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Spinning the Web: The History and Infrastructure of the Internet

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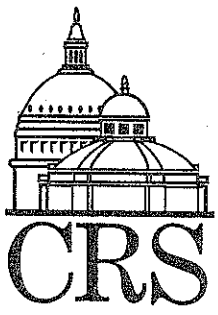

ABSTRACT

The Internet is an international, cooperative computer "network of networks" that links many users. This report discusses the Internet's organization (the nonprofit entities which develop standards and consensus) and infrastructure (how the networks connect), the history of the Internet, and proposals for the future: the Next Generation Internet (NGI) and Internet2 (I2).

There is a discussion of the types of the major applications on the Internet (e-mail, electronic discussion lists, the World Wide Web, and Java). The report gives statistics on the phenomenal growth of the Internet, and on the number of users worldwide and in the United States. Finally, selected useful Internet sites, books, and CRS reports are listed. For more detailed discussion of Internet-related policy issues, see CRS Report 98-67, *Internet: An Overview of Six Key Policy Issues Affecting Its Use and Growth*. This report will be updated periodically.

Spinning the Web:
The History and Infrastructure of the Internet

Summary

The Internet is an international, cooperative computer "network of networks" that links many types of users, such as governments, schools, libraries, corporations, hospitals, individuals, and others. No single organization owns, manages, or controls the Internet. However, the Internet is not free. The major costs of running the network are shared by its primary users: universities, national laboratories, high-tech corporations, and governments.

The original network, ARPANET, was created in the late 1960s. Its purpose was to allow defense contractors, universities, and Department of Defense (DOD) staff working on defense projects to communicate electronically and to share the computing resources of the few powerful, but geographically separate, computers of the time. In 1990, ARPANET ceased operation because NSFnet and various midlevel networks, sponsored by the National Science Foundation, made the Internet viable for commercial traffic. DOD continues to run a military network.

The last few years have seen dramatic expansion in Internet connections by corporations, governments, schools, and individuals. The Internet connects more than 43 million host computers in 247 countries.

The most powerful Internet application is the World Wide Web. With the appropriate browser software, a user can view images, listen to audio files, or see motion pictures.

While the Internet offers almost limitless possibilities for the free communication of ideas, research, and information, there are serious business and consumer issues concerning accessibility, cost, privacy, fraud, security, copyright, and standardization.

This report provides background information on the history, infrastructure, growth, and costs of the Internet.

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Spinning the Web:
The History and Infrastructure of the Internet

The Internet is an international, cooperative computer "network of networks" that links many types of users, such as governments, schools, libraries, corporations, hospitals, and individuals, among others. An immense amount of information is available on the Internet: speeches by world leaders; full texts of books, magazines, and newspaper articles; radio broadcasts; movies; medical fact sheets; electronic discussion groups; library catalogs; college courses; recipes; games; Supreme Court rulings; legislation; scientific papers; government documents; music lyrics; software; sports schedules; weather reports; résumés; satellite images; and much more.

This report provides background information on the history, growth, and costs of the Internet. In addition, it describes the applications available on the Internet (e-mail, telnet, and FTP) and some online tools for using the Internet—Gopher, Archie, Veronica, Jughead, Wide Area Information Servers, the World Wide Web, and Java.

Organization

No single organization owns, manages, or controls the Internet. It is a fusion of cooperative yet independent networks. Member networks may have presidents or CEOs, but there is no single authority for the Internet as a whole. Substantial influence over the Internet's future now resides with the Internet Society, which is a voluntary membership organization whose purpose is to promote global information exchange through Internet technology.

A number of non-profit groups keep the Internet working through their efforts at standards development and consensus building. They include the Internet Society, the Internet Engineering Task Force (IETF), and the Internet Architecture Board (IAB). A group of invited volunteers, the Internet Architecture Board, meets regularly to approve standards and write engineering rules, for example, on how to assign Internet addresses.[1]

Internet users express their opinions on how the Internet should operate to the IETF, a volunteer organization of 1,000 members, who meet three times a year to discuss operational and technical problems of the Internet. If a problem deserves special attention, the IETF sets up a working group to discuss it. The working group

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[1] CPSR One-Planet, One-Net Fact Sheet #3. *Who Runs the Internet?*, last updated May 3, 1998, at: [http://www.cpsr.org/onenet/whoruns.html] and *Internet Acronym Soup* at: [http://www.cpsr.org/onenet/acronym.html], last updated May 3, 1998.

eventually issues a report or recommendation, which can be either voluntarily accepted or sent to the IAB to be declared a standard.

Among the key technical standards the IETF is currently working on is the next generation of the Internet Protocol (IP), the foundation of the Internet. IP Version 6 (IPv6) will offer a variety of new services, such as enhanced security, automation of many administrative tasks, and expanding the capacity of network addresses.

The IETF began work on IPv6 out of concern that the Internet would eventually run out of unique addresses. Originally published in 1981, Ipv4 was designed to link a small number of research networks. IPv4 only allows addresses up to 12 digits, which equates to about 4 billion unique addresses. Ipv6 will provide the Internet with one billion-squared addresses, which should suffice for many years. On July 14, 1999, the Internet Assigned Numbers Authority (IANA) announced the worldwide deployment of IPv6, the next-generation numeric addressing system for the Internet.[2] Although there is already some demand for IPv6 addresses, full transition to the new system will take between 6 and 10 years. Currently there are no IPv6 routers or browsers, but there is a need for IPv6 addresses, so IPv6 routers and browsers will most likely be produced.

Standards that affect the Internet are also developed in other places, such as the Internet Engineering Steering Group (IESG), the Internet Architecture Board, the Asynchronous Transfer Mode (ATM) Forum, and the World Wide Web Consortium (W3C).

History

The existing Internet in the United States began as a program of the Defense Advanced Research Projects Agency (DARPA) in the Department of Defense (DOD). The Pentagon needed a military command and control system that would continue to operate in the event of nuclear war. In 1964, a researcher at the Rand Corporation named Paul Baran designed a computer-communications network that had no hub, no central switching station, and no governing authority. In this system, each message was cut into tiny strips and stuffed into "electronic envelopes," called packets, each marked with the address of the sender and the intended receiver. The packets were then released like confetti into the web of interconnected computers, where they were tossed back and forth over high-speed wires in the general direction of their destination and reassembled when they arrived. Baran's packet-switching network, as it came to be called, became the technological underpinning of the Internet.

The original network, ARPANET, was created in the late 1960s. Its purpose was to allow defense contractors, universities, and DOD staff working on defense projects to communicate electronically and to share the computing resources of the

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[2] For the text of the July 14, 1999, letter on the delegation of IPv6 address space see: [http://www.iana.org/ipv6-announcement.txt] and also, NASA's Ames Research Center *IPv6* at: [http://www.ipv6.nas.nasa.gov/].

few powerful, but geographically separate, computers of the time. In September 1969, a one-node packet-switched network was created at the University of California at Los Angeles (UCLA). Shortly thereafter four nodes were installed and operating effectively. The ARPANET grew rapidly. By 1977, it had 111 hosts. Since many universities and research facilities on the ARPANET later connected their local area networks to the ARPANET, it eventually became the core network of the ARPA Internet, an internetwork of many networks using the Transmission Control Protocol/Internet Protocol (TCP/IP) communication language as the underlying architecture. ARPANET was very important in the development of the Internet. In its time it was the largest, fastest, and most populated part of the Net.

In 1984, ARPANET was split into two networks: ARPANET and the Defense Data Network (DDN). DDN continues today as one of the Internet's component networks. (MILNET is the unclassified portion of DDN.) In 1990, ARPANET ceased operation because NSFNet and various mid-level networks, sponsored by the National Science Foundation, made the Internet viable for commercial traffic. The Department of Defense continues to run a military network.

In 1985, the National Science Foundation (NSF) funded several national supercomputer centers, with the intention of making these supercomputer centers available to the research community in universities across the country. Many state and regional universities had already developed local and regional networks, and some were TCP/IP based. The National Science Foundation funded a 56 kilobits per second (Kbps) network linking the five original supercomputer centers and offered to let any of the regional and university computer centers that could physically reach this network connect to it. This was the "seed" of the Internet network as we know it today, and the original reason to connect to it was for remote access to supercomputer facilities.

A number of universities linked to the NSF network (NSFnet) to gain access to the supercomputers. In addition to research, they found that the network was useful for electronic mail, computer file transfer, and newsgroups. The traffic on the network rose fairly dramatically. In November 1987, the National Science Foundation awarded a contract to Merit Network, Inc., in partnership with IBM, MCI, and the state of Michigan, to upgrade and operate the NSFnet backbone, the first level of connection to the Internet.

The purpose of the NSFnet backbone by this time was to link the growing "regional" networks created by various university systems. The term "the Internet" was beginning to be used in 1983 to describe the concept of interconnecting networks.

In May 1993, the National Science Foundation radically altered the architecture of the Internet, because the government wanted to get out of the backbone business. In its place, NSF designated a series of Network Access Points (NAPs), where private commercial backbone operators could "interconnect." In 1994, NSF announced that four NAPs would be built, in San Francisco, New York, Chicago, and Washington, D.C. The four NSF-awarded Network Access Points (NAPs), were provided by Ameritech, PacBell, Sprint, and MFS Datanet. An additional interconnection point, known as MAE-West, was provisioned by MFS Datanet on the West Coast.

On April 30, 1995, the NSFnet backbone was essentially shut down, and the NAP architecture became the Internet.[3]

The Internet's Infrastructure

For different computers on the Internet to connect with each other, they use protocols, which are rules or agreements on how to communicate. The language of Internet is TCP/IP, which stands for Transmission Control Protocol/Internet Protocol. Any computer seeking to communicate on the Internet must "speak" TCP/IP. This standard is an "open" standard, meaning it is not a proprietary product of any single company. The predominant operating system is UNIX, but the Internet standard has been adapted for use on the most commonly used systems, such as UNIX, PC, and Macintosh.

The Internet consists of interconnecting networks among universities, government agencies, the military, corporations, and other entities. These networks are connected to each other with equipment such as routers, bridges, and switches. Routers decide which direction to send network data by sending packets to the destination network and then "routing" the data to the proper destination computer, where the packets are reassembled. Bridges join together two segments of cabling within a network, while switches are devices that open or close circuits.

In the United States, the Internet has various components: local networks, mid-level networks, and the various national "backbone" networks.[4] Local networks are the local and wide area networks (LANs and WANs) within an organization. Examples of local area networks range from agency-wide computer systems to PC-based LANs. It is through a local network that most users access the Internet. Mid-level (regional) computer networks provide Internet access to large organizations such as universities and federal agencies in a given geographic area. There are about

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[3] Information on Internet history was taken from the following sources:
Hardy, Henry Edward. A Short History of the Net. November 17, 1998. [http://www.ocean.ic.net/ftp/doc/snethist.html]
Leiner, Barry M., et al. A Brief History of the Internet and Related Networks. *All About the Internet,* Internet Society, last revised February 20, 1998, at: [http://www.isoc.org/internet-history/brief.html].
Martin, Richard. Present at the Creation: An Oral History of the Dawn of the Internet. *PreText Magazine*, March 1998. [http://www.pretext.com/mar98/features/story1.htm]

[4] Much of the discussion of the Internet's infrastructure is explained clearly and thoroughly in *Internet Architecture,* by Jack Rickard, 1999 at: [http://boardwatch.internet.com/isp/summer99/internetarch.html].
See also: *Internet: "The Big Picture": What Are the Major Pieces of the Internet, and Who Are the Major Players in Each Segment?* by Russ Haynal, 1998, at: [http://navigators.com/internet_architecture.html].
See also: CRS Report 97-392, *Internet Technology.*

20 mid-level networks in the United States, for example, GTE Internetworking in the southeast, CERFnet in New York state, and BARRnet in the San Francisco area.[5]

The Internet backbone, now known as very-high-speed backbone network services (vBNS), is maintained by IBM Corp., MCI Communications, and Merit (a nonprofit organization owned by 11 public universities in Michigan).[6] At the four NAPs, anyone in theory can interconnect with the rest of the Internet. Examples of Network Access Points are WorldCom, Inc., MFS Datanet, Ameritech, SprintLink, PSI, MCI, GTE Internetworking, Netcom, UUnet Technologies, and others.[7] These service providers connect midlevel networks to each other and also offer services directly to customers in some areas of the country.

The second level of access is through a series of Metropolitan Area Exchanges (MAEs) connections in large metropolitan areas across the country. This is basically a fiber-optic data ring around a city which connects customers to a citywide network. There are MAEs in San Jose, Los Angeles, Dallas, Chicago, and two in Washington, D.C.

In addition, there are two Federal Internet Exchange (FIX) points, at the University of Maryland in College Park, and at NASA's Ames Research Center at Moffett Field, California. These exist to interconnect MILNET, NASA Science Net and some other federal government networks.

The third level of the Internet is regional network operators, such as CERFnet in San Diego, ioNET in metropolitan areas in the Midwest, ONENET in Oklahoma, and Brightnet in western states. Typically, they operate backbones within a state or among several adjoining states. They usually connect to one or several national backbone operators.

The fourth level of Internet access is the individual Internet Service Provider (ISP). These vary from small two- or three-person operations to those with thousands of customers. They do not operate a backbone or regional network of their own. Rather, they lease connections to a regional or national backbone. They generally operate an equipment room in a single telephone area code and offer dial-up and leased connections to consumers and businesses in their area.

The four levels of Internet connection are somewhat arbitrarily constructed, but basically functional in operation. There is a fair amount of cross-connection, however. For example, Sprint is a NAP, as well as one of the largest national backbone operators, and also provides consumer access nationwide.

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[5] For a map of the Network Access Points and regional network connections, see *Inter-regional Connectivity Under the New Internet Architecture* at:
[http://www.cerf.net/cerfnet/about/interconnects.html].

[6] Standard & Poor's Industry Surveys. *Computers: Consumer Services and the Internet*, March 25, 1999, p. 14.

[7] Information on the National Science Foundation's NSFNet transition is explained in *The NSF Networking Architecture of the Late 1990's*, Merit Network, Inc., at:
[http://www.merit.edu/nsf.architecture/.about.architecture.html].

Internet access is also provided via Internet Service Providers such as America Online, MCI, Sprint, MindSpring, AT&T, Netcom, EarthLink, Concentric, SpryNet, and Microsoft Network. As of March 1999, the number of ISPs totaled some 5,000, more than triple the 1,500 that existed in mid-1996.[8] Internet service providers purchase access to the Internet from the companies running the NAPs; they then provide access to their customers (consumers, businesses, and smaller ISPs). Most services offer a month's trial with a few free hours and a flat-rate price per month upon subscription. These services typically provide Internet/Web access, e-mail, chat rooms, games, news, reference sources, online publications, and technical support. There are more than 34.5 million worldwide subscribers to Internet Service Providers.[9]

Next Generation Internet and Internet2

In October 1996, President Clinton proposed the Next Generation Internet (NGI). This project is a plan to build a national network that connects universities and federal research organizations at rates 100 to 1,000 times faster than today's Internet.[10] (For a more detailed discussion of the Next Generation Internet, Internet2, and related initiatives, *see* CRS Report 97-521, *Next Generation Internet and Related Initiatives).* Seed money for development of the network will go to the Department of Defense, the Department of Energy, NASA, and the National Science Foundation.[11]

NGI is constructing a high performance distributed laboratory consisting of the 100 NGI sites at universities, federal research institutions, and other research partners at speeds in excess of 100 times that of today's Internet. This laboratory will be large enough to provide a full system, proof-of-concept testbed for hardware, software, protocols, security, and network management required by the commercial NGI. Second, NGI will develop ultrahigh-speed switching and transmission technologies and end-to-end network connectivity at more than one gigabit per second. Such networks will be pioneering networks limited to 10 NGI sites at speeds 1,000 times faster than today's Internet.

Many agencies and research universities are already working on related communications projects, including the less ambitious Internet2 project. The Internet2 project is slated to provide high-capacity communications links among the 100 top research universities that run the project. Many of these universities receive extensive government grants for technology research.

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[8] Standard & Poor's, *Computers*, p. 8.

[9] ISP Market. *Iconocast*. May 27, 1999.

[10] Information on NGI is available at: [http://www.ccic.gov/ngi/].

[11] CRS Report 97-521, *Next Generation Internet.*

Types of Applications Available on the Internet

The major applications of the Internet are electronic mail and the World Wide Web.

Electronic Mail and E-mail Discussion Lists

Electronic mail (e-mail) is used for two main purposes: person-to-person communication and participation in electronic discussion groups. A listserv is an organized system in which a group of people are sent messages pertaining to a particular topic. The messages can be articles, comments, or whatever is appropriate to that topic. There are more than 90,000 electronic mailing lists covering nearly every imaginable topic.[12]

Another popular use is the electronic journal, or e-journal, in which full-text issues of journals are available electronically to subscribers to e-mail lists. Other electronic magazines are available via file transfer protocol (FTP) or at World Wide Web home pages. For example, the *Journal of Computer-Mediated Communication* is available through its Web site at: [http://www.ascusc.org/jcmc/]. Some online journals are available only to paid subscribers, e.g., the *New England Journal of Medicine* at: [http://www.nejm.org/content/index.asp].

World Wide Web (WWW or "the Web")

The World Wide Web is currently the most powerful Internet search tool because as a hypertext information browser, it is a seamless integration of linked text, graphics, audio, and video. Hypertext allows a user viewing one document to jump to a related item in another document through hypertext links. With the appropriate software (such as Netscape, Internet Explorer, Opera, or Lynx), a user can view images, listen to audio files, or see motion pictures through the World Wide Web.

In 1990, the main architect of the Web, Tim Berners-Lee, a programmer employed at CERN, the European Particle Physics Institute in Geneva, Switzerland, collaborated with colleague Robert Caillau on a design document that explained hypertext as a way to link and access information. It described how documents would be interwoven in a network of links called a web. The 1990 document discussed notions fundamental to the Web as it is known today: the ability of links to cross computer or network boundaries; a simple common protocol for exchanging documents (Hypertext Transfer Protocol, or HTTP); a common document protocol for the suppliers and consumers of information (Hypertext Markup Language, or HTML); support for index searches; and the ability to view these documents with text or graphics browsers.[13]

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[12] A good guide to electronic discussion lists is available at Liszt, a mailing list directory at: [http://www.liszt.com].

[13] Wiggins, Richard W. Webolution: The Evolution of the Revolutionary World-Wide Web. *Internet World*, v. 6, April 1995. p. 35-38.

The most noteworthy Internet development in the last few years has been the expansion of the World Wide Web. In 1992, the Web was text-based and relatively unknown outside of academia, and used mainly by engineers, scientists, and computer hobbyists. In the spring of 1993, a software program called Mosaic was developed by a team of students at the University of Illinois/National Center for Supercomputing Applications. The Mosaic browser allowed users to view both text and graphics. This transition to a visual interface sparked rising interest in the Web. Marc Andreesen, one of the students who created Mosaic, cofounded Netscape, one of two dominant Web browsers (the other is Microsoft's Internet Explorer).

Java

Java, a programming language based on C++, launched by Sun Microsystems in May 1995, is a new technology that many technology specialists believe has yet to fulfill its promise. Programmers use Java to write mini-applications called "applets" that run inside Web browsers such as HotJava, Netscape Navigator, or Microsoft's Internet Explorer. Applets can perform any function—a spell checker, writing program, game, animation, etc.

Programmers use Java to write "platform-independent" software, instead of different versions for Windows, Mac, UNIX, etc. The applets also run on virtually any type of computer, from hand-held personal organizers to large mainframes. Instead of residing on a desktop computer hard disk like most programs, Java applets reside on network servers. Whenever a user needs to perform certain computing functions, such as opening a word processor, an applet is sent from the server to the desktop computer.[14] Since Java programs are maintained centrally on servers and can run on inexpensive, scaled-down computers, the new software has the potential to bring down the cost of maintaining desktop personal computers (PCs).

Although Java is often said to be aimed at replacing operating systems like Windows, this is true only in a very narrow sense. At least for now, Java is not an operating system and cannot perform traditional system functions such as sending characters to a screen, documents to a printer, or files to a hard drive. Its appeal lies in its value as a "platform" upon which programmers can build their code.

Other Applications

In addition to the World Wide Web and Java, the Internet supports other online tools to help find and retrieve information: Telnet, FTP, Gopher, Archie, Veronica, Jughead, Wide Area Information Servers (WAIS), and search engines:

- Telnet—Telnet allows Internet-connected computers to contact and search other computers. Once a connection is established with a remote computer, via telephone lines and a modem, users can search that remote system as if their computer were a hard-wired terminal of that computer. An Internet user

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[14] For information on Java, see the Java FAQ Archives at: [http://www-net.com/java/faq/]. and PC Webopedia entry at: [http://www.pcwebopedia.com/Java.htm].

can connect to a computer on the other side of the world as easily as he or she can connect to one in the next building.

- FTP (File Transfer Protocol)—The FTP command allows an Internet-connected computer to contact another computer; log on anonymously; retrieve texts, graphics, audio, or computer program files; and transfer desired files back to itself.

- Gopher—This software program, developed at the University of Minnesota, organizes information into a series of menus. Using Gopher is like browsing a table of contents: a user crawls through a set of "nested" menus to zero in on a specific subject. There are more than 2,000 Gopher servers on the Internet, some dealing with very narrow topics and others more broadly based.

- Archie—Archie helps find files available at FTP hosts. When searching for a particular term, Archie searches the database and displays the name of each FTP host that has that file or directory and the exact path to that directory.

- Veronica and Jughead—Veronica is an indexer that can query every Gopher on the Gopher system to search for a key word or phrase in a menu title and give the address of all menus with those key words. Jughead works like Veronica but usually restricts its search to a single Gopher on a local campus. It provides a menu-item search of the files located on a local Gopher server.

- WAIS (Wide Area Information Servers)—WAIS is in important respects a more powerful retrieval tool than Gopher, because it actually searches the full text of a document to look for key words. WAIS accepts plain-English queries, which makes it easier to use than Boolean logic. There are more than 250 WAIS libraries on the Internet. However, since the information is maintained by volunteers, usually in academia, subject material tends to favor research and the computer sciences.

- Internet search engines—Search engines such as Hotbot, Northern Light, Yahoo, AltaVista, InfoSeek, and Excite collect and index Internet resources automatically. These software agents roam Internet sites (mostly World Wide Web, Gopher, and FTP sites), search them, and create databases from them that can be searched to provide requested information to the user.

Growth

The Internet connects more than 43 million host computers in 247 countries.[15] The Internet is now growing at a rate of about 40% to 50% annually, according to the latest data from the Internet Domain Survey, the longest-running survey of Internet hosts (machines physically connected to the Internet.) Such exponential growth has

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[15] International E-mail Accessibility Based on International Standard ISO 3166 Codes. This document is a guide to country codes, showing which countries have access to the Internet or general email services. Released June 1, 1999 at: [http://www.nsrc.org/codes/].

led to the expansion of the Internet from 562 connected host computers in 1983 to 43.2 million computers in January 1999.[16] At any time from 1983 through 1996, half of the Internet's historical growth had occurred in the preceding 12 to 14 months.[17]

Another way to think about growth in Internet access is to compare it to other technologies from the past. It took 38 years for the telephone to penetrate 30% of U.S. households. Television took 17 years to become that available. Personal computers took 13 years. Once the Internet became popular because of the World Wide Web, it took less than 7 years to reach a 30% penetration level.[18]

Estimates for the number of people using the Internet differ greatly. The difficulty in measuring Internet usage is due to the fact that analysts use different survey methods and different definitions of "Internet access." In any event, the Internet keeps growing exponentially. Various research and consulting firms have estimated the number of U.S. users to be 31.3 million, 83 million, and 92 million in 1999. There are other estimates of 102 million in North America, to 179 million people worldwide.[19] These figures do not include military computers, which for security reasons are invisible to other users. Many hosts support multiple users, and hosts in some organizations support hundreds or thousands of users.

According to the Computer Industry Almanac Inc., the United States has an overwhelming lead in Internet users with over 50% of the total 150 million Internet users at the end of 1998; but, the United States is only ranked fifth in Internet users per capita. The Nordic countries (Iceland, Finland, Norway, and Sweden) are the leaders with 29% or more of the population being regular Internet users.[20]

More Americans than ever have access to telephones, computers, and the Internet. At the same time, however, according to the U.S. Department of Commerce's recent report, *Falling through the Net: Defining the Digital Divide*, there is still a significant "digital divide" separating American information "haves" and "have nots."[21] Indeed, in many instances, the digital divide has widened in the last year. As the Commerce Department report states, there is a persistant discrepancy between the information rich (who frequently include whites, Asians/Pacific Islanders,

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[16] Number of Internet Hosts. Network Wizards. January 1999 at: [http://www.nw.com/zone/host-count-history]

[17] Standard & Poor's, *Computers*, p. 6.

[18] *State of the Internet: USIC's Report on Use & Threats in 1999*. United States Internet Council, April 1999 at: [http://www.usic.org/usic_state_of_net99.htm].

[19] Headcount.com summarizes market research reports which estimate the size of the Internet worldwide (at the home page, choose the "region count" or "country count" buttons) at: [http://www.headcount.com/], and Nua Internet Surveys links to estimates of Internet users at: [http://www.nua.ie/surveys/how_many_online/index.html].

[20] Computer Industry Almanac Inc. press release, July 6, 1999, at: [http://www.c-i-a.com/199907ciaiu.htm].

[21] *Falling through the Net: Defining the Digital Divide.* National Telecommunications and Information Administration (NTIA), July 8, 1999, at: [http://www.ntia.doc.gov/ntiahome/fttn99/contents.html].

those with higher incomes, those more educated, and dual-parent households) and the information poor (many of whom are younger, with lower incomes and education levels, certain minorities, and those in rural areas or central cities).

Households with annual incomes of $75,000 and above are more than 20 times as likely to have Internet access as households at the lowest income levels. Households that identified themselves as being black and Hispanic are only 40% as likely as white households to be online. The differences cannot be explained by income alone. More than a third of white families earning between $15,000 and $35,000 per year owned computers, but only one in five black families at the same income level did.

Regardless of income, Americans living in rural areas are, in general, lagging behind in Internet access. Indeed, at the lowest income levels, those in urban areas are more than twice as likely to have Internet access than those earning the same income in rural areas. Community access centers, such as schools, libraries, and other public locations, play an important role. The 1998 data demonstrate that community access centers are particularly well used by those groups who lack access at home or at work. These same groups (which often include those with lower incomes and education levels, certain minorities, and the unemployed) are also using the Internet at higher rates to search for jobs or take courses.

Although the number of people using the Internet can only be estimated, the number of host computers can be counted fairly accurately. A host is a computer hooked to the Internet. The growth of Internet hosts is show below:

Year	**Number of Internet Hosts**
1969	4 hosts
04/1971	23 hosts
08/1981	213 hosts
08/1983	562 hosts
12/1987	28,174 hosts
07/1988	33,000 hosts
07/1989	130,000 hosts
10/1990	313,000 hosts
07/1991	535,000 hosts
07/1992	992,000 hosts
07/1993	1,776,000 hosts
07/1994	2,217,000 hosts
07/1995	6,642,000 hosts
01/1996	9,472,000 hosts
01/1997	17,753,266 hosts
01/1998	29,670,000 hosts
01/1999	43,230,000 hosts[22]

[22] Internet statistics are compiled by Mark Lottor of Network Wizards. The Internet Domain Survey attempts to discover every host on the Internet by doing a complete search of

(continued...)

Packet traffic, a measure of the amount of data flowing over the network, continues to increase exponentially. Traffic and capacity of the Internet grew at rates of about 100% per year in the early 1990s. There was then a brief period of explosive growth in 1995 and 1996. During those two years, traffic grew by a factor of about 100, which is about 1,000% a year. In 1997, it appears that traffic growth has slowed down to about 100% per year.[23] UUNet, an Internet access provider, estimates that Internet traffic is doubling every 100 days.[24]

Domain Names

Host computers are identified by their type of organization: commercial, government, educational, military, nonprofit, or network. The Internet's commercial domain (.com) has been the fastest-growing segment since 1995 and is now the largest domain. The nonprofit (.org) and network (.net) domains are the next largest segments.

In February 1997, the International Ad Hoc Committee (IAHC)[25] announced a proposal to add seven new generic Top Level Domains (GTLDS) in addition to the existing ones (.com, .net, .org, .edu, .mil, .gov) under which Internet users may register Internet names.[26] The new proposed domains and fields of use are:

.firm	for businesses or firms
.store	for businesses offering goods to purchase
.web	for entities emphasizing activities relating to the WWW
.arts	for entities emphasizing culture and entertainment
.rec	for entities emphasizing recreation/entertainment
.info	for entities providing information services
.nom	for those wishing individual or personal nomenclature

Previously, the National Science Foundation had been funding the administrative costs of registering the addresses, but it became increasingly burdened with these

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[22](...continued)
the Domain Name System (DNS). Survey results are available from Network Wizards at: [http://www.nw.com/zone/host-count-history]. Graphs are available from General Magic at: [http://www.genmagic.com/Internet/Trends/slide-3.html].

[23] *The Size and Growth Rate of the Internet*, First Monday, October 5, 1998, at: [http://www.firstmonday.dk/issues/issue3_10/coffman/index.html].

[24] *Framework for Global Electronic Commerce, Chapter Two: Building Out the Internet*, U.S. Department of Commerce, Secretariat for Electronic Commerce, updated April 16, 1998, at: [http://www.ecommerce.gov/chapter2.htm].

[25] Organizations naming members to the IAHC include: the Internet Society (ISOC), the Internet Assigned Numbers Authority (IANA), the Internet Architecture Board (IAB), the Federal Networking Council (FNC), the International Telecommunication Union (ITU), the International Trademark Association (INTA), and the World Intellectual Property Organization (WIPO).

[26] For information on the plan to add new top level domain names, see the Internet Society's press release at: [http://www.isoc.org/whatsnew/iahcreport.html].

costs. Since 1993, the vast majority of domain names have been assigned (registered) by a single registry, Network Solutions, Inc. (NSI), a Herndon, Virginia, consulting firm which is supported by cooperative agreements with the National Science Foundation. In 1995, NSI registered only 200 domain names per month. In July 1997, the volume reached more than 125,000 names per month.[27]

The National Science Foundation's cooperative agreement with Network Solutions, Inc., expired on October 7, 1998. The Administration issued a White Paper in June 1998 endorsing the creation of a new not-for-profit corporation of private sector Internet stakeholders to administer policy for the Internet name and address system. On November 25, 1998, the Department of Commerce (DOC) formally approved a new corporation, called the Internet Corporation for Assigned Names and Numbers (ICANN). Meanwhile, on October 6, 1998, DOC and NSI announced an extension of the cooperative agreement between the federal government and NSI through September 30, 2000. During this transition period, government obligations will be terminated as domain name system responsibilities are transferred to the private sector. For a further discussion of these issues, see CRS Report 97-868, *Internet Domain Names: Background and Policy Issues*.

For domain names with registration dates on or before March 31, 1998, the fee is $100 a year. For domain names with registration dates on or after April 1, 1998, the fee is $70 a year. There is a renewal fee for domain names with anniversary dates on or before March 31, 1998, of $50. For domain names with anniversary dates on or after April 1, 1998, the fee is $35. The fee applies only to businesses, organizations, and individuals who register domain names directly. The fee does not apply to the millions of Americans who get their Internet access indirectly through employers, commercial online or Internet services, schools, or other organizations. The government will continue to subsidize the cost of addresses for educational institutions and federal agencies, and the online service providers pay the fees on behalf of their subscribers.[28]

Who Pays for It?

The Internet is not free. Some of the networks are partially funded by certain government agencies, especially the National Science Foundation and other science agencies, for use by scientists, researchers, and the education community.

The major costs of running the network are shared by its primary users: universities, national laboratories, high-tech corporations, and governments. Each institution, organization, corporation, or individual with access to the Internet

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[27] Testimony of Gabriel Battista, CEO of Network Solutions, Inc., before the House Committee on Science, Subcommittee on Basic Research, September 25, 1997 at: [http://www.house.gov/science/battista_9-25.html].

[28] Information on the domain name registration fee is available from the InterNIC at: [http://www.networksolutions.com/announcements/fee-policy.html].

purchases that access through a Network Service Provider offering Internet access in its area.

Universities, agencies, and other institutions with direct connections via a mid-level network usually absorb the cost of Internet connections in their data processing budgets without charging the costs back to the end users. This is why many Internet users refer to Internet as being "free." In reality, however, direct connections usually require a one-time, up-front capital investment in hardware and software (usually $10,000-$20,000). The cost of the connection itself varies depending on its speed—from $20,000-$25,000 for a T1 connection (1.544 Mbps) to $70,000-$80,000 for a 10Mbps ethernet connection.[29] The mid-level network also may assess an annual membership and/or maintenance fee (from several hundred dollars on up). These costs are frequently absorbed by the computer or communications department and/or distributed evenly throughout an organization.

Individual users without the benefit of organizational access to the Internet must get their access from commercial Internet Service Providers (ISPs), such as Delphi, PSI, The WELL, Portal, Panix, and Netcom. Users need a computer and a modem and can gain access, usually through a local telephone call, to a terminal server (computer). The costs vary from $10 to several hundred dollars per month on a connect-time basis, but many commercial providers charge a flat-rate monthly fee. In addition, "free nets" have been established in an increasing number of cities for no-cost or low-cost public access to the Internet.[30]

Conclusion

Historically speaking, many major breakthroughs in technology have held out the promise of wondrous benefits for society, and have actually brought about unimagined and sometimes undesirable changes as well.

While the Internet offers almost limitless possibilities for the free communication of ideas, research, and information, there are serious business and consumer issues concerning accessibility, cost, privacy, fraud, security, copyright, and standardization.

The Internet has a long way to go if it is to achieve a goal of universal access at a reasonable price for all citizens. This is a daunting technical challenge and will require that very complex social and political questions be addressed as well. The Internet expands and diversifies every day, and planning and managing these changes is a challenge for the future.

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[29] Dennis, David H. The New Internet Provider FAQ. Last updated March 19, 1999, at: [http://www.amazing.com/isp/hooking-up.html].

[30] Information on free nets is available from: Organization for Community Networks, P.O. Box 32175, Euclid, OH 44132, and from their World Wide Web site at: [http://ocfn.org], and Center for Civic Networking, P.O. Box 53152, Washington, D.C. 20009, and from their World Wide Web site at: [http://www.civic.net:2401/ccn.html].

Further Reading

Hundreds of books and thousands of articles have been written that provide detailed instructions on using the Internet and analyzing its impact on society. Information on these materials can be obtained at a local public library or bookstore. The Internet itself provides the most current information on new developments in Internet technology. Below is a list of selected sites which may be particularly useful.

Internet Sites of Interest

Guides. Books, Journals, and Magazines about the Internet: A Library of Congress Internet Resource Page.
[http://lcweb.loc.gov/global/internet/inet-pubs.html]

The Help Web: A Guide to Getting Started on the Internet—a beginner's guide to the Internet, including e-mail, FTP, and the World Wide Web.
[http://www.imagescape.com/helpweb/welcome.html]

Scout Toolkit—a collection of quality resources, searching techniques, monthly articles, reference guides, Web tools, and Internet publications.
[http://scout.cs.wisc.edu/index.html/]

History. Hobbes' Internet Timeline.
[http://info.isoc.org/guest/zakon/Internet/History/HIT.html]

NetHistory: An Informal History of BITNET and the Internet.
[http://www.geocities.com/SiliconValley/2260/]

View from Internet Valley: Web and Net History.
[http://www.internetvalley.com/intval.html]

News.com—News about the Internet from Cnet, updated daily.
[http://www.news.com/]

TechWeb—Technology news from CMPNet, updated daily.
[http://www.techweb.com/]

Books

Baczewski, Philip, et al. *The Internet Unleashed.* 4th ed. Indianapolis, Sams.net Publishing, 1997. 1269 p. TK5105.875.I57 E46 1997

Hafner, Katie, and Matthew Lyon. *Where Wizards Stay up Late: The Origins of the Internet.* New York, Simon & Schuster, 1996. TK5105.875I57H338 1996

CRS Issue Briefs

CRS Issue Brief 95051, *The National Information Infrastructure: The Federal Role*, by Glenn McLoughlin

Selected CRS Reports

CRS Report 98-1015, *Internet: A Checklist of CRS Products*, by Bonnie Mangan.

CRS Report 98-67, *Internet: An Overview of Six Key Policy Issues Affecting Its Use and Growth*, by Marcia Smith, et. al.

CRS Report 97-868, *Internet Domain Names: Background and Policy Issues*, by Lennard G. Kruger.

CRS Report 97-392, *Internet Technology*, by Ivan P. Kaminow and Jane Bortnick Griffith.

CRS Report 97-521, *Next Generation Internet*, by Glenn J. McLoughlin.

CRS Report 97-556, *Point & Click: A Guide to Internet Search Engines and Searching Techniques*, by Rita Tehan.