computers itself replaces their non-digital equivalents, thus providing an extended medium for cyberspace: the idea of the information city, smart buildings, and intelligent architecture constitutes much of this geography.

Some further explanation of the place–space relation is necessary. Space is geography's or the geographer's abstraction of place but *Figure 1* does not distinguish this in terms of where traditional geography is situated. Cspace, cyberspace and cyberplace all involve digital representation but there is a necessary translation from place to space before such digital representation is possible. In the cell marked by nodes and place, we blur this issue by implying that the translation from place to cspace usually involves non-digital abstractions, theories, models, whatever, of space. The circularity implied in *Figure 1* is meant to suggest the order in which space and place has been influenced by the gathering momentum of the digital world; with standalone computing first being the norm in terms of cspace, then networking applications between computers—cyberspace—becoming significant, and the impact of computers and communications on place itself following in this wake. Of course once set in motion, this process of influence feeds back and forward in every conceivable way, and it is perhaps at the boundaries between these classes that the most interesting questions emerge—between place and space, cspace and cyberspace, cyberspace and cyberplace... .

At the micro-level, we can picture the territory of each of these place–space foci as an array of real and imagined geographical abstractions, diversified by the ways in which such digital abstractions might be used. Personal, individual, organizational, and collective uses in cspace, cyberspace, and cyberplace abound and in the rest of this paper, we will elaborate these uses to give some sense of exactly what might compose a virtual geography built around this classification. Once we move below the level of place and space, our foci embody the ethereal in contradistinction to the material of the macro level but these distinctions are fluid and expedient, and obvious examples that stretch this paradigm are easy to define. Our typology is simply a tool to get started, a way of

structuring discussion, for in the rapidly emerging world of 'unthinkable complexity' that the digital and the virtual now imply, classifications are intrinsically limited to provide total comprehension as each change in the perception of this new world generates a different emphasis.

Cspace

From the digital beginning, all potentially computable activities that involved intensive and/or extensive data were rapidly affected by the development of computers. Transaction processing and scientific calculations formed the essential activity of computation throughout the 1950s and 1960s and these embraced rudimentary geographic research in which researchers began to develop spatial analytic models based on extensive spatial data as geography itself became more quantitative.[15] It is now hard to disentangle the development of this type of geography over these years from the development of computation, but in hindsight, geographers used their computers merely as large-scale calculators, rather than as a new medium in which to conceive and manipulate geographic theory. Cspace was at arms length until the advent of the personal computer although it is hard to argue that computers did not change geography during these early years: it is clear, for example, that models and analytical methods were applied to data in ways that would have been inconceivable before the digital age but it was the development of nascent simulations, which is likely to turn out to be more important to virtual geography than simply the uses of computers to crunch ever bigger and more data intensive geographic applications.

Much of what has happened in terms of the way computers have disseminated throughout society during the last 50 years applies to everything else as much as it does to geography. Representation of (geographic) systems through data, analysis of spatial relationships, simulations of spatial processes, and applications to policy are all generic features of computable geography. GIS, computer cartography, spatial analysis packages, simulation models, decision support systems, optimization, and computer-aided design (CAD) are all distinct features that now act as methods for embedding geography in cspace. As the computer revolution has progressed, applications have become ever more graphic with GIS representing a current obsession, and ever more qualitative data in the form of pictures being processed digitally through remote sensors and the like. Against these professional-research uses, educational applications based on computer-aided learning are taking off, while the development of generic software based on word and graphics processing is becoming central to a range of high and low level functions that comprise the activity of geography.

What defines the development of cspace is the contrast between the early use of computers as extended calculators and the current personalized use in which very high level software is the medium through which much geographical study now takes place. This is marked by the divide between traditional and contemporary computing through the development of graphics-based software where the mode of use is very different from the uses of computers a generation ago. Where the dominant media is digital in contrast to the age when digital media were simply another extension of geographic research and study, the influence of computation on geography is wide but subtle and hard to unravel.

The very first applications of digital computers to geography were doubtless in the 1950s, probably from the 1950 US Census, with the very development of the punched

card machine and of IBM itself directly attributable to Herman Hollerith's invention of such devices for the US Census of 1890. Large-scale number crunching has always driven computing and will continue to do so. But it was in the development of quantitative geography from the mid-1950s at places like the University of Washington that the first simulation models and spatial statistical techniques were developed by pioneers such as Berry, Marble, Garrison and others.[16] In a parallel vein, transportation modelling began with computing in the Chicago Area Transportation Study in the mid-1950s while municipal governments in the US and UK had begun to use computers for a variety of transactions processing onto which scientific applications were grafted. Graphics began during this era too but it was not until the development of the microprocessor that useful applications for more routine problems became possible. The story is one of continual and remorseless advance driven by developments in computing and graphics, but one which is now so significant that magazines such as the British monthly *Geographical* give over regular columns to developments of the latest geographical software defining cspace.

Most of this domain involves geographical study that in an earlier era was accomplished independently of computers, although many of the methods and some of the questions are intrinsic to digital computation *per se*. However what depends almost entirely on digital computation for its rationale are the imagined geographical worlds that are central to computer games and also appear to a more limited extent in educational software. The basic adventure games (MUDS — *M*ulti-*U*ser *D*omain*S* or their earlier equivalents—*M*ulti-*U*ser *D*ungeons and dragon*S*) are intrinsically geographical as are many kinds of simulation that make use of geographical backdrops while formal games, such as *SimCity* and *Civilization*, take these applications much further in that they combine both reality and imagery in a way that accords in some measure to geographic theory.[17] How far the imagined penetrates the real in cspace is difficult to measure but increasingly computers are being used to visualize what might be. In one sense, all human endeavour is a blend of the real and imagined. Computers provide new ways in which such endeavour might be developed: new ways of illustrating real geography are imaginary in some sense while the best geographical fiction seeks to confuse the real with the imaginary as in all the creative arts.[18] It is not our purpose to trace the impact of cspace on geography and geography on cspace but we must note some of the major innovations that the digital world brings. Simulation is clearly of major import, indeed simulation is the essence of virtuality,[19] but the other key is what we will call 'the digital relation'. As digital media has developed, it is now possible to link any aspect of software or data to any other within any application. Different software running on the same computer can be accessed from any application, thus enabling the possibility of building digital relations between any and every piece of data and software. For example, running animations, enabling drawing, simulation, playing games, using whatever software, from within, say, a word-processing package (read any other software package) is now possible. This ability of linking diverse activities wherever they are on the desktop is called 'hotlinking' and it is now widespread in cspace. In fact, this is equivalent to networking within the machine and its generalization to physically remote machines, individuals, and places lies at the basis of cyberspace and cyberplace.

Cyberspace

Interactivity between remote computers defines cyberspace. The move from nodes to nets requires more than simply links that swap information, for cyberspace is only created

through communications that link purposeful agents which, to all intents and purposes at present, are humans. Clusters of professionals who surround a computer on which some application such as CAD might be being performed and who are engaged in using the output collectively, does not constitute cyberspace, nor is linking into some single remote computer without links between the users. Cyberspace differs from cyberplace in that the spaces created do not map in any one-to-one relation onto real places, but cyberspace is not necessarily imagined space—it is real enough in that it is the space set up by those who use remote computers to communicate.

Cyberspace emerged in three distinct ways in the 1970s and 1980s. First, the high energy physics community and the US Department of Defense resolved to build a network between their computers that would be 'bullet-proof' to the nuclear holocaust, but the net that emerged—DARPANET—soon became the medium for electronic communication—for professional e-mail. The world's science community began to connect up and by the mid-1980s, all kinds of academic networks ranging from simple e-mail—BITNET—to Unix-based networks—UUNET — were in existence. This was the beginning of the Internet. Second, local area networks began to emerge in the mid- to late-1970s. At Xerox Parc, the Ethernet was invented and the notion of clients and servers was borne. Most of the 1980s was based on the remote connection of dumb terminals to main-frame or minicomputers on which applications were run with perhaps constellations of those computers sharing tasks. But subtly, inexorably, this began to change as servers were used to download information to remote machines with the same or more processing power and where software and data were swapped back and forth to optimize computation. Third, proprietary internets offering e-mail and bulletin boards and commercial information of all kinds such as *Compuserve* and *America OnLine* had been formed by the late 1980s, and these enabled those without access to academic networks to link up.

In the 1990s, this network paradigm is now writ large, '...the symbol of science for the next century...' as Kelly[20] persuasively argues. Computation can take place between any place and any other, software and data can be similarly remote, and processing can take place anywhere and everywhere. The best example of this phenomena is the rise of the World Wide Web, the paradigm of late 20th century computing, which is in many senses the visual interface to the net; to e-mail, the downloading and use of software and data; to bulletin boards and newsgroups, and all the other information sources that are now linked together in the anarchic organization of the net. The kind of geography that is emerging in this cyberspace is one that in its clearest form, mirrors local communities or interest groups linked through some common purpose as virtual communities, virtual self-help groups, groups that talk and act across the net, informally, expediently, embodied in net-action; as ephemeral as 'internet relay chat' to formal research groups such as those based on professional communication amongst peers involving frequently asked questions, preprints of articles, announcements of meetings in cyberspace as well as real place. These kinds of geography are being popularly discussed, explored and charted[21] but the geography is simple and the spaces only identified superficially and informally to date.

To chart the limits of cyberspace more formally, we must identify its activities. Any and every type of human interaction has some potential to be representable in cyberspace. Production and consumption for work or leisure, both in routine and less routine contexts, are beginning to find their expression across the net while within these, generic activities such as communication, learning, simulation and decision are all behaviours

that are being influenced by digital interaction. The range of applications is potentially enormous although so far, distinct types dominate and we will note a small number that provide a best sense of what is happening. The marketplace is the archetypal example. Cybermalls represent an extension of passive information systems based on advertising, where buyers engage in simple interaction across the net with remote hosts that check supplies, record decisions to purchase, and dispatch orders. Banking and related services are moving online and e-money is slowly appearing with credit card services representing the current modes of exchange. Such online shopping is hardly interactive in the sense of users being part of an active community although the cybermarket does involve linking producers to consumers over the net. Its extension to the actual production process is only a matter of time. The Web is replete with such examples.

Low level consumption for leisure is another growth area where tourist-type information and interactive navigation around various data portrayed as real space, product-space, learning space and so on constitute the message. The Web is dominated by such sites which really represent the simplest way of engaging in cyberspace. All these activities are routine but it is when the focus is on less routine activities that cyberspace becomes enriched. Science across the net for example is not merely an extension of e-mail and bulletin boards to specialist peer groups but provides new ways of articulating theory, experiment, research and development. Examples from urban planning are worth noting. Real time monitoring of routine urban change such as movement, micro-climate and pollution patterns is now possible on the net and this provides data sources relevant to a new array of micro-simulation models such as the TRANSIMS models for the US Department of Transportation at Los Alamos National Laboratory.[22] Less routine information that supports such use based on Census data, the geometry of the built environment and various value-added data products are now accessible in the same way. On the horizon, software such as GIS, which traditionally has resided in cspace, on the desktop, will be available over the net for free, for rent, or for purchase. All the elements are in place to begin online simulations that use data and software from remote places but brought together in cyberspace. This offers the prospect of remote experimentation with users being able to run their own simulations in cyberlabs whose software is invented, set up, and managed by others.

An extension of such collaboration involves the very construction of the simulations by communities of remote users using various forms of collaborative decision-making. This is the ultimate quest of cyberspace use in that the net is used as a medium for the sharing of intellects in the pursuit of common goals or the resolution of common problems. It involves highly-organized decision-making, appropriate structures for relevant software, data access and use, and innovative ways of personal consensus building that have hitherto not been widely developed in society-at-large. The net thus provides new structure to action which involves a truly different development of institutions for sociality.[23] In some ways, elements of this type of interaction already form part of more routine consumption and production using inter- and intranets but more routine usage is usually focussed around clearer, simpler objectives. The difference between computer-aided manufacturing and computer-aided design clarifies this. CAM is well structured, no less difficult software-wise than CAD but with clearer goals. CAD, however, in a group context is not well-defined and may never produce usable results unless the process is highly managed. Cyberspace provides highly constrained structures that make this kind of man-

agement feasible, at least in principle, and the same points are relevant to any kind of collaborative decision-making, problem-solving and planning.

Cyberplace

We could say more, much more about cyberspace, but it merges, sometimes imperceptibly, into cyberplace, which we define as the substitution, complementation, and elaboration of physical infrastructures based on manual and analogue technologies by digital. In one sense, the net itself is part of cyberplace in that the myriad of networks and computers that it comprises have real physical presence. But here we have more specific uses in mind. Changes in physical movement patterns traditionally associated with mechanical devices such as cars and trains due to electronic communications are part of cyberplace insofar as the built form changes in response to such substitutions and complementations. The emergence of command and control structures that sense the environment and human behaviours in countless ways, from CCTV in public places to smart building infrastructures that control whole building functions, are part of cyberplace although their use might be classed as cyberspace.

In short, cyberplace consists of all the wires that comprise the networks that are being embedded into man-made structures such as roads and buildings. It extends to the material objects that are used to support this infrastructure such as machines for production, consumption and movement that are now quickly becoming a mix of the digital and the analogue. It is an open question as to whether cyberplace encompasses the natural world for there are clear signs that nature is being complemented by digital devices; man-made structures will become more 'organic' in form as biophysics and the digital world begin to merge. Within a century, there is the clear prospect that buildings and other such structures might be 'grown' rather than manufactured. In this discussion, however, our focus is shorter term, on the networks that are now defining places and the way those networks are used physically. One of the great limits on developing the field of virtual geography is the fact that networks are largely invisible to immediate observation, and this makes any traditional spatial analysis problematic. The Internet is simply the tip of the iceberg. The way the phone system is being linked to new forms of net such as ISDN, ethernet, ATM and so on, the way organizations at many scales from the local firm to the municipality to the global corporation and world agency are making use of existing and building their own intra- and area-wide networks has been hardly charted at all. The best we can say is that cyberplace seems to be reflecting traditional place but cyberspace is clearly changing this.

This undiscovered world can be sensed in terms of the way buildings are being wired for control of energy, access, and security, as well as the very functions that are performed therein. We see the way in which work is being changed through digital communications, which in turn is changing the needs and requirements for centralized programmed work environments. Telecommuting and mobile communications are making office environments more ephemeral. Entire buildings are being configured for just-in-time service activity, for hot-desking, while cars and other forms of transport are being configured as mobile offices. In terms of transportation *per se*, roads are being wired. The notion of the intelligent highway involves new forms for the control of vehicles that optimize many varieties of performance and energy. Digital sensors within cars that enable better navigation are appearing, but the most exciting prospects are for wired highways where single

vehicles can be linked in platoons to speed travel and increase safety. These kinds of automated highway are being tested, for example in the California PATH project at Berkeley, and within a decade, it is likely that such systems will be implemented. Developments in trains and planes will presage the same as more and more digital technology is used to control their use.

Perhaps the most perplexing developments in cyberplace involve communications without wires—wireless interaction. Although networks are hard to see, they do exist physically but wireless communication is through the ether and the impact on physical, material infrastructure is indirect. In fact, there is a case which says that wireless communication presents a new kind of non-physical infrastructure, that is different from cyberspace, which is its use, and different from cyberplace, which to date we have defined as the embedding of the digital into the physical. But this is where our typology begins to reach its limits, and to qualify this, we must examine the way these various digital places and spaces fit together.

Intersecting c(***) spaces and places: two examples

The trouble with any typology, certainly one as ill-formed and as preliminary as this early foray into virtual geography, is that examples are rarely ideal types. Computer use in terms of tasks that involve single or networked communications invariably involve all four components of our classification. To get started, real place and space are the driving forces, computer or cspace is necessarily a prerequisite to the communications that dominate cyberspace while the very act of use involves infrastructure that is cyberplace. In fact as in all classifications, the really interesting questions occur at the boundaries of the classes where experimentation and innovation dominate.

Examples abound, but two that illustrate virtual geography, provide relevant tests of our typology. The first is based on linking computer-aided representation of building forms to various types of network communication, while the second involves representing network communications in virtual geographic space. Our first example was originally motivated by the need for a user-friendly graphical interface to a simple information system, which comprised data on the rooms and buildings in University College London (UCL). All the data about the physical plant of UCL is recorded in such a system. To get access to this in a meaningful way it has been linked to an *AUTOCAD* model of the College's buildings and spaces. Pointing to a room or space within a building and clicking on that location enables a user to retrieve information about the object in question—a simple and conventional use of a spatial information system that is clearly part of cspace. Slightly more ingenious development of the system has added a video interface to the *AUTOCAD* model so that users can move and pan around exteriors and interiors of the College and retrieve information as though they were actually walking within the College but this is still cspace.

However, contemporary software is increasingly open to other software and communications that exist on any computer. This application which is entitled *Virtual UCL* or the *UCL Navigable Movie* is stitched together in *Hypercard* in which intrinsic hotlinks to other software exist. It is possible to use the objects that are rooms and spaces to locate the links to other software. The system enables the user to click on a room and not only extract the Internet address associated with the person or agent in that place but launch the software that activates the link and move to the real location where that agent has

its own computer space. In short, network links that can be accessed through the interface provide links between cspaces, which is another definition of cyberspace. The visual interface thus provides a link from that virtual space to any other computer space. It is entirely general in that it enables any place to link to any other place through the cspaces associated with those real places. Any kind of software can be accessed at any time, anywhere.

As we navigate through rooms and spaces, we come across icons such as globes and pictures behind which lie pointers to software and data in other places accessible through the Internet. For example, in *Figure 2*, we show an example where the user begins the navigation in the College's main quadrangle as indicated in the *AUTOCAD* model, enters the North Cloisters through the video window, finds an earth globe on a table, spins the globe to a distant location, and then clicks on that globe to access the relevant Internet address. The example in question shows how we can access the WWW home page of the Geography Department at the State University of New York at Buffalo from UCL. A Web-based version of the system is available using the Virtual Reality Markup Language (*VRML*) and readers can find this at http://www.ps.ucl.ac.uk/vucl. At one level, the software is for retrieval of information, at another for communication and as anything can be linked to anything else, it is generic—the way we will all be linked to one another in the future.

Our second example represents an even further twist in that it starts with cyberspace

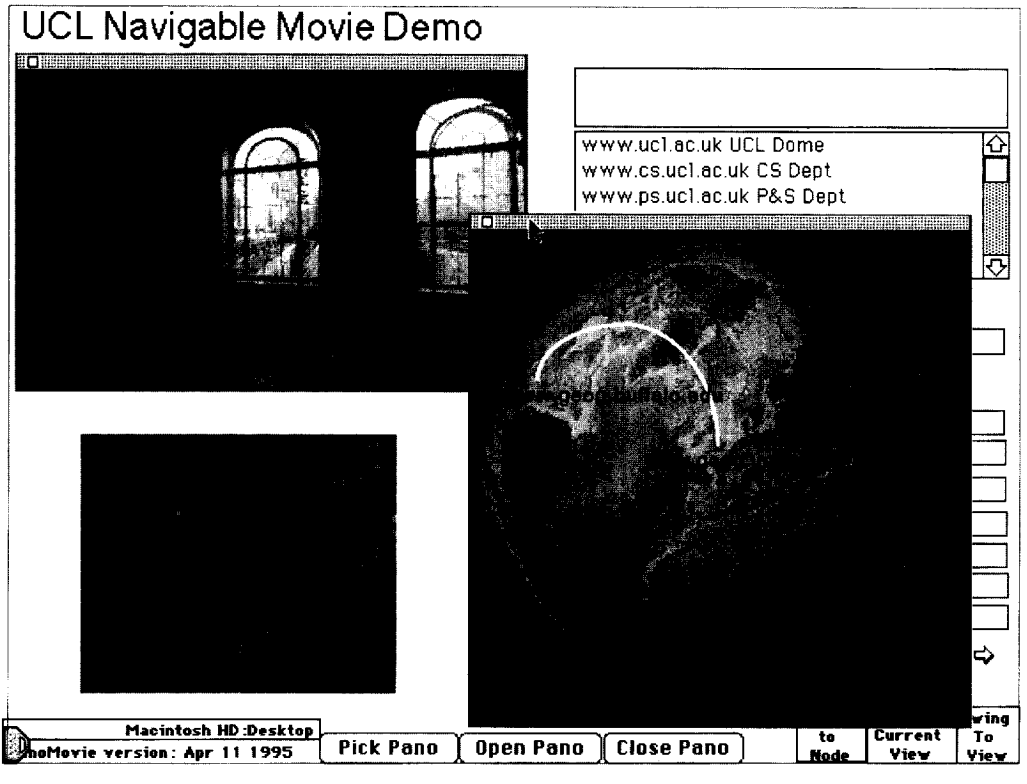

Figure 2. Virtual UCL: Navigating cyberspace through computer space.

and links it to cspace but a cspace based on deeply immersive virtual reality. There are now many attempts at charting and mapping Gibson's[24] matrix of cyberspace portrayed by the Internet.[25,26] But mapping actual telecommunications traffic is hard as it is not easily broken down to relevant categories. Special software to detect it is required, and as in all geographic space, traffic is not always logged at the point where it originates or is destined. At the University of Illinois' National Center for Supercomputing Applications (NCSA) where the original Web browser *Mosaic* was developed and which is the intellectual home of *Netscape*, the traffic on Web browsing is still heavy enough for researchers there to have developed quite sophisticated geographic monitoring in real time. Lamm, Reed, and Scullin[27] have developed *Avatar*, an immersive VR system for real-time analysis and visualization of this traffic where the user enters a VR 'CAVE' theatre or uses a headset to experience the mapping and visualization of this traffic.

A typical visualization from the CAVE is shown in *Figure 3*, which illustrates the

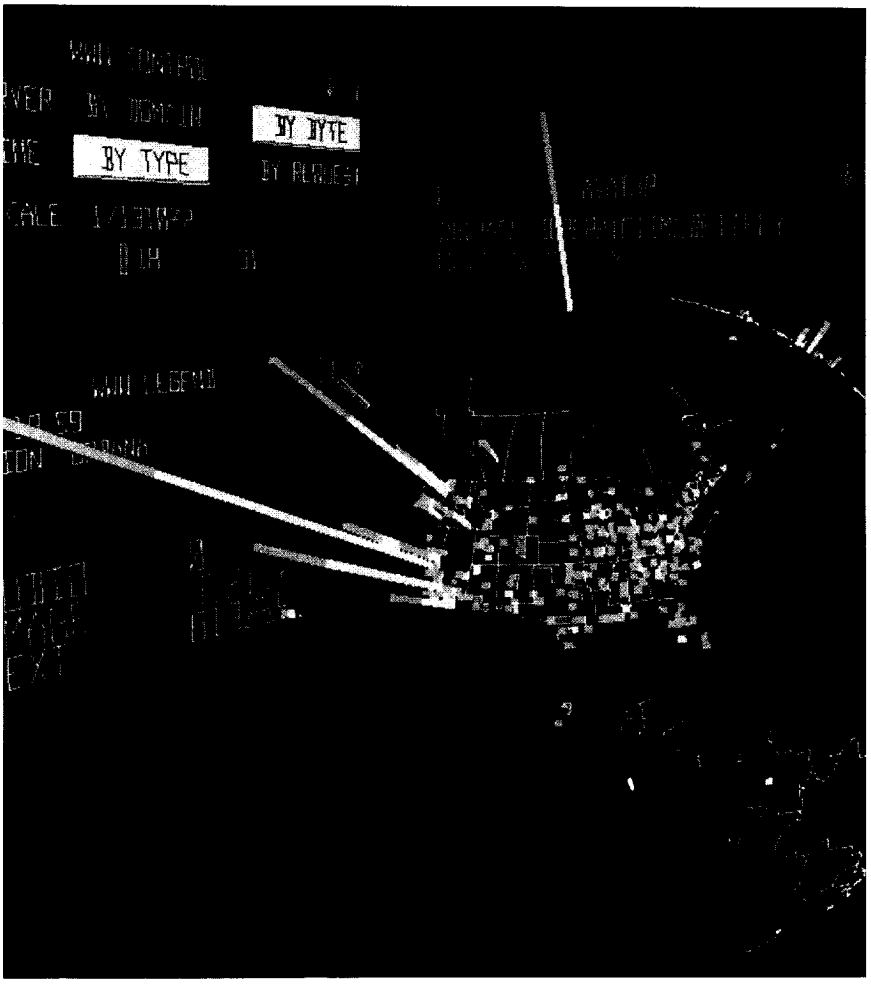

Figure 3. Immersion in cyberspace through virtual reality (from Lamm, Reed, and Scullin, reference[27]).

global origins of all traffic destined for NCSA at Urbana-Champaign. The 3D mapping of origins provides measures of the density of this traffic. Users can see the traffic partitioned into different categories, at present those that the data loggers can detect and that involve different types of graphics and text, but are easily generalizable to geodemographic content. On the horizon of the globe in *Figure 3* lies Europe where the visualization in terms of 3D bars gives as near a city skyline representation of cyberspace as one might take this kind of mapping. Users can of course spin the globe and generate their own scientific experiences from these portrayals. Once again, the application is generic for it might apply to any kind of data that can be sensed from nodes or nets. Extensions of the VR visualization to 2D displays through *VRML* are planned. Details are available from http://wwwpablo.cs.uiuc.edu/Projects/Mosaic/WWW3/. This kind of application links cyberspace back to cpsace but also provides a virtual sense of cyberplace. It is as close to Gibson's images of cyberspace portrayed in his succession of novels as we are likely to find at present. Although no mention of how users might communicate out of their VR CAVE is given, doubtless it is possible to use the visualization to communicate back to those originating the Web traffic, perhaps to those originators who are actually spawning this traffic from within immersive virtual environments. Once again, this kind of virtual world crosses the boundaries of all c(***)spaces and places.

The geography of real virtuality

Our final word on this emergent world requires us to stand back and examine the geography of virtual geography. We have loosely amalgamated geographies and the method of their study under the banner of virtual geography but we must now pull these themes to a meta level where their study in more traditional terms is significant. Castells[28] has called this entire edifice of the network society 'real virtuality'. Real virtuality is not virtual geography per se but it is cspace, cyberspace and cyberplace. When the geography of these digital places and spaces is also considered, then all of this comprises virtual geography. Once again, our terminology is not well formed, it is contingent, but it will suffice.

In fact, the traditional study of the geography of the information society and economy (see for example Hepworth[29]), and the geography of high technology industries (see for example, Saxenian[30]) is the geography of real virtuality in that these studies are removed from the virtual world *per se*, and attempt to record and understand it in a non-digital, non-virtual mode. Most do not use digital methods in this quest except insofar as word processors and statistical analysis comprise their work. There are few if any studies to date that attempt as Lamm, Reed, and Scullin[31] have done, to sense, measure and analyze virtuality through its own media although doubtless, traditional geographies will begin to do so as the boundary between non-digital and digital usage blurs and dissolves. The location of high technology industries, and the development of high technology movement patterns such as telecommuting are the clearest examples of this geography but the geography of near high tech such as services, the geography of the world and global city, and of course the basic geography of telecommunications are all forms of real virtuality.[32]

Virtual geography like the net and cyberspace itself is confused, anarchic, illformed and rapidly evolving. It mirrors late 20th century intellectual responses to society whose immediate logic is one of superficiality, the hallmark of postmodernism.[33,34] If this kind of complexity is unthinkable, then charting it in the way we suppose here is likely to increase rather than tame it, likely to obfuscate rather than simplify. Nevertheless, some

structure to what is happening to place and space is necessary, yet no one would pretend that the perspective adopted here is at all complete. Local and global differentiation, and the way space itself and time are shrinking and expanding are issues that geography is grappling with and which a virtual geography must embrace. What we have laid out here are the rudiments of an approach that connect geography both to its mainstream, and to its future, and to many other perspectives on the digital world, which involve place and space informally, unselfconsciously and unwittingly. This is a prolegomena for a virtual geography, one that might help us to begin an understanding, but one that is unlikely to last as this perspective evolves. What is crystal clear however is that the future subject matter and method of geography will be very different as place and space and time itself become virtual in an age where the digital permeates all human activity.[35]

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