Introduction:

In 1983 the Internet comprised only 200 host computers. As of May 1994: there were 5 million host computers in 94 countries. The Internet is growing at 12%/month with an estimated 50 million users. As solo practice gives way to group practice and soon to corporate medical practice, corporate business skills will be required to get a job. These include familiarity with the vocabulary of accounting and management, and the ability to access resources and to communicate via electronic digital computer systems. In attempting to maintain one's professional knowledge base, and to economize on scarce travel and subscription dollars, formal meetings and paper journals will give way to subscription list servers (online discussion groups) and manuscript preprints. Some journals are experimenting with online publishing, and in April 1994 our Otolaryngology training program began publication of a textbook via the Internet. Already there is an otology listserver operated by the Shea Clinic in Memphis, and an otolaryngology/head and neck surgery listserver run by the Baylor Department of Otolaryngology. In fact, Baylor just announced their Web Homepage, and promised to make their own grand rounds available online.

In many corporate environments the inability to use the company computer system is looked upon as a significant occupational disability. Some of you may know that one of our recent resident graduates was able to locate and rent a home close to her new office by means of the Internet. She accessed the web home page of the local newspaper, and found what she wanted before leaving Galveston.

History:

The beginning of the Internet is generally regarded to be the ARPANET (Advanced Research Projects Agency Network) assembled in 1969 by the precursor of the Defense Advanced Research Projects Agency of the Department of Defense. This network established connections
among major research centers throughout the US. During the ensuing two decades, several regional networks were connected into ARPANET, resulting in a national computer network, at least in function, if not in name. The initial purpose of the ARPANET was to connect military research centers in a way that could withstand partial outages, such as bombing, sabotage, and still continue to function. This gives us a general idea as to the architecture and function of the present Internet: a multiply connected network of networks.

In 1986, the NSFNET was created by the National Science Foundation. This was a much higher-speed net and it replaced the ARPANET. It operated at 56,000 bits per second, fast enough to send two full typewritten pages every second. Present speeds are faster by orders of magnitude. Gradually, more and more regional networks became connected to the NSFNET, forming a "network of networks", or the Internet. Until very recently, the NSFNET has been the "backbone" of the Internet. As early as 1987 the National Science Foundation awarded a contract to Merit Network Inc., to manage NSFNET. At the present time, the role of the National Science Foundation as NSFNET sponsor is being assumed by commercial organizations, a result of the current federal trend towards privatization of governmental services.

During the same time as the ARPANET was evolving, Ethernet local area networks (LAN's) were coming into being at universities and research organizations. In 1983, with the advent of the desktop workstation computers, local area networking simply took off. Most of these workstations were Unix machines, enabling their users to communicate directly with the Internet.

As of April, 1994, more than 30,000 individual networks were connected to the Internet, with more appearing almost daily. Responsible observers have predicted that in 1997 the Internet will collapse of its own complexity, or at least will come to a stumbling halt, as the addressing mechanisms become overloaded.

In 1991 the US Congress Sen. Al Gore sponsored the High-Performance Computing Act of 1991, which authorized construction of a high-speed network connecting all higher-education academic institutions, research centers, and federal organizations in the US. This addition to the Internet is called the National Research and Education Network, (NREN) and is able to transmit data at gigabit speeds (billions of bits per second.)

Digital telephone systems will gradually replace analogue systems in the service of electronic communications, and in many areas, one can replace his residence phone system with ISDN (Integrated Service Digital Network) service, allowing both voice and high-speed data communication, for not much more than one pays currently for analogue voice service. In fact, current telephone services represent one of the significant bottlenecks for expansion of the Internet.

**Physical realization:**

Some useful terms, essential to any understanding of the Internet:
Host: a computer, capable of supporting more than one user at a time, which stores data and programs that can be accessed by remotely sited computers, itself acting as a "terminal emulator", or as a "client."

Server: a computer, usually local to the user, connected as part of a LAN, which acts as a "host" to local "client" machines on that same LAN and provides access to data, programs, and most importantly, to networks beyond the LAN.

Client: a small computer, usually a desktop PC, or a Unix workstation, which accesses a local network "host" or "server" and makes use of the resources provided by the server and by the networks to which that server has access.

Router: a computer system which transfers data between two networks which use the same protocols. It is principally concerned with assuring correct addressing.

Bridge: a form of router which is realized in hardware and is used typically in linking services between nearby buildings having similar LANs.

Gateway: a computer system that transfers data among incompatible networks or applications. Data is reformatted to be acceptable for the new application or network prior to passing it on. Sometimes the term is used (mistakenly) for a "router."

The physical connectivity can be achieved in a number of ways. Much as the connections among members of a LAN can consist of coaxial cable ("Ethernet"), twisted pair ("Cheapernet"), and fiberoptic cable, wide-area networks (WANs) utilize high-speed copper or fiberoptic cable, microwave and satellite transmission. The connection to the user is implemented by the user's LAN, or via local telephone company cable. In the case of amateur radio operators, wireless access to the Internet can be achieved by packet radio repeater stations ("digipeaters") connected to an Internet "wormhole." Commercial wireless service is also available using cellular telephone service and mobile radio communication vendors.

Functional realization (governance, protocols, IP, TCP/IP, UDP, Unix)

The ultimate authority for the direction of the Internet is the Internet Society, or ISOC, a voluntary membership organization. It appoints a "council of elders," the Internet Architecture Board, or IAB. The IAB meets regularly to approve standards and to regulate the assignment of addresses. Internet users voice their opinions through the Internet Engineering Task Force or IETF, another volunteer organization, made up of working groups having different functions.

The Internet is not "free," although in the case of academic users, the cost is usually transparent, for the university pays for its connection to a regional network, which in its turn pays a national provider for its access. Residential users, of course, pay providers such as Compuserve, America Online, Prodigy, for access to the Internet. This is in addition to whatever they are billed for telephone services.
To illustrate how information is transferred via the internet, consider the following familiar services: the telephone, the personal radio, and the postal service. The voice telephone provides "full duplex" communication, in that both parties can talk at the same time and still hear each other. The personal radio offers "simplex" communication, or "push-to-talk" interaction. Only one user can talk at one time, hence the convention, "over," common in radio communication. These two methods are examples of "realtime" communication.

The Postal Service provides "packetized" communication, in a "store-and-forward" mode. A small message (a letter) is enclosed in an envelope which bears the address of sender and receiver on the outside, insuring prompt and accurate delivery (in most cases!).

The telephone is a circuit-switched network, in which the user is given complete use of one piece of the network for the duration of the call. The Internet, by contrast, is a packet-switched, store-and-forward system, similar to the Postal Service. Each message or file is broken into small pieces, called "packets" each of which is from one to 1500 characters long. Each packet is stamped with the address of the sender and the intended receiver, and sent on its way. This is accomplished by a collection of software referred to as the Internet Protocol, or IP.

Packets may get lost, or delayed, or arrive out of sequence, resulting in confusion at the receiving end. For this reason, another protocol called Transmission Control Protocol, or TCP is used to supplement the IP. At the receiving end, TCP collects the individual packets, checks for missing or corrupted packets, obtains retransmission when necessary, arranges them in the proper order, and delivers them to the addressee computer system. The protocol is called TCP/IP and is pretty much the standard throughout the Internet.

Geography:

The Department of Otolaryngology US Postal Service address is 77555-0521. This zipcode is sufficient to ensure delivery to the UTMB Otolaryngology Department from any place in the US. Similarly, computers connected to the Internet are identified by a numeric address consisting of groups of three digits separated by periods, i.e., 192.200.342.009. Each group of three digits identifies a "domain", the final group pointing to an individual machine. Numeric addresses are difficult for human users. Imagine each of us being identified only by our social security numbers, rather than by our names. For this reason, "name-servers" have been created, to map numeric addresses onto the names of places, organizations, regions, and machines. For example, one of our computers, on which some of you have user accounts, is "andre.utmb.edu." "edu" represents the "high-level domain", "utmb" represents this campus, and "andre" is the domain name of a particular computer in our lab.

There are six original high-level domain names:

- **com**: commercial organizations, i.e., businesses
- **edu**: educational organizations
- **gov**: non-military government organizations
- **mil**: military
- **org**: other organizations
Additional high-level domain names represent countries, i.e., "ca" indicating Canada, "np" indicating Nepal, etc.

A Compuserve subscriber would have an address like 72355.4455@compuserve.com. An America Online subscriber would have an address such as "newnose@aol.com"(Jack Kridel's Internet address.) One can have more than one address, representing either user accounts on several computers, or aliases for a single account. Major modes: e-mail, telnet, ftp, gopher, WWW, USENET News: The most prevalent use of the Internet is e-mail. It is also the simplest and generally the cheapest in terms of resource cost to the user. When the network is working well, it is almost as good as a telephone call, inasmuch as transmission is almost instantaneous. This tends to introduce a pleasant degree of informality. So far, there is no specified format for an e-mail message, as there is, for example, for a business letter. This informality can be a problem, if one happens to act impulsively, for e-mail communications are not entirely secure, and once sent on its way, and e-mail message cannot be retrieved, nor can one be sure that the message is not archived somewhere and available for later public review, as in the case of Oliver North's Whitehouse correspondence in the Iran-Contra case.

E-mail can be encrypted by the user, and decrypted by the receiver, of course, but a great deal of controversy has arisen over the permissible degree of encryption, with the federal government making a strong effort to retain access to encrypted interstate communication (the "Clipper Chip" issue) ostensibly motivated by its concern over organized crime activities, the narcotics trade, money laundering, and of course, national security.

Telnet is a method of accessing a host computer from a remote location. One is required to have user privileges on the host, and the remote computer must have a terminal emulation program installed. We used this function last February in Atlanta, in order to check our e-mail on our machines here at UTMB.

FTP ("file transfer protocol") is a method of shipping computer files to and from remote host computers, and may or may not require that the user have login privileges on the host computer. In some cases, files will be available via "anonymous ftp" wherein the user logs in as "anonymous" and enters his e-mail address for the password. In the case of anonymous ftp access, the user is permitted limited access to the host computer resources, and is only able to "download" files from the host computer. The UTMB Otolaryngology Department Grand Rounds files are available on the Internet via anonymous ftp.

A more versatile access mode is "gopher", named after the Golden Gophers of the University of Minnesota, where the software was created. A gopher provides assistance in navigating the connectivity of the Internet and makes available files on various places around the net, depending on the number and nature of links to other gophers which the gopher server maintains. The name, gopher is apt in that the gopher server will "go for" the information the user is seeking, accessing many widely separated gopher servers in its search, and retrieving the desired data in a way that is transparent to the user. Gophers have become so popular that there are now thousands of them installed at various sites throughout the world, and it is an exciting experience
to find yourself visiting data collections in Finland, Sweden, Switzerland, Australia, and other distant sites using only a few keystrokes and in less time than it takes to read this paragraph.

Enhancements to gopher searching are available (Archie, Veronica.) Archie ("archive") is a service that does keyword searches of all the public files available on the Internet. Veronica maintains a collection of all the menu items of most of the Internet gopher servers. The user institutes a veronica search via a gopher client connected to a veronica server. Veronica asks for a keyword and answers with a list of menu items from other gopher servers. The user indicates the item of choice and is then connected to a computer providing the desired resource. Gopher server and client software is available free from the University of Minnesota, and can be downloaded via the Internet. The UTMB Otolaryngology Grand Rounds are available via a gopher server on one of our Unix based computer systems.

The latest and most popular access mode is the **World Wide Web**. This mode offers the user text, graphics, audio, and images in color. Rather than presenting information in menu format, WWW offers "hypertext links" to data, represented either by numbered items or by graphic images on the screen. Considerable bandwidth is required for transmittal of graphics and images, and this can be felt by the user as barely acceptable slowness in navigating and downloading. The newer WWW clients permit telnet, ftp, and gopher access as well. Some less sophisticated WWW clients are available without charge via the Internet. The most popular commercial client software packages are "Mosaic" and "Netscape." An individual or organization wishing to appear on the WWW will create a "homepage" with information about the individual or organization, and often a picture of the person or institution. The "homepage" gives access to hypertext links to additional information which the person or organization wishes to make available publicly.

**USENET News** allows the user to read and post messages sent to public "newsgroups," which are really bulletin boards or discussion groups. USENET is the worlds largest bulletin board service, and the categories of information listed numbers in the hundreds. There is a "sci.med" newsgroup which boasts several subgroups, among them a pathology discussion group.

**User access modes: grades of connectivity, vendors, costs**

The highest grade of connectivity is **TCP/IP**. At this level one has access to the entire list of Internet services: bulletin boards, electronic mail, file transfer, index programs, remote login, etc. With TCP/IP the user's computer is part of the Internet and is able to contact every computer service on the Internet.

It may not be necessary to invest in this level of connectivity, however. It is entirely practical to obtain an account on a timesharing computer system which itself if connected to the Internet. In fact, this is how most home users access the Internet. In this case, however, one does not download files directly to the home computer. Rather, files are "ftp'ed" to the timesharing host computer, then transferred via modem to the computer in the user's home. Some access vendors use software which makes this requirement transparent to the user, however. In a nutshell, the real test of full connectivity is whether or not one can run Mosaic on the home computer. If so, then your service allows you the full range of Internet resources.
One need not always spend one's own money to obtain access to the Internet. Most colleges and universities, as well as many large corporations, have connections to the Internet which you may be able to utilize for little or no cost via telephone. Authorized users may find the services they seek by dialing with their modem. Large organizations such as universities and major corporations have "dedicated" access, costing many thousands of dollars annually, but which allows as many computers as they wish to access the Internet, with each computer a full fledged member of the Internet.

Less expensive versions of highspeed "dedicated" access are now available in forms that will operate over dialup telephone lines using a highspeed modem. These methods are based on SLIP ("Serial Line Internet Protocol") and more recently, PPP ("Point-to-Point Protocol") and give the user excellent response characteristics at a much lower cost that true dedicated access. SLIP and PPP are very useful in connecting a residential computer to a local network, which itself is connected to the Internet. This method has considerable appeal to the home user who has user privileges on a university or large corporate network. It gives the home user the same environment as she would have if she were actually on campus or in her corporate office. Again, these protocols require a highspeed (at least 9600 baud) modem and one must purchase the software for SLIP or PPP, but a residential dialup telephone is all that is necessary to accomplish the connection.

One is not, however, limited to a choice between dialup telephone access and dedicated line. A service, ISDN ("Integrated Services Digital Network") provides very fast access at low cost, offering, for example, two 56 or 64 kilobit digital channels for between $20 and $50 per month. Channels may be multiplexed to implement both voice and data services as needed. Specially constructed digital telephones are required for voice use, however, and sometimes it is difficult to find an ISDN service provider, particularly in rural areas.

Finally, the simplest and cheapest way to connect to the Internet is with a low- or medium-speed modem, a terminal emulator software package (i.e., Kermit,) a residential dialup telephone, and a subscription to a timesharing computer service, like Compuserve. With this arrangement one can probably enjoy e-mail, file transfer, and bulletin board access. One should not expect to run fancy applications such as Mosaic on this kind of link, but the cost can be less than $100 up front and $30 per month with perhaps an additional charge for connect time. A local example of this type of service would be "Phoenix.net" which advertises a $30 onetime connect charge and a $25 monthly charge.

The Future:

Security problems are inherent in an "open" network developed in a Libertarian environment, and migrating to a competitive and commercial atmosphere. Encryption is the obvious solution but it brings its own set of problems, such as massivly increased overhead, and the policy of the federal government of banning encryption schemes which can be exported to other countries. Court battles over the right to use certain domain names resembling trademarks are already looming into view. Censorship of materials deemed obscene is at present being considered in the Congress, and perhaps worst of all, a patchwork of State regulations may soon appear, reducing all to confusion. As an example, Tennessee has recently indicted the operators of a California
bulletin board because their files, presumably images of questionable taste, could be viewed in Tennessee. The Internet is facing a conflict of cultures, the Libertarian, jeans-and-tees-shirt crowd against the buttoned-down dark gray summer wool attache case daytimer set. Believe it, things are going to be different when these two face off. Look what happened to the USSR when it was hit by Xerox machines and PC's.

BIBLIOGRAPHY


Kantor, Andrew: Jack In And Geek Out; Internet World: July 1995 pp 26-28 Internet World: Mecklermedia Corporation

Glowniak, Jerry V. & Bushway, Marilyn K; Computer Networks As A Medical Resource; JAMA vol. 271, No. 24; Jun 22/29 1994

Mann, Charles: Regulating Cyberspace; Science Vol.268 May 1995; pp 628-9