Chapter 9: Internet's impact on software innovation

"NCSA Mosaic is a network navigational tool that allows the user access to networked information at the click of a button. Mosaic users can view text, image, movie and audio files." Gordon Housworth, CompuServe 721 10,1666

For years, the Internet has been difficult to use. The ability to collaborate via electronic mail at low cost virtually anywhere in the world has motivated millions of users to master an archane system. The Internet's roots are deep within the UNIX operating system. For those familiar with the cheerful icons and graphical devices of Macintosh, Windows or X-Windows, the commands required to accomplish even the simplest of tasks are cryptic. Because the Internet is a construct built of thousands of different computer networks, there is no single set of commands that can reliably be used in these different systems.

Newcomers to Internet learn the commands of their home system, use them when navigating to another system, and discover that the commands no longer work or do not work as they do on the user's home system. One of the trademarks of an Internet expert is a grasp of different commands to accomplish specific tasks; for example, ending a session on a remote computer quickly and easily. Beginners often turn off their computer or simply unplug the network connection.

A newcomer to the Internet requires one or two handbooks. The multiplicity of systems, sources and commands that are part of the fabric of the Internet can be confusing to an expert, overwhelming to a newcomer. Because the Internet has exploited the UNIX operating system, a reference guide to UNIX commands and conventions is useful as well.

A person exploring the Internet confronts a system of systems. There are basic functions of the Internet that most users encounter early in their forays into cyberspace. Electronic mail, ftp (file transfer protocol) and various types of online discussions are ubiquitous. The commands to send, receive, delete and file messages are seen as part of the system.

Complicating the software issue is the communications software used to connect to a system that provides Internet access. Because of the wide range of commercial software programs that can be used to connect with Internet nodes or third-parties providing intermediated access to an Internet node, it is helpful to keep in mind that software loaded on one's personal computer poses its own challenges.

Once the access software has been mastered, the person wanting to explore the Internet must confront the Internet itself as it is represented on the local node or intermediary system the users has selected. In a nutshell, the layers of software are often confusing and difficult to differentiate.

But the number of new users of the Internet has created a significant market for easier-to-use tools. As a result, rapid software innovation is underway.

1. Electronic Mail: a core application

The ability to send and receive messages at low or no cost has made electronic mail the foundation of a significant portion of Internet usage. It is impossible to untangle electronic messaging from other types of services.

Electronic mail is activated by selecting mail from a menu, entering the command *mail,* or clicking on an icon. Unlike traditional paper-based mail, Internet mail can consist of text or different types of information, including sound, pictures, even video footage. In comparison with most commercial mail services, the Internet mail capability is more flexible and performs with remarkable speed. Most messages arrive within minutes of their being sent. The delays are minimal even compared to those encountered on such commercial services as CompuServe, which offers its customers an Internet mail forwarding function. In general, data transfers via the Internet are surprisingly fast despite the surge in usage that Internet has experienced in the last twelve months.

Typical electronic mail applications include:

- Routine communications with colleagues.
- Interactions with peers or those with similar interests throughout the world.
- Obtaining messages on specific topics automatically.
- Retrieving text, image and executable files.

Statistics about the Internet count packets of information, not the users' intent for those packets. One indication of the importance of the Internet as a communication medium is the sense that an Internet address is becoming more and more important in personal, business and professional life. With the range of Internet addresses and their complexity, UNIX allows the user to set an 'alias' for frequently used addresses. An alias is an nickname that is easily remembered. When an alias is set and used in the address block of an electronic mail message, the system substitutes the complete Internet address for the nickname. Capabilities such as this allow a user to send a message to one or thousands of people with few keystrokes.

Other features of electronic mail include:

- The ability to forward messages to another user or group of users. (Mail systems forward messages from sender to recipient, and they permit the recipient to forward a message to other users. To forward a message from another user, it is necessary to begin another message and then to insert the message to be forwarded.

- Text files may be included in a mail message.

- A mailing list can be used to send a single message to a number of people. The alias command can be used to refer to a group so a terse address sends the message to people whose names appear in a separate file.

- Messages and replies can be stored in folders. (On certain commercial access providers, folders may not be supported. Messages can be stored in an undifferentiated workspace or temporary filing area. Check the fees associated with use of these temporary storage areas.)

- A person can send binary data in ASCII. An executable file can be sent via electronic mail if it is first processed with a program that converts the higher order ASCII characters in binary files to flat ASCII. Once the file appears in the mailbox, it is identified as a un-encoded file. To restore the ASCII file to its binary format, a program called *undecode* restores the file to its original format. Another program that handles this conversion is *BinHex*.

- Certain servers permit files to be transferred via electronic mail. There are several techniques available to users.

The point is that electronic mail on the Internet is robust and capable of transmitting from point to point a wide range of information objects.

Every system connected to the Internet supports some type of electronic mail or message passing system. The basic premise of the Internet's mail system (SMTP or Simple Mail Transfer Protocol) is that machines on the Internet are always ready to receive mail. When one host has mail to deliver, it contacts the destination host using SMTP and transfers the message.

Hosts have one or more programs running in the background to handle the mail functions. This *daemon* is usually named *smail* or *send mail.* The program handles all of the housekeeping tasks associated with moving messages, storing them until the destination machine is online, and notifying a person when new mail has been received.

The UNIX-to-UNIX copy program (UUCP) handles the Internet mail. It works on a relatively straightforward addressing scheme. The syntax is the person's name or *handle* and his domain; for example, *s_arnold@delphi.com*, but there are several problems associated with this naming scheme.

Some hosts are running out of address space. The reasons for this are rooted in the structure of the naming scheme itself. A committee is working to develop more robust naming schemes. In the meantime, when hosts run out of address space, it may be necessary to seek another host with address space. (For commercial entities adopting the Internet, the limitations of address space can pose a problem if there are large numbers of employees, all of whom receive Internet addresses. One way around the problem is to add another host, but the cost of this is prohibitive for many organisations).

Trade publications tout the benefits of the X.400 and X.500 addressing and naming conventions. These standards provide one way around the limitations of the Internet's approach. However, these standards are beginning to gain momentum. The X.500 standard, often referred to as the directory model, allows a user to search for an address by typing a person's name. The X.500 standard is not widely

supported at this time. The ideal of a single, current, accurate listing of electronic mail addresses is the focus of the X.500 standard as well as the efforts of American Telephone & Telegraph Co., British Telecom and MCI, and dozens of other organisations throughout the world. Addressing remains one of the most trouble-some aspects of electronic mail.

Finding the address of a person on the Internet is difficult. Specialised programs like *finger* will search a server's list of users and return the person's address via electronic mail. However, the syntax for finger must be expressed precisely.

There are two usually fool-proof ways to get an address:

- Telephone the person and ask for the electronic mail address.

- Ask the person to send you electronic mail.

Of these two approaches, the header information on the electronic mail message is the most accurate and reliable. However, some systems — notably CompuServe — may not be able to send messages to certain hosts; for example, the University of Regina's host cannot be reached from CompuServe.

1.1 LISTSERV

The LISTSERV software performs a number of functions. Among the most important, the LISTSERV software tool can process requests for information sent via electronic mail automatically. For example, a user can request that he or she be added to a specific mailing list by sending an electronic mail message. The LISTSERV software processes this request, extracts the sender's electronic mail address, and automatically adds the individual to the mailing list specified. Auto-mation of LISTSERV is a widely used and routine function on the Internet. Companies such as Clarinet use this core functionality to provide filtering tools. These tools route selected information to users for a fee.

More commercial organisations want to link their internal electronic mail systems to the Internet. Computer systems managers face a potentially bewildering number of choices about hardware, software and Internet service providers. Vendors of corporate electronic mail software -for example, Lotus's Notes and Office Suite Products — provide a graphical interface for information stored on the server to which the user's workstation or personal computer is connected. A gateway or a direct connection to the Internet is required between the corporation and the Internet in order to pass messages directly. If the corporation deals with a third-party provider, the user or the corporation's server can log on to the third party's machine and download mail. Once the mail is on the corporation's server, the user can access the electronic mail from Notes or some other commercial electronic mail package.

Although electronic mail seems ubiquitous, it is not as simple as one might presume. It is a pivotal service upon which many activities turn. Without electronic mail, the Internet would not exist in its present form, nor would it have the compelling grip on the imaginations of entrepreneurs it now enjoys.

Specialised mailing software such as that published by Computer Witchcraft in Louisville, Kentucky, allows the user to handle most mailing functions within a Windows environment. Online time is sharply reduced because the software automatically messages and logs off. According to Michael Tague, President of Computer Witchcraft: "Electronic mail is the major Internet application for most users."

Electronic mail on the Internet has its own set of conventions. In addition to the system specific addresses, users of Internet mail make use of:

- *Acronyms.* These are often cryptic and have become a way of reducing the number of keystrokes required to convey a frequently-used phrase. Representative examples are IMHO for 'in my humble opinion', or BTW for 'by the way'.

- *Smileys.* These are devices created from the standard ASCII keyboard. They are intended to convey a particular type of sentiment or inflexion to the otherwise bland electronic message. Representative examples are a happy face :-) or a wry comment face ;-) to show that a remark is offered in jest.

- *Etiquette.* It is considered bad form to market products and services directly, particularly using mass electronic mailings. Most topics attract several dozen to several thousand participants. An electronic message can be sent to these individuals with a few keystrokes. Breaches of etiquette may be handled by silence; that is, others do not respond to a message. In certain instances, individuals may notify other people about a breach of etiquette. Strongly worded messages about another's messages is described as *flaming.* System operators may block an individual's access to a particular service or host.

Among the challenges in electronic messaging are privacy, security and locating addresses.

One characteristic of Internet's electronic mail is that it can easily be forwarded to one or more people. In fact, once an electronic message has been sent to an individual, the sender has no control over the ultimate disposition of the message. One might argue that paper or facsimile mail is subject to the same lack of control. Electronic mail, because it can be sent to one or 1,000 with a few keystrokes, poses a different type of risk.

To minimise this risk, a person may wish to:

- Encrypt the message. The recipient may, of course, send the unencrypted message to others.

- Check the content, style and tone of the message. Electronic mail conveys essential facts well. It does not handle nuances or shades of meaning as well as other types of communication.

- Formulate messages offline. Responding in real time does not facilitate careful editing or rewriting.

Electronic mail may consist of a standard message in ASCII or a message consisting of a binary file. A person may send the equivalent of a letter or memorandum, a computer program or some other object, or a combination of a message and an attachment. Multipurpose Internet Mail Extensions (MIME) has increased the capabilities of ASCII-text messaging. With the MIME extensions, the basic electronic mail facility can go far beyond transferring binary data and messages. With sufficient network capacity, the basic electronic mail functionality can move objects that, when decompressed, can yield sound, real time video and multimedia messaging.

MIME messages are identified in the header of the mail message. However, these enriched mail messages require processing once they are received. In contrast, an ASCII-text mail message may be read online. (Many files are transferred in a compressed format that makes the file smaller and reduces the amount of storage space required and the time necessary for transmitting the file. A compressed file must be processed on the user's workstation or personal computer. A wide range of compression techniques are used. The recipient of a compressed binary file must have the software to decompress the file.)

1.2 USENET

Usenet is a collection of news groups. It is a set of guidelines for maintaining and passing messages in news groups on thousands of different subjects. The usual categories are:

- *comp.* Computer science
- *news.* News about news
- *rec.* Hobbies and various pastimes
- *sci.* Science and engineering
- *soc.* Social science and social issues
- *talk.* Controversial subjects
- *misc.* Any other subjects.

In addition, alternative news group hierarchies exist. These alternative groups include *alt.* for unusual world views, *bionet* for biologists, *biz* discussions of business issues, *ieee* for discussions overseen by the electrical engineering institute, and numerous others.

For people who obtain mail from mailing lists or listservs, USENET readers provide access to these messages outside of the electronic mail system. USENET browsers allow the user to examine information from listservs more quickly than electronic mail's functions.

It is difficult to differentiate mail functionality from other Internet software tools. In fact, there are three broad categories of software tools that share some of the functions associated with electronic mail. They are:

- Commands or programs native to the system a person uses; for example, once a connection to an Internet server is established, the File Transfer Protocol (ftp) retrieves the file. If a person is accessing the Internet from a computer using the UNIX operating system, a complete suite of utilities is available. These are comparable to commands that copy, rename and delete files.

- Interface software created by individuals or companies to minimise the user's need for system specific commands. There are two main approaches to providing interfaces, and they are often blended. One is the use of a graphical interface such as Windows, Motif or the Macintosh. The other is a text-based systems of menus such as those implemented by Delphi. The user selects a specific action from the menu.

- Agent software automates to some degree the processes of formulating, retrieving and displaying the information that the user desires. AT&T's licensing of Lotus Notes and signing an integration deal with Novell is an indication of seamless access to Internet mail from any company with a telephone line, a network and a computer.

Many software tools are available to perform such housekeeping functions as formatting text with line breaks, using text prepared in an editing workspace, and similar tasks.

Other refinements are coming to market to automate certain routine functions such as processing and filtering messages.

2. Moving data: ftp and telnet

The communications functions of the Internet often capture user's attention first. Electronic mail wires the user into a virtual community and an enormous volume of **textual** information. Electronic mail, the fora and the news groups, bind a large percentage of Internet users into a loose confederation in cyberspace. But electronic mail is one aspect of a large, complex, rapidly evolving environment. Electronic mail is a means of communication.

The Internet has been a source of innovative software for decades. The early adopters of the Internet were those with knowledge of the UNIX operating system and a knack for programming. Thus, it is not surprising that software is an important component of the Internet environment. Many user-created programs make the system work. In a sense, the Internet is a software construct first, and a hardware construct second. The complexity of the system provides an almost ideal environment for new programs, different approaches and fresh techniques to be developed, displayed and disseminated. Thus, the Internet is more than a source of information; it is a source of innovation.

Two software tools enable Internet users to have significant control over the Internet's immense computing resources. The ability to download files using *ftp* or file transfer protocol, and the ability to use a remote computer as if it were on one's desk via the *telnet* functionality, merit closer examination for several reasons:

- These two tools give the individual considerable power over the system. As difficult as the Internet is to learn, the effort is repaid because an individual can access almost any resource on the Internet as if it were on his desktop.

- Technical information and computing resources lie at the core of the Internet tradition. When computing resources were in short supply, open access was simply the easiest way to facilitate learning, trouble shooting and experimenting.

- The system architecture was structured to allow harried computer engineers and systems managers to provide remote computing services without having to process each task manually. Automation of routine activities such as processing requests for downloads or queuing data for a specialised computer or software program to process, has been for decades a fundamental tenet.

One of the observable outcomes of these three factors has been the strong, cultural commitment to giving the individual with access to the Internet the tools necessary to achieve computing objectives with a minimum of administrative guidance. Contrast this approach to the procedures put in place by the commercial online services. A user of Dialog Information Services, STN, and most commercial text-oriented online services, pays for the privilege of looking for information that *may* not be *on* the *system.* These are the time charges levied for each search or for the number of minutes spent browsing for potentially useful information. Once the information has been located, the user often also pays per information block retrieved. The charging mechanisms vary, but the intent is the same: generate revenue for the commercial online service.

The Internet historically has required the user to go through most of the steps associated with signing up for a commercial online service, but with one important difference: a large amount of information is available for low or no cost. Until the push for commercialisation of the Internet, most users paid little or nothing for access. Fees for access through an intermediary are significantly lower than for many of the business-oriented online services. The Internet's 'software' empowers the individual and encourages a different approach to the online process. Software makes the Internet a place, an electronic community, which has evolved into a new communications medium.

2. I *ftp* (File Transfer Protocol)

A decade before Ward Christenson, a computer expert in Illinois created the first personal computer-based online system — usually referred to as a *bulletin board system* or a BBS — users of ARPANET and Internet were downloading programs, source code and technical information.

The File Transfer Protocol, commonly abbreviated to *ftp*, provides a user with an interactive tool for copying files from a remote system to a local computer. There is no accurate estimate of the total number of programs available from the ftp sites on the Internet. A number of commercial CD-ROM products have been published.

Their contents, such as the UNIX source code and executable disc from Walnut Creek CD-ROM, Inc., are drawn from a single ftp site. A single large bulletin board system such as Rusty and Edie's may house several thousand files. Tens of thousands of files are available via ftp.

The concept of freeware and shareware originated on the Internet. Shareware is software that may be used for a period of time without charge. The person who finds the software valuable pays the fee set by the author. Upon registration, the author of the shareware usually sends the customer a printed user manual, the current version of the program, and adds the customer's name to a list of people who are notified of upgrades to the product. Shareware assumes that the majority of people using software recognise its value and will pay the author. The Association of Shareware Professionals (US) provides a catalogue of products written by its members. This catalogue is available at many ftp archives sites and on consumer online services.

UNIX users have had to rely upon one another for technical tricks, information about bugs and techniques of solving problems peculiar to one of the many versions of UNIX. Reliance upon the communications resources and archives of programs was often the only way to solve certain technical problems.

Many Internet sites allow users to access the archives stored at that site. Providing access to repositories of software gave people a way to tap useful information without having to make a telephone call, write a letter or pore through volumes of printed documentation. The archives were set up so that users could access them without having to interact with the system manager of the site. To gain access to an archive, a user enters *anonymous* at the log-in prompt of the remote system.

The premise of commercial online operations was somewhat different. The customer had to interact with the online service before access to the information would be granted. Monthly billing required a specific name and address. Internet users accustomed to the open access of archives and the ftp tool, chaff under what to them seem to be fundamental changes in the way electronic information should work.

What type of software is available from archive sites? A wide range of computer platforms, operating systems and application programs is supported. One of the rapidly growing applications software areas is Windows 3.x programs. UNIX software is available in abundance. There are also extensive files for Macintosh, OS/2, Amigas and for most computer types.

Effective use of ftp requires some knowledge of UNIX. The UNIX directory listing is similar to that of MS-DOS, Windows and the Macintosh. The user must navigate to the directory containing files pertinent to the operating system or subject area of interest. UNIX commands are needed to browse the directory. Retrieving files requires knowledge of basic file transfer protocols and the syntax they require.

Once a file has been downloaded, the user often has to process the file before it can be used on his machine. Most software and much technical information is compressed. Compression reduces the size of the file. A variety of compression schemes

are available for each computer platform. At this time, working with ftp requires that the user know how to decompress files for particular platforms.

Despite the apparent complexity of ftp, the benefits are significant:

- The 'cost' of the shareware or freeware is reasonable even when the user pays for telecommunications (Freeware is software for which the author does not expect any payment. Many utilities that solve a particular problem with a program or operating system are made available as freeware for the benefit of the computer-using community. Freeware may be found on ftp archives, commercial online services and bulletin board systems.)

- Internet archives gather files from other sites, pooling them for the convenience of the user. Although duplicate files often appear under different file names, the large number of files and the number of new files entering the archive usually guarantee that something of value can be located

- The combination of source code and executable programs often provides ideas for solving specific problems. As a source of ideas, ftp archives are almost unparalleled as an information resource.

Weighed against these benefits, ftp is an important tool for the Internet user.

2.2 Telnet

Telnet is the Internet function that lets a user use a remote computer as though it were on his desk. A user in Chicago, Illinois, can issue a simple command and use a computer connected to the Internet wherever it may be.

A telnet connection is the father of today's distributed computing environments. Once a user has been granted access to the remote computer, its resources are available to that user. Security is the responsibility of the remote system's manager. From a workstation or personal computer with a direct connection to the Internet, issuing the command *telnet* and the address of the remote computer is all that is needed to establish a connection.

Users must have a working knowledge of the idiosyncrasies of the telnet session; for example:

- Have the address of the remote computer
- Know what computer port on the remote system supports telnet [1]
- Know the terminal type supported by the remote system

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[1] A server is a software application that runs on a remote computer. A machine, therefore, may have many servers, and each server has a port assigned to it by the system manager. A port is simply an address that makes sure the packets routed to it arrive.

- Know what password to use, or be able to experiment until an accepted password is located *(guest, anonymous,* etc.)

These data are arcane and are sufficiently opaque to thwart most casual users. For a determined person who wants access to a particular collection of information or a machine's capability, telnet provides a powerful, reliable mechanism to satisfy the user's need.

Many telnet connections allow the user to browse the information on the server through a series of menus. The user selects a category of interest and examines the data catalogued in that category. Telnet connections support direct commands so that the user can navigate directories, run programs and instruct the system to copy or download data to the folder or location the user specifies.

A session on Dow Jones/News Retrieval or any other online service is in many ways like a telnet session. The difference is that Dow Jones, Questel, or any other commercial service, restricts the user to the information available on that service's computers. If the user wants to jump to another service — for example, Dialog Information Services or the European Space Agency's databases -the user must log off Dow Jones. In many cases, the user must issue a specific command to link to the next system, log on and explore that system. In some cases, a user will have to disconnect and dial another telephone number.

A telnet user can telnet to other telnet sites from a single connection. There are practical limits to how many different telnet sites one can jump to in a single session; the user, for example, must know what type of terminal each remote system supports, and how to terminate sessions on each remote system. There are tricks that telnet wizards use, such as redefining the escape key sequence for each session so that graceful backtracking can be accomplished. But the critical fact is that a telnet session allows a user a wide range of action. The commercial online systems, in contrast, are confining, and they carry a comparatively larger price.

Newcomers to the Internet are struck by the strong feelings that surface on many fora about the culture and community of the Internet. These are real phenomena to be sure, but the emotions spring from a desire to maintain the freedom of access that telnet provides. Many users find the discussion groups, the software retrieval tools and the popularity of the Internet, sufficiently strong factors to support the status quo. The culture of the Internet, however, is rooted in the ability of the individual to interact with a large number of computers. The limits of the freedom are defined by one's ability to learn the system, not by economic factors.

3. Triggering innovation

Mail, ftp and telnet have been the triggers for much Internet software innovation. The reasons include:

- The heaviest users of the ftp and telnet services are among the most skilled computer users on the Internet. Knowledge of UNIX and the C programming language equip these individuals to create programs that let them locate and retrieve information more easily and efficiently. The

complexity of the UNIX environment has contributed to a steady flow of programs, tools and procedures that have allowed the Internet to evolve more rapidly than commercial online services.

- The open environment of the Internet has stimulated an exchange of knowledge about the Internet, its systems and its resources. The lack of formal restrictions has allowed a continuous flow of shareware and freeware for more than two decades. Users have co-operated to provide an extraordinary number of programs to other users for no or low cost.

- The archive system operates with little or no human supervision. Although abuses occur, they are surprisingly infrequent. The majority of Internet users abide by the loose codes of conduct established by particular sites and archives. The risk, of course, is loss of the archive system.

3.1 Mosaic: the first commercial Internet application

The evolution of Internet software has been difficult to observe. With the attention the Internet has begun to generate, the pace and profile of Internet software development has risen sharply. This is most clearly illustrated by the emergence of Mosaic, a set of tools that permits a graphical interface to the World Wide Web.

Text and images are tagged using a scheme similar to SGML. This coded text is loaded on Web servers which allow the user to examine information and jump via hypertext links to related information stored on any other Web server.

The Mosaic tools allow the user to have access to WWW information in a robust graphical environment. Text appears in different fonts. Images are displayed in real time. Online help and automation (macros) tools are available at all times.

Mosaic has overshadowed text-based software to access WWW services. The Mosaic tools, developed at the University of Illinois' National Center for Super-computer Applications, is the engine used for such commercial services as O'Reilly & Associates' Global Network Navigator, and Meckler Media's Mecklerweb.

Unlike other Internet software innovations, Mosaic has a high profile. Despite the demands Mosaic places upon the personal computers and workstations running it, the Mosaic toolset leapfrogs commercial communications tools and points the direction for realtime access to compound documents, high resolution imaging and integrated full motion video delivered via the Internet or an Internet-type service.

The explosion of interest in Mosaic has drawn attention away from other Internet tools such as WAIS, a WWW browser that arrays data in a book metaphor with files, tables of content, sections and pages.

The direction of software development on the Internet is clear. The new tools are:

- easy to use
- graphical
- able to support text and graphics
- sufficiently flexible to support the automation of routine functions.

It is important to recognise the importance the freedom and self-regulating nature of the Internet has been to software innovation. Those who have become avid users absorb the etiquette of Internet. Many programmers write code to enhance a specific function of a particular aspect of a site. If this program does its job well, Internet users who discover this gem will spread the word via the Internet. News of a particularly useful program or a technical work spreads throughout the system rapidly. The Internet gives birth to and sustains its most effective software. This is one more example of how a complex environment becomes self-organising. The 'products' are able to compete in the commercial market despite their emergence from an online system, not a commercial product development operation.

As a result, the Internet viewed solely as an online system is both more complex and easier to use than most commercial services. This apparent contradiction underlines the challenge of using an immense distributed computer network of thousands of systems and the abundance of software designed to make the system accessible. Heuristic search engines, graphical user interfaces, filtering tools — each of these innovations is available and has been available on the Internet for years. Commercial services are just now coming to grips with natural language queries and client-server architectures.

If the software lets the user down, there is support. The communications infrastructure of the Internet itself provides almost instantaneous access to people who can answer a question, direct the user to a source of information or to system operators who can alter the system if warranted.

Against this backdrop, the Internet ranks as one of the historically significant sources of innovation in computing.

4. Outlook 2000

By the end of this decade, graphical access tools will be ubiquitous. Users will be able to take advantage of virtually all Internet resources without having to learn UNIX commands. By 2000, Internet users will have:

- Software agents that process, seek and present information without user intervention.

- Access to electronic documents that incorporate high-resolution images and full motion video.

- The ability to move seamlessly from public to private networks as required by the information task.