■ SPECIAL ARTICLE

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The Internet

A Practical Guide for Anesthesiologists

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THE Internet is probably the largest revolution in the computer industry since the advent of the personal computer (PC) and is a valuable clinical tool for physicians and other health care personnel. It can be used to communicate with colleagues around the world, to obtain information (including practice guidelines, abstracts, and journal articles), and to arrange travel and meetings.[1] Although the technology on which the Internet is based was developed in the mid-1960s, it was not widely available until almost 1990, and access was primarily limited to universities, government agencies, or the computer industry. Until recently complex software and restricted access have required Internet users to have a sophisticated understanding of computers, networking, and programming. New technology has, however, made the Internet available to nearly anyone with access to a PC and a modem (a device that connects the PC to other computers over telephone lines).[2] Getting information on the Internet is now as easy as inserting a disk, clicking a "Setup" icon, and then pointing to a topic with a mouse (a small device that can be moved around a desktop to select an item). Sophisticated multimedia documents, including video, sounds, and pictures, and which cover every topic from fiberoptic intubation to the stock market, are accessible nearly anywhere in the world.[3,4]

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History

The Internet's history begins in the mid-1960s, during the Cold War, at which time the United States Department of Defense relied on a network of powerful supercomputers to control ballistic missiles and other weapons. It was determined that in the event of a war, it might be necessary to change this network rapidly or add new computers on short notice (*e.g.*, by parachuting computers into an area and connecting them by radio). As a result, the military, through the Defense Advanced Research Projects Agency (ARPA), began to investigate new simple and reliable ways to connect computers.[4]

The central assumption of this new technology was that physical connections were unreliable, *i.e.*, a connection could be lost at any time. To avoid this problem, each computer would keep a constantly updated list of its neighbors and would be able to find alternative pathways to a particular destination if a connection were severed. To provide reliable communication in this environment, two closely interacting protocols were developed: the "Internet Protocol" (IP), which moves small packets of information from one computer to another, and the "Transport Control Protocol" (TCP), which

breaks large blocks of data into small chunks and reassembles them on the other end. These intertwined protocols are commonly referred to as "TCP/IP." Sending a file across the Internet using TCP/IP can be compared with mailing a long letter, one page at a time. TCP separates the letter into individual pages, numbering each page; IP is the envelope that contains each page and gets it to its destination. TCP is not the only method of sending information across the Internet, but it is the most commonly used.[4]

Personnel at institutions connected to the ARPANet (the Department of Defense TCP/IP network) quickly learned that linking of computers could permit research reports, programs, data files, and other information to be shared nearly instantaneously with colleagues at remote locations. Subsequently other government agencies used the TCP/IP protocol to connect their computers. The National Science Foundation (NSF) created NSFNet, a TCP/IP network to link its five supercomputers and to provide remote users with access to its resources. The National Aeronautics and Space Administration (NASA) created the NASA Science Network.

By the early 1980s, the biggest impediment to growth of the Internet was bureaucracy. The US government set strict "appropriate use" policies that governed what information could be sent and how each network could be used. Administrators were encumbered by the regulations and by the careful record keeping that was required. To solve this problem, Congress passed a law combining ARPANet, NASA Science Net, and NSFNet into the National Research and Education Network, administered by the NSF. The Internet was born.

Researchers and scientists at universities and federal agencies, who soon discovered that TCP/IP networks were easy to connect and that they could expand without disrupting existing networks, were the initial users of the Internet. To promote widespread use of the new network, the NSF created policies that encouraged institutions to make access available to individual users. In 1993, commercial Internet service providers (ISPs) were allowed to sell access to the general public, and the number of Internet users increased rapidly. Shortly thereafter, the development of advanced Internet services, in particular the World Wide Web (WWW), greatly simplified use of the Internet and further increased the rate of growth. Nearly all of the Internet is currently privately funded and maintained by telecommunications and computer companies, educational institutions, and other organizations; the government now funds only those sections that it uses.

The Internet—Structure and Function

Computer Networks

A network is a group of computers that are connected so that information can be shared between them. A group of computers sharing a word processor or spreadsheet in an office and computers that retrieve laboratory results from a hospital nursing station are both examples of a network. Computers can be connected together using ordinary telephone wire, coaxial cable (like that used for cable television systems), or fiberoptic cable, which consists of thin glass strands that carry information using bursts of light. A computer network in an office or hospital is frequently called a "local area network" (LAN) because all of the computers are in the same floor or building. A "wide area network" (WAN), or "internetwork," is a group of LANs that have been connected by telephone wire, radio waves, or satellites.

The Internet is not a single network but rather a network of networks that spans the globe. There is no single cable or piece of equipment that one can point to and say, "This is the Internet." Each computer on the Internet is connected to an institutional network (a LAN) that is in turn connected to an ISP. The ISP connects the individual LAN to a regional network that may span a few square miles, an entire city, or a large part of the country. These larger regional networks are then interconnected to form even larger national or international networks. A piece of information travels from one computer to another by "hopping" from network to network until it reaches its final destination. This system is redundant because the individual sections are connected together at more than one point. Information can therefore automatically find new pathways to a specific destination if part of the network is not functioning properly. This allows TCP/IP networks to be expanded as needed without disrupting service; the Internet is never closed for construction.[5]

No single entity owns, maintains, or even plans the Internet. The United States government, through the NSF and other organizations, formerly funded the Internet. Many telecommunications companies, large and small, now work in cooperation with nonprofit organizations and volunteers to maintain the network. The ultimate authority for determining the future of the Internet belongs to the Internet Society (ISOC), a volunteer organization that promotes global Internet access and use. ISOC appoints another group of volunteers, the Internet Architecture Board, to approve new standards, allocate Internet addresses (a number that locates a spe-

cific computer on the network), and formulate long-range policies. ISOC also periodically appoints members to the Internet Engineering Task Force, which in turn creates "Working Groups" that solve specific short-term problems and handle technical issues. The only permanent entity that has been assigned a specific responsibility is Internic, a non-profit organization. Internic assigns network addresses and names, which must be controlled by one group so that every address is unique.

Many people believe that the Internet is "free." This is not true, although some schools and companies do not pass their costs on to employees or students. Academic institutions and corporations pay for their connection to a regional network; in the case of educational or non-profit institutions, part of this cost may be offset through federal subsidies. People can obtain an Internet connection for home use from either a commercial ISP such as MindSpring or AT&T or through an online service such as Prodigy or America Online, which provides Internet access as one of many features.

Client-Server Technology

Most Internet services, such as the WWW (see below), use client-server technology, a model that consists of two discrete pieces of software that work together to provide a flexible, powerful information retrieval system. The server program accepts requests for information and responds by sending data in a standard format that is independent of the type of computer. The server can be any computer on the Internet, from a small desktop computer to a mainframe that fills an entire room. The client program formulates requests for information based on user input and displays the results (*e.g.,* a document, picture, sound, and so on) on the user computer. Each document must be retrieved each time it is used; updates are therefore reflected immediately. Most WWW clients are easily customized by the user, who controls what typestyles will be used for headings and highlighted text and what helper application, or viewing program, will be used for a given file. This arrangement gives the designers of Internet resources a considerable amount of freedom because the document need not be designed for a specific computer.

Hostnames and Universal Resource Locators

Each computer connected to the Internet has a "hostname" that is assigned by the administrator of the local network. A hostname identifies a particular computer on the Internet, just as a street address identifies a particular house in a city. A hostname actually consists of several different names, divided by periods, or "dots," and usually reveals the institution at which the computer is located (or the Internet service provider through which the computer is connected to the network) and possibly the function or owner of the computer. For example, the name of the *GASNet* server (an Internet resource for anesthesiologists) is *gasnet.med.yale.edu.* Working from right to left, *edu* indicates that the computer is located in an educational institution; *yale* is the name of the institution. Each name to the left of *yale* has been assigned by the network administrator at Yale University. At this particular institution, all computers at the medical school have been placed in a "subnetwork" named *med.* The leftmost part, *gasnet,* is the name of the computer itself.

Universal resource locators (URLs) provide a system for identifying the name of each computer, each file of interest, and the exact method of retrieving the file. Developed primarily for the WWW, URLs are now commonly used to describe most resources on the Internet. URLs consists of three parts: a code identifying the transfer protocol to be used, the hostname of the computer being accessed, and the path and file to be retrieved. For example, *http://gasnet.med.yale.edu/index.html* is the URL for the anesthesiology section of the WWW Virtual Library (a list of hundreds of Internet resources for anesthesiologists). Working left to right, *http* indicates that the address is for the WWW (it actually stands for *hypertext transfer protocol;* other protocols, *ftp, telnet,* and *gopher,* will be described). A colon and two forward slashes always follow the protocol name. The next part is the name of the computer, in this case *gasnet.med.yale.edu.* The last part, *index.html,* is the name of the specific file to be retrieved. Sometimes the part after the hostname is empty, in which case a default (or index) file is usually returned.

Internet Services

The Internet by itself is of academic concern only to researchers in computer networking; it is the information contained within the Internet that makes it important for everyone else. Resources, including practice guidelines, lectures, weather reports, and online journals, are accessed with a variety of computer programs and are referred to collectively as *Internet services.*[6] Internet services can be divided into two broad classifications. "Basic services" are primarily text-based and were the first applications to be developed for the Inter-

net; they include a terminal program (telnet), the file transfer protocol (FTP), and electronic mail (e-mail). "Advanced services" include Gopher and the WWW and have existed for only a few years. They take advantage of the high-speed connections currently available, as well as the graphical user interface provided by Microsoft Windows (Redmond, WA), the Apple Macintosh (Apple Computers, Cupertino, CA), computer, and other operating systems. Even more sophisticated services, such as interactive documents, teleconferencing, and video on demand, are being introduced at a rapid pace.

Most Internet services use client–server technology, a model consisting of two discrete pieces of software that work together to provide a flexible, powerful information retrieval system. The server accepts requests for information and responds with data in a standard format, independent of the type of computer. The client program formulates requests based on user input and displays the results (*e.g.,* a document, picture, sound, and so on) on the user's computer. Each document must be retrieved each time it is used, allowing users to view the most recent version of an article. Most graphical client software is easily customized by the user, who controls what typestyles will be used for headings and highlighted text and what "helper application," or viewing program, will be used for a given file.

Electronic Mail

Electronic mail (e-mail; fig. 1) is probably the most frequently used Internet service.[6] For many people, e-mail is a primary method of exchanging messages, sending documents, or arranging meetings and appointments with someone in the next office or on another continent. Although e-mail was originally designed to transmit plain text messages, modern software allows word processing files, spreadsheets, and even pictures and sound to be sent. There are many e-mail programs available today, and although they differ in screen appearance, features, and the exact sequence of commands necessary to send a message, they share many common features.

Sending e-mail is relatively straightforward and in many ways resembles mailing a letter. The user types in a message, adds the recipient's address (see below) and "attachments" such as a picture or sound, and then clicks the "Send" button on the keyboard or with the mouse. When e-mail was designed, it was intended for short, plain text messages. As it became popular, however, users wanted to send other information such as formatted word processor documents, programs, sounds, and pictures. Because this information is represented differently, the information may need to be converted to a format that resembles plain text before it is mailed and then converted back to its original format on the receiving end. This conversion is usually done automatically by most e-mail programs, but older software may require the use of a pair of programs named uuencode and uudecode.

As with postal mail, the e-mail address of each recipient must be specified. E-mail addresses typically consist of two parts: the username and the hostname, which are separated by the @ (at) sign (*e.g.,* ruskin@gasnet.med.yale.edu). The user name refers to the user identification of the intended recipient, which is usually assigned by the system administrator. Some institutions such as universities and large companies maintain e-mail directories for their own employees. There are also several directories on the Internet (*e.g.,* Four 11, *http://www.four11.com*). If a person moves from one e-mail service to another, the location to which his or her e-mail address must be delivered will change. Many users, however, have one or more e-mail "aliases," which forward e-mail to another address.

The Internet contains many "mailhosts," whose responsibility is to store and forward e-mail to its destination. The e-mail format most commonly used on the Internet is the "simple mail transfer protocol" (SMTP), which defines how the mail messages are formatted and the mechanism by which the mail is delivered. Some e-mail software packages, such as Microsoft Mail, do not adhere to this standard, and proprietary software is required to use them on the Internet.

Mailing lists permit users to broadcast information to a few tens of subscribers or to thousands of subscribers. Mailing lists can consist of a simple list of e-mail addresses maintained by an individual or of a "list processor." A list processor is a program that maintains a database of e-mail addresses in a centralized location and automatically forwards any message addressed to the list to the individual subscribers. Mailing lists can be moderated (each message is approved by the list manager before distribution) or unmoderated (messages are forwarded automatically on receipt). Subscription to mailing lists may also be restricted to a specific group (*e.g.,* members of the American Society of Anesthesiologists [ASA]). The *GASNet* Anesthesiology Discussion Group currently has 2,200 subscribers; its members are located in countries around the world, and topics of discussion range from political developments to questions about patient care or research.[7] Many societies offer mailing lists to facilitate communication among their members

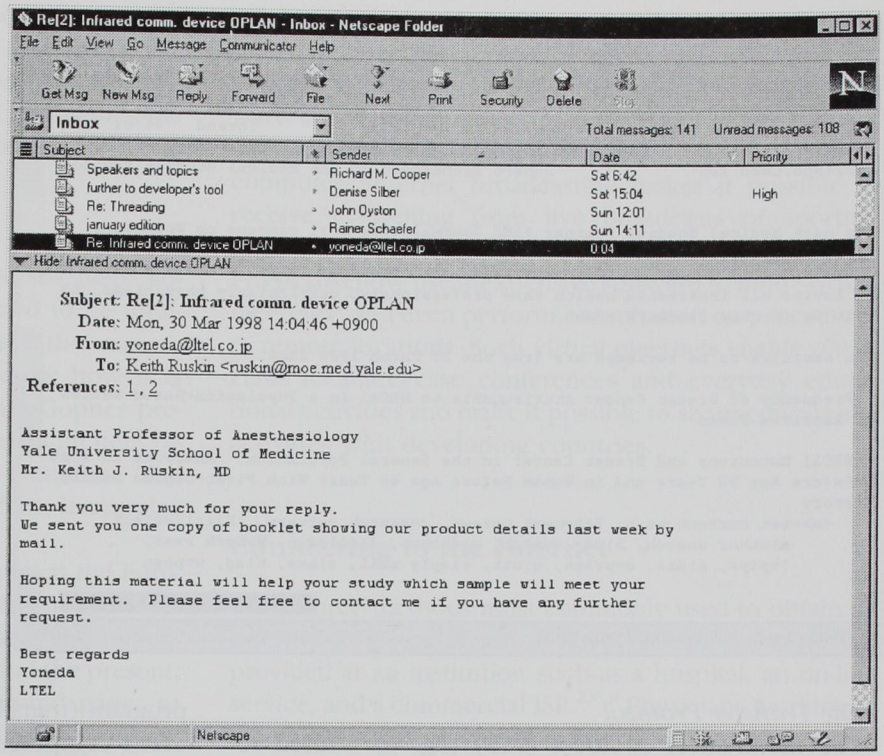

Fig. 1. Electronic mail. The mail program (in this case Netscape Navigator Mail) lists the subjects of all received messages in the upper right corner. The current message is at the bottom of the window.

or to broadcast news of important events. For example, the ASA uses a mailing list to keep its members informed of developing news.

USENET News

USENET News (fig. 2) resembles a bulletin board that contains information on thousands of categories covering many topics. It can be used for scientific research, to get information about a product or service, or to obtain help with computer hardware or software. Newsgroups can either be moderated, in which a person (moderator) reviews each message before distribution, or unmoderated, in which messages are transmitted without review. It is important to remember that most groups are not restricted—anybody can read and respond to any message sent to the list. It is often best to read the messages in a group before participating in a discussion to gain a sense of what is normally posted.

USENET postings resemble e-mail messages because they contain "from" and "subject" lines, but they are posted to the newsgroup instead of being addressed to an individual recipient. Many newsreaders resemble e-mail programs. Some examples of useful groups include the following.

alt.med.equipment: Medical equipment

comp.os.ms-windows.win95: Information about Windows 95

sci.engr.biomed: Biomedical engineering

bit.med.resp-care.world: Discussions about respiratory therapy

rec.food.restaurants: Where to eat at the next ASA meeting

Telnet

One of the earliest applications of the Internet was to connect remote computers together so that the keyboard and monitor of the client computer acted as if they were a terminal connected directly to the host computer. Telnet allows the user to access the host computer as if he or she were seated at a terminal that is directly connected to it. The most common uses for telnet include connecting to literature search databases and for receiving other, character-based information such as the weather. Telnet can also be used to retrieve e-mail from a mainframe computer. Figures 2 and 3 are examples of Telnet sessions.

Occasionally the instructions for a specific resource indicate a connection to a specific port, *e.g.*, for weather reports, telnet to downwind.sprl.umich.edu port 3000, or telnet://downwind.sprl.umich.edu:3000. This connection number tells the computer which program to run. Most resources that previously used telnet now use the WWW.

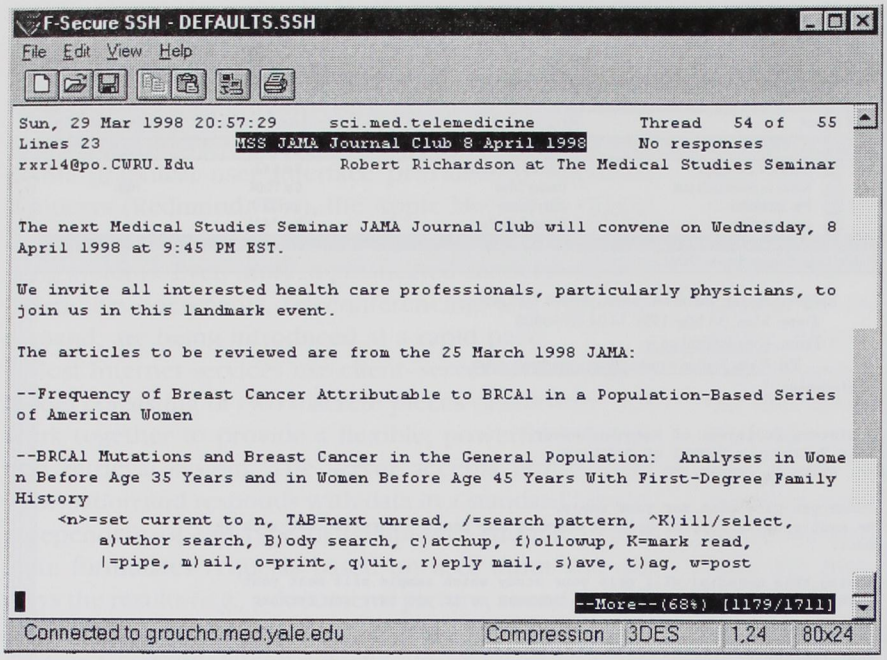

Fig. 2. A USENET News article.

File Transfer Protocol

The file transfer protocol (FTP) (fig. 3) is used to exchange files such as word processor documents, experimental data, or even computer programs over the Internet. FTP has also been supplanted to some extent by the WWW, which is much easier to use. FTP is still a convenient way for two people to exchange information and is also commonly used to obtain new software or updates. FTP might be used, for example, to download National Institutes of Health grant guidelines or a new program (transfer the information from a server to the user's computer) or to upload a completed grant application (transfer it from a local PC to another computer).

Nearly all computers require a user identification and password to allow access. Many computers, however, distribute publicly available files (*e.g.*, a new program or a video clip) using "anonymous FTP," which allows limited access to a computer to people without an account on that system. Anonymous FTP can be accessed by responding to a request for a username with the word

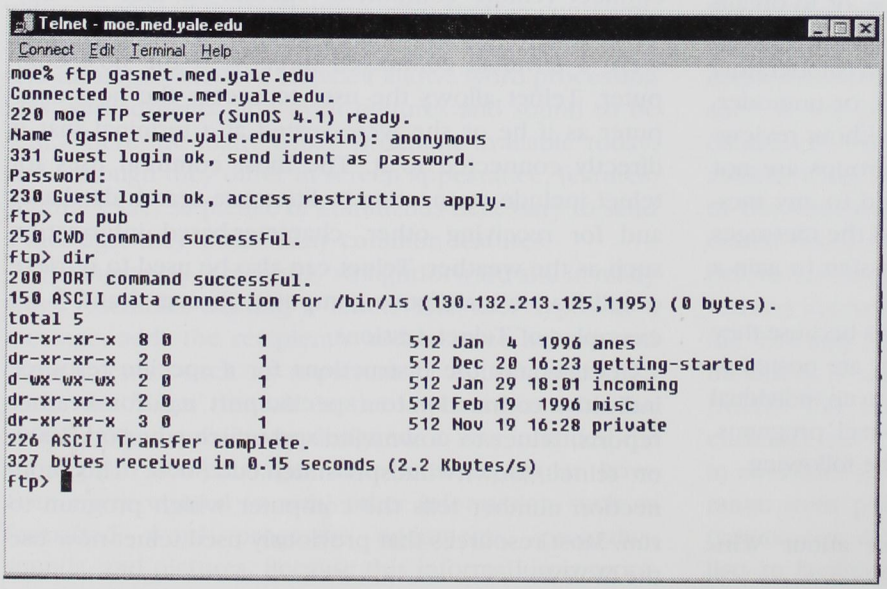

Fig. 3. An FTP Session. This user has connected to an anonymous FTP server and asked for a directory of files.

"anonymous." "Netiquette" (Internet etiquette) dictates that an e-mail address should be given as a password, even though none is required. Most anonymous FTP hosts allow files to be downloaded only, although some computers allow files to be uploaded to a single directory (frequently called "incoming").

Gopher and the World Wide Web

Gopher and the WWW are two of the so-called "advanced" Internet services and are designed to be intuitive and easy to use. Both systems allow the user to obtain information without having to know how it is stored or where it is located. The Internet Gopher presents a menu from which the user can select an item by clicking it with a mouse or by entering a number. The list can include text, pictures, or other files. It can also contain links to other gopher servers.

The WWW (fig. 4) was initially developed at the European Laboratory for Particle Physics (CERN) in 1992 as a method of publishing distributing abstracts and papers in the physical sciences.[8] Between 1992 and the present, its content has grown from a few thousand pages to more than 21 million pages of information.[9] The WWW client runs on the user's computer and presents information using an intuitive, graphical user interface that resembles a printed page in appearance and can include text, pictures, sounds, and video clips. Documents can contain highlighted references (hyperlinks) to information on the original computer or on any other Web server on the Internet; these are referred to as hypertext documents. When the user clicks on a highlighted word or phrase with a mouse, the new file is automatically loaded and displayed.

Hyperlinks provide easy access to the wealth of information on the Internet and have made the WWW the centerpiece of the information superhighway. They make it possible for a document to be retrieved without knowing its composition or even where it is physically located. Hyperlinks may be located anywhere in the document and are indicated by highlighted or underlined words that can be clicked on with the mouse to activate the linked document. Hypermedia documents (multimedia documents that contain hyperlinks) reside on thousands of WWW servers located around the world. A session on the WWW may take the user from the East Coast to West Coast in the United States or to Europe, Asia, or Australia all within a few seconds.[10] Many WWW clients can also access other Internet services such as Gopher, Telnet, FTP, and Usenet, allowing a single program to be used for most tasks.

Audio, Video, and Teleconferencing

Faster Internet connections and improved data compression techniques, combined with inexpensive hardware and software, make it possible to send real-time audio and video using only a desktop PC or Macintosh computer. Internet broadcasting makes it possible to receive everything from live broadcasts of sporting events to ASA safety videos over an ordinary modem. Physicians now use inexpensive software to hold "virtual meetings" and even perform consultation on procedures in remote locations. Such virtual meetings enable physicians to share case conferences and everyday educational activities and make it possible to share educational activities with developing countries.

Connecting to the Internet

The three methods most commonly used to obtain an Internet connection are a direct Internet connection provided at an institution such as a hospital, an on-line service, and a commercial ISP.[2,6,9] Physicians working in a hospital whose network is connected to the Internet may already have access at the hospital. Institutions may connect their computers in one of several ways. The most common method ("network topology") is called "Ethernet" and allows computers to communicate at the rate of 10 million or 100 million bits per second. If this method is used, it is necessary only to contact the institution's computer department (frequently called Information Technology, or IT) and ask to be connected to the Internet. A technician will install any necessary programs or accessories to connect the computer to the network. Because institutions usually purchase high-speed Internet service, a direct connection is usually very fast, even though it may be shared with many other users. In addition, an on-site person (or department) responsible for troubleshooting problems is usually present. The primary disadvantages are that Internet usage is limited to computers within the institution, and the institution may enforce local use policies or restrict access in other ways.

Access from the home or personal office is usually through "dial-up" telephone connections using a device called a *modem,* a term derived by combining the words *modulate* and *demodulate.* The modem connects a computer to an ordinary telephone line and transmits digital information by converting it into sound. Although a dedicated telephone line is not necessary for dial-up access, it is convenient. The primary advantage of using

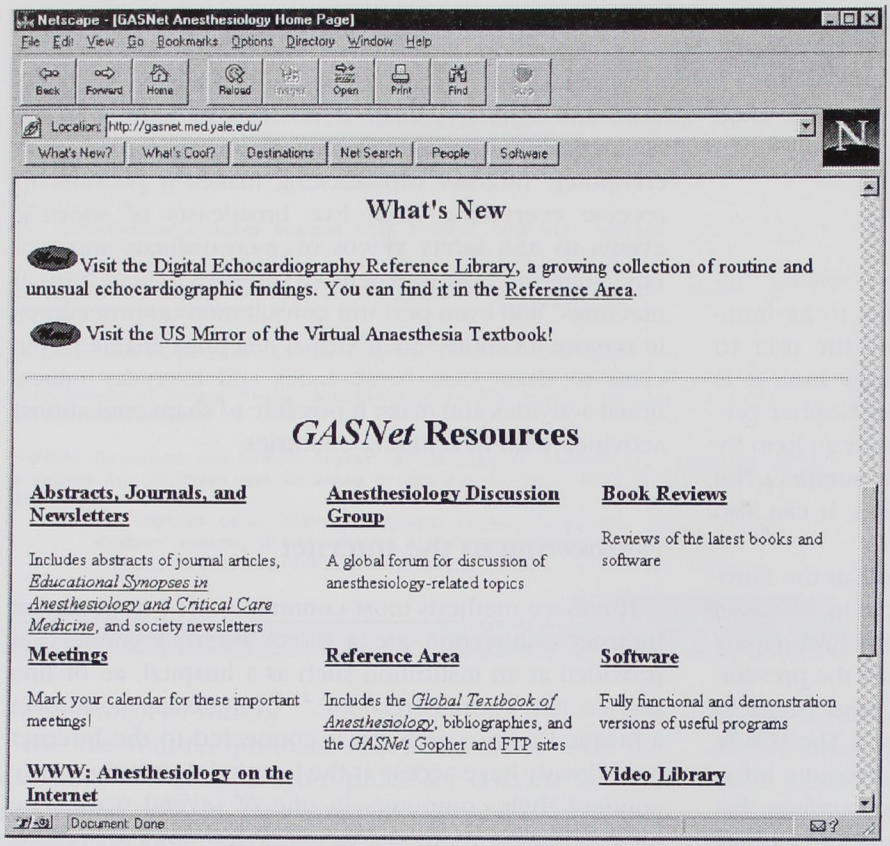

Fig. 4. A typical WWW page.

modems is that they are relatively inexpensive and easy to use. Other technologies that are currently available, and will probably soon be popular, include ISDN (a digital telephone service) and cable modems (which connect a computer to the Internet through the cable television network).

On-line services, such as America Online and Prodigy, provide an easy pathway to the Internet and offer access to the Internet as one of many features. They nearly always provide a "mailbox" for e-mail and sometimes provide network news. On-line services also provide other valuable services such as stock quotes, professional information (*e.g.,* Medline searching), travel and theater reservations, shop-at-home services, and more. In addition to these services, on-line services facilitate the set-up process and offer comprehensive customer support. All that is usually required is to insert a disk into the computer (frequently packaged with modems or included in direct mailings), click on an "Install" button, and provide billing information as requested. The software automatically configures the computer and establishes a connection. Disadvantages of on-line services include slow Internet access as a result of many users vying for the connection and, typically, a higher cost than ISPs. In addition, they are somewhat more restrictive, requiring the use of proprietary software and sometimes preventing access to some Internet resources.

The sole service of ISPs is to provide access to the Internet. Like on-line services, ISPs usually offer an e-mail box and network "news feed," but they do not provide services such as stock quotes or travel services (although they are available on the Internet). They may also have access numbers nationwide or in other countries. ISPs typically provide more flexibility than on-line services. Many institutions with Internet access provide dial-up access services similar to ISPs as a service to their employees or students. Modems and other computer equipment are frequently packaged with software and starter accounts for one or more ISPs. The advantages of using an ISP are that the cost is usually lower than that of on-line services and they frequently provide faster service (fewer users vying for the Internet connection). Their basic design allows use of any Internet software and few or no restrictions on what can be accessed. Internet service providers do, however, have some disadvantages: they are somewhat more complicated to set

up, and customer support may not be optimal. Potential customers of a particular ISP should inquire about the company's reputation for responsive customer service and fast, reliable access.

Internet Security

Many Internet users are concerned about the security of a computer connected to the Internet and security of information transmitted on the Internet. The Internet has grown from a small community of researchers to a huge metropolis that includes millions of users, and safety measures are only now starting to be considered. Because the Internet spans nearly every country in the world, many of which have different (and sometimes conflicting) privacy laws, legal remedies are frequently not feasible. Computer "hackers" represent only a small proportion of Internet users and are a minimal risk to most Internet users. A few simple precautions, combined with common sense, can minimize the risk of information theft or damage. It is important to remember that no computer is completely safe if it is connected to the Internet and that no information transmitted through the Internet is completely secure.[11]

Most desktop computer operating systems, including Windows 95, Windows NT, and MacOS, are capable of sharing files and resources (such as a printer) over a network. Network access to PCs should be allowed only when necessary and should be protected by a carefully chosen password. A password should ideally consist of a series of letters, numerals, and punctuation marks that can be easily remembered by the owner of the computer but difficult to guess by anyone else. Items such as birthdays, the name of a relative or a pet, or a social security number are not good choices. Passwords consisting of a single word are also easy to guess. Passwords should be given only to people well known to the owner of the resource and should never be sent by e-mail or posted on a WWW page.

Accessing information on the WWW may also place a PC at risk. Java and JavaScript are programming languages that allow a piece of software to be executed on a variety of different computers and can be automatically included as part of a WWW page. Extensions to Java may provide the remote server with access to the local computer's file system and allow a malicious program to steal or erase sensitive files. For this reason, Java and JavaScript should be disabled unless information is being retrieved from a resource familiar to the user.

Software and hardware allow information to be captured as it moves through the Internet. Confidential information (*e.g.,* credit card numbers or patient information) should therefore not be sent across the Internet unless it has been encrypted and should be sent only to a well-known recipient. Netscape Navigator and Internet Explorer work with some WWW servers to automatically encrypt transactions using a system known as "Secure Sockets Layer." A connection to a secure server is identified by a blue line above the WWW page and a solid key (Internet Explorer and Netscape Navigator version 3.0) or by a solid lock (Netscape Navigator 4.0). Information that has been encrypted is nearly impossible to decipher by unintended recipients.

A virus is a program that, when executed, "infects" one or more computer programs. These programs, when run, then infect other programs. The virus may do nothing more than announce its presence from time to time, or it can delete or change information or render the host computer unusable. Viruses can travel as part of an executable program or as part of a word processor, spreadsheet, or database file. Simply reading an e-mail message cannot spread them. For this reason, it is advisable to purchase an "antivirus" program that will automatically scan all new programs and files for the presence of a virus and remove one if found. It is also advisable to download software only from well-known sources.

Anesthesia and The Internet

Anesthesiologists have much to gain by using the Internet.[7,12] Our specialty requires a broad base of knowledge that encompasses theoretical and practical information as well as a variety of manual skills. Although didactic teaching, lectures, journal articles, and textbooks are used most commonly to transfer this information, some ideas may best be conveyed by other means.[13] Electronic publications use video, sounds, and pictures to present some ideas (*e.g.,* characteristics of a heart murmur) that may be difficult to convey with printed text. Publication on the Internet offers the added advantages that information can be distributed worldwide and can be easily and rapidly updated to reflect the state of the art.

Anesthesia resources on the Internet include information about a department or institution or information for medical professionals, such as clinical information or research data. The Internet can be used to gather infor-

mation for academic, scientific, and clinical applications.[14] Anesthesia departments at many institutions publish information about residency programs and research interests and faculty directories. Some medical equipment manufacturers provide customer support and specifications for equipment on the Internet. The US government also provides information for physicians, including product alerts from the Food and Drug Administration and free searches of the National Library of Medicine using Pubmed. There are also several meeting calendars and information about lectures and other academic activities.

Information about a department might include a personnel directory, a list of services provided by the department (*e.g.,* an outpatient pain service or office-based anesthesia), or directions to the hospital. The University of Iowa Virtual Hospital (http://indy.radiology.uiowa.edu) is good example of a resource developed for clinicians and patients. This page is divided into information for patients and information for physicians. The section with information for patients includes a directory of services, an explanation of the anesthesiologist's role, general instructions for patients undergoing surgery, and directions to the medical center from major highways and the airport. The information for physicians includes a referral directory, specific services offered by the department, and information about the department's ongoing research.[15]

Information for physicians includes referral information, treatment guidelines, research results, and review articles. There are hundreds of resources available for physicians, published by independent organizations, academic medical centers, private departments, individuals, anesthesia societies, publishers, and companies. *GASNet* (http://gasnet.med.yale.edu), for example, is a resource based at Yale University. *Educational Synopses in Anesthesiology* (http://gasnet.med.yale.edu/esia) is a peer-reviewed, on-line journal of anesthesiology. Academic journals use the WWW to provide abstracts of articles, tables of contents, and other information. ANESTHESIOLOGY (http://www.anesthesiology.org) has information designed for lay people, readers, and authors and even offers authors the ability to track the status of a manuscript. The Anesthesiology Discussion Group is a global forum that uses e-mail to link anesthesiologists from around the world. Penn State University Hershey Medical Center (http://www.anes.hmc.psu.edu/AnesthHome.html) has a comprehensive WWW site with a job listing service, case presentations, and links to other anesthesiology WWW resources. The Mount Sinai School of Medicine Department of Anesthesia WWW page (http://www.mssm.edu/anesthesia) is typical of many academic departments, with information about the residency program, lists of frequently asked questions, a schedule of upcoming conferences, and links to sites of interest to the department.

The ASA (http://www.asahq.org) maintains a comprehensive resource designed for its members and for the lay public. It includes lists of ASA subcommittees and officers, abstracts for the annual meeting, and links to other sites. The Anesthesia Patient Safety Foundation web site (http://gasnet.med.yale.edu/apsf) contains information about the Foundation, as well as a variety of protocols and videos of the anesthesia machine check-out and cricothyroidotomy. Other societies including the Society for Neurosurgical Anesthesia and Critical Care (http://ira-mac.ucsf.edu/snaccweb/SNACC.html) and the Society for Technology in Anesthesia (http://gasnet.med.yale.edu/societies/sta) publish bibliographies and newsletters on the Internet.

Patients can use the Internet to find information about anesthesia and surgery. Information is also available for patients and physicians. Hospitals and individual departments can create WWW pages with information about special services, commonly asked questions, and instructions for patients on how to prepare for surgery (*e.g.,* NPO guidelines). The ANESTHESIOLOGY and ASA web sites offer information about the specialty for the lay public. Essays discuss the history of anesthesiology and the role of the anesthesiologist during the perioperative period. These services may help to improve public understanding and appreciation of the important role that anesthesiologists play. Unfortunately, however, patients may also "shop" the Internet for information and demand a specific treatment based on possibly inaccurate information.

Publication of medical information on the Internet raises questions about quality assurance and academic recognition of electronic publications. Many physicians regard information obtained on the Internet with distrust and are also reluctant to publish electronically. It is important to remember that anyone can create a WWW site on any topic. For this reason, it is important to consider the source of the information and, in particular, whether it has been peer-reviewed and contains references. Once a resource has been indexed by one of the major sites (*e.g.,* Excite) it will appear in the results of any search for that topic. Although the information may be addressed to professional colleagues, much of it is also available to the general public. Patients and other

nonphysicians may also distribute information that is not subject to the rigors of peer review. Although a physician may be able to sort through some of these data, patients may be unable to do so.

Perhaps the most pressing concerns for most users of electronic medical literature are quality control and peer review.[16,17] Although the traditional academic press may publish an article with erroneous or misleading results, this possibility is made less likely by the critical review process that each article undergoes before publication. Resources on the Internet, however, can be updated instantly and may contain unsubstantiated data.[18] Moreover, the author of nearly every article published in the traditional literature is identified. Many Internet resources are maintained by anonymous authors and may sometimes even deliberately mislead the reader as to the author's true identity. For example, an antiabortion activist recently created a WWW site that purported to be maintained by Planned Parenthood.[19]

Relatively few academic institutions regard electronic publications as equivalent to paper publications. Academicians are therefore reluctant to publish original research or review articles that may be published in printed media. In addition, many printed journals consider electronic distribution to be equivalent to previous publication when determining whether an article will be accepted for publication. These two factors discourage academicians, who might otherwise consider contributing to online publications. This problem may be resolved as electronic publication is better understood and becomes more widespread.

The Future

The Internet is still a relatively new development that has already begun to change the ways in which medical professionals communicate. As more users gain access to the Internet, new services are being added almost daily. Technologies under development include new methods of presenting information and of making more efficient use of limited resources. For example, improved data compression speeds transfer and decreases the time required to download images and sounds over the WWW. Internet broadcasting makes it possible to receive everything from live broadcasts of sporting events to ASA safety videos over an ordinary modem. Physicians are using inexpensive teleconferencing software to hold "virtual meetings."[20] This technology was used to broadcast (Intercast) the Rovenstine lecture from the ASA Annual Meetings in New Orleans and San Diego over the Internet. Lastly, Java, a new programming language, is used to create applications that run on nearly any computer. WWW pages can include programs that offer features such as an embedded blood gas calculator or sophisticated applications such as an Internet-based patient simulator.

The number of Internet users and the sophistication of applications are growing faster than the network can grow to accommodate them. As a result, telecommunications and computer companies are developing ways of delivering faster connections to individual users. ISDN, for example, is a digital telephone service that provides data transmission rates of up twice as fast as many modems. Cable modems use the existing cable television infrastructure to transfer information at speeds ranging from several hundred thousand to millions of bits per second. Several ISPs now use technology similar to that of direct satellite television to offer inexpensive, high-speed Internet access.

In conclusion, the Internet is a promising technology for distributing information. It allows anyone to collaborate on projects without regard to time zones or location and offers a unique opportunity to create a truly global specialty. The Internet is growing at a rapid rate, and new resources, which offer new ways to learn and to communicate, are added almost daily. As the technology matures, the Internet will play an even greater role in medical education, research, and clinical practice. The sound and video images produced by Internet teleconferencing software are rapidly improving, and low cost, wide availability, and ease of use make this technology a potentially valuable tool for clinicians and researchers. This technology is viable now, and there will continue to be exciting developments in this field of international communication and collaboration. As Internet technology matures it may become the predominant method of communication between medical professionals.

A Brief List of Internet Resources

One of the biggest problems facing people new to the Internet is the sheer volume of information. As a complete review of all Internet resources of interest to physicians is impractical, the practical resources described here provide starting points for further exploration. Each of these resources is on the WWW and is accessible with any WWW browser.

World Wide Web Virtual Library: Anesthesiology; http://gasnet.med.yale.edu/vl. A comprehensive listing of all known resources of interest to anesthesiologists.

Anesthesiology and Critical Care Resources on the Internet; http://www.eur.nl/FGG/ANEST/wright. This is another comprehensive listing, complete with descriptions of each resource and a "Pick of the Week."

ANESTHESIOLOGY; http://www.anesthesiology.org. Information about the Journal, including a guide for authors, abstracts, and tables of contents.

The ASA Home Page; http://www.asahq.org. Information about the Society, sections for both laypersons and members.

GASNet Anesthesiology Home Page; http://gasnet.med.yale.edu. Maintained by the author; includes abstracts of journal articles, *Educational Synopses in Anesthesiology and Critical Care Medicine,* an on-line journal, and the *Global Textbook of Anesthesiology.*

International Association for the Study of Pain; http://weber.u.washington.edu/~crc/IASP.html. Information about the society and information about acute and chronic pain.

International Standards Organization Anesthetic Equipment Page; http://www.iso.ch/meme/TC121.html. All one ever wanted to know about anesthesia equipment standards.

Penn State Anesthesia; http://www.anes.hmc.psu.edu/homey.html. Maintained by Jeffrey M Taekman, M.D., this site includes a moderated, electronic anesthesia case conference and an anesthesia employment archive.

Society for Ambulatory Anesthesia; http://www.sambahq.org. Information about the society and links to ambulatory anesthesia resources.

Virtual Museum of Anesthesiology; http://umdas.med.miami.edu/aha/vma. A fascinating collection of portraits, photographs of equipment, and other interesting items.

Free Medline; http://www.nlm.nih.gov/databases/freemedl.html. National Library of Medicine *Index Medicus* literature searches.

Alta-Vista; http://www.altavista.digital.com. A comprehensive listing of more than 30 million pages on 225,000 servers worldwide, with powerful search capabilities.

Excite; http://www.excite.com. A concept-sensitive WWW search engine.

Yahoo; http://www.yahoo.com. A comprehensive listing of hundreds of thousands of Internet resources, organized by topic. An ideal starting point.

Four11; http://www.four11.com. A comprehensive directory of Internet users. Entries include name, address, telephone number, and e-mail address.

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