

# Lecture 19. Digital world without boundaries: from ARPANET to WWW

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Fig. 1. The World Wide Web. Source: unknown

## Introduction

For many people, the involvement with computing is reduced almost entirely to their use of the Web. They use it to get information (whether reliable or not), to stay connected with other people, to be involved in social media activities, to access multi-media resources (images, movies, music, TV programming, gaming, and other forms of entertainment), to conduct business.

To them computers are Internet accessing appliances and the Web itself – the most significant computer application.

But before the Internet became the "information superhighway" for everybody, a lot of efforts were expended to build knowledge and technologies about computer networking, that is about interconnecting computers both locally as well as at distant locations, so that information can be accessed and shared easily and inclusively.

Even today, at a local IT office or at home, we can see the traces of these early networking technologies and solutions when we navigate the Web.

In this lecture we trace the very many paths that eventually converged into what we now call Internet and the World Wide Web. The subject matter is too fresh and too dynamic to offer definite conclusions concerning even the early developmental stages of the Internet and the Web. Therefore in what follows, we shall concentrate more on facts than on drawing such conclusions.

## **From ARPANET and Ethernet to Internet**

From the very beginning of the computer industry, computers were designed with interconnectivity in mind. Clearly, computers had to be connected to peripherals, such as printers, displays, and input/output devices (e.g. card and paper tape readers and punchers).

Then, we had to figure out how to connect two and more computers together to share data and other resources. Such interconnectivity involved the development of special hardware for sending and receiving digital information, say, by phone line. It also involved the development of the so-called communication protocols which regulated the entire process of communication between interconnected computers (e.g. how to request and transmitting data, how to confirm the successful receipt of data or request its retransmission in the case of detected transmission errors).

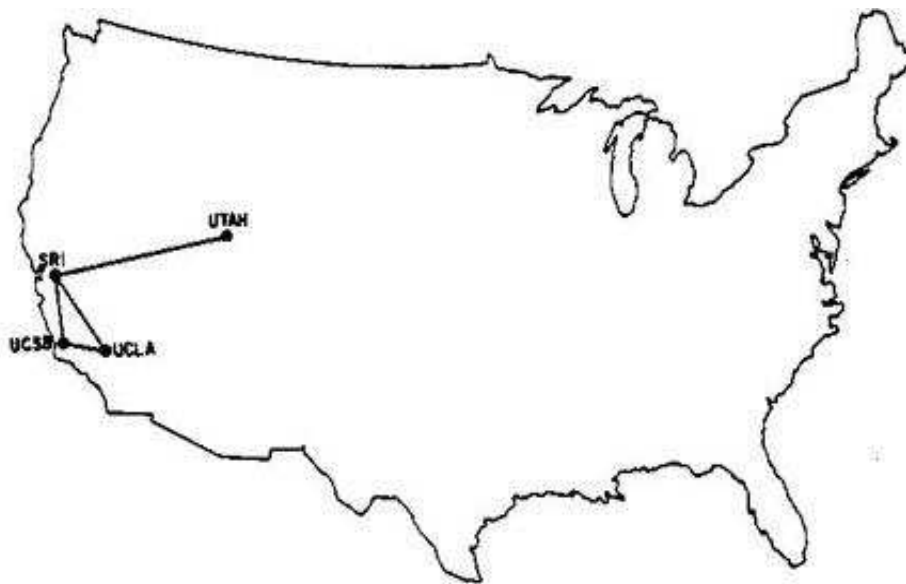
As it is frequently the case in the history of technology, there can be a large number of solutions offered to solve a technological problem or necessity. Some of these solutions would never see the implementational stage due, for instance, to financial constraints. Other solutions would fight for dominance in the market place and the winners could be accepted as industry standards. The history of computer networking, the Internet, and WWW can serve as canonical examples confirming this observation.

Because of the large number of historical events involved in paving the historical way to the Internet and WWW, our discussion will necessarily be incomplete. We begin with a brief history of the network that is considered by many the Internet's precursor.

**ARPANET:**

Let us turn the history clock back to the end of the 1960s. In 1967, the Advanced Research Projects Agency (ARPA) of the US Department of Defense initiated a networking project whose objective was to interconnect a number of computers at various locations in the US in order to widely share expensive computer resources owned or sponsored by ARPA.

ARPA's network—to be known as ARPANET—was launched in 1969 and initially interconnected just four locations (see the top map of Fig. 2). By 1972, when the network was unveiled to the public, there were 30 interconnected ARPA nodes.



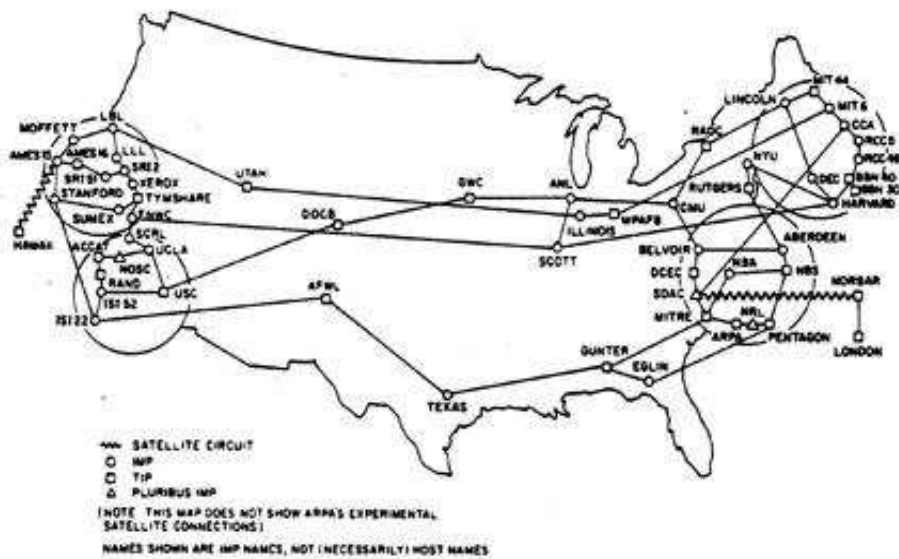


Fig. 2. The development of ARPANET: from 4 nodes in 1969 to over a hundred in 1977. Source: <http://classes.design.ucla.edu/Spring06/161A/projects/camile/arpanet/index.html>

The ARPANET was dismantled in 1988 but not without leaving a wealth of ideas and technologies that found their way into other networking concepts some of which are still shaping our present day digital reality.

**Ethernet:**

ARPANET offered a global interconnection of computer resources using phone networks. It was not particularly well suited for local connection of computer resources: a few minicomputers in an office sharing a printer and other peripherals.

A local area network (LAN) that revolutionized local networking of mini-computers (or workstations) was invented at Xerox-PARK in 1973 by Robert Metcalfe and David Boggs. Based on ideas from ARPANET and the first "wireless" network ALOHAnet, they proposed Ethernet – a local area network that was interconnecting a large number of hardware at very large speeds (in comparison with ARPANET). Ethernet was adopted by large corporations such as Intel, Digital Equipment, and Xerox, and by most manufacturers of UNIX-based equipment. It also played a significant role in the

development of PC-based networking.

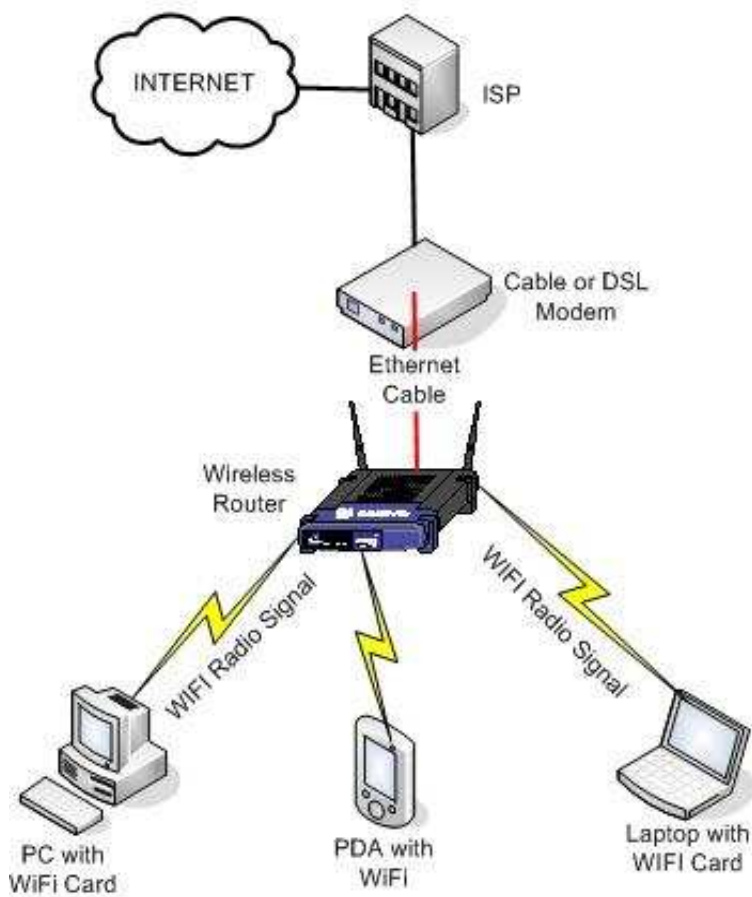


Fig. 2. Wireless home network setup using Ethernet connection. Source: unknown.

As historian Paul Ceruzzi expressed in [1],

If the Internet of the 1990s became the "Information Superhighway," then Ethernet became the equally important network of local roads to feed it.

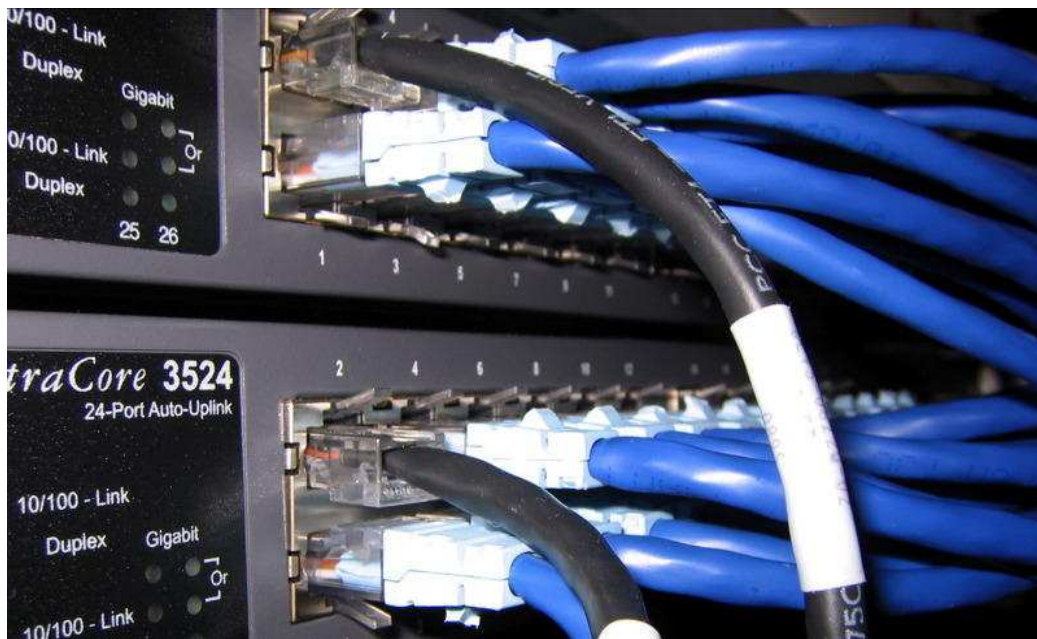


Fig. 3. Network switching equipment with Ethernet connections. Source: unknown.

### **Internet:**

Internet is not a single network such as ARPANET but rather several interconnected networks spanning the globe: a web of interconnected backbone networks communicating with each other at high speed. Some of these contributing networks are "open" or accessible to everybody connected anywhere to the Internet. Other contributing networks are restricted to only those users who possess access rights (networks created by some financial institutions and governmental agencies can serve as examples).

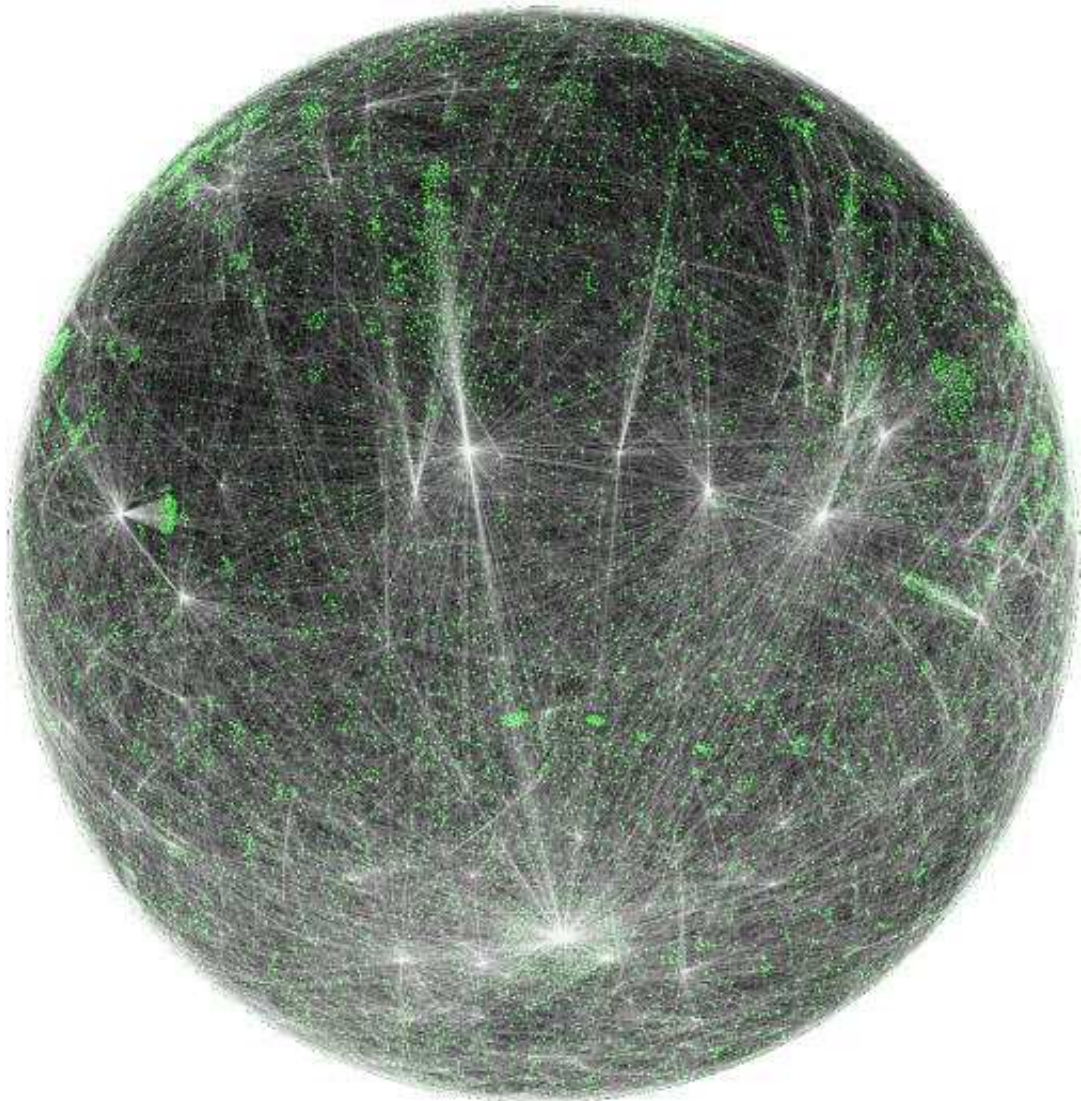


Fig. 4. Internet topology. Source: <http://cheleby.cse.unr.edu>

This time around, the problem was not to connect incompatible computers (as was the case with ARPANET) but incompatible networks. In the early 1970s, the work begun on developing a new communication protocol for ARPANET. The result of that work were the TCP (Transmission Control Protocol) and IP (Internet Protocol), or TCP/IP protocols later adopted for the Internet. This work was influenced by another network CYCLADES created in France in the early 1970s.

The new TCP/IP protocols were adopted by ARPANET in 1980. The acceptance of the protocols by important institutions (e.g. the US Department of Defense) and the protocol's inclusion in the popular UNIX operating system helped to create more and more interconnected networks communicating in TCP/IP, spanning the Internet.

Local area networks (powered, e.g. by Ethernet) allowed a large number of computer users to gain access to the Internet.

By mid 1980s, ARPANET was just one of the interconnected networks on the Internet.

## **Before the WWW**

The usefulness of the early Internet depended critically on services that it could provide and its content which was the responsibility of the contributing networks. Before we discuss this subject further, let us look at other networking and information service undertakings of the 1970s and 1980s since some of them contributed to the social acceptance of the Internet and WWW.

### **IPSANET:**

While ARPANET was weaving its web across the US, a Toronto-based company I.P. Sharp Associates (or IPSA) was building a world-wide network. IPSANET, to provide its clients an access to software and application programs (including electronic mail) as well as private and public databases and libraries.

In the early 1970s, the access to IPSA's computer facilities was extended from North America into Europe via trans-Atlantic cable. A decade later, the IPSANET communications network was known world-wide for its reliability and high-performance. By the end of the 1980s, IPSANET was linking over 800 cities in 80 countries and territories. It had wholly-owned subsidiaries in Australia, Austria, Belgium, Denmark, France, Hong Kong, Ireland, Italy, The Netherlands, Norway, Singapore, Spain, Sweden, Switzerland, UK, USA, and West Germany. The company maintained one of the world's largest collections of on-line business-oriented data.



Access to IPSANET was via a phone line which was a local call to a main-frame computer located at IPSA's computer center in Toronto. The network was successfully used by many international companies world-wide. Its success was due to the extent, quality, and reliability of its services.

Since mid 1980s, data could also be retrieved from the I.P. Sharp Online Service using a personal computer and downloaded efficiently for local analysis and processing.

In 1987, I.P. Sharp was acquired by Reuters Holdings PLC. Although some attempts were made to link IPSANET to the Internet, due to a rigid business model and underestimation of the Internet, IPSANET was discontinued soon after the acquisition.

### **Information Services:**

Besides IPSA, there were very many other companies around the world that wanted to bring a range of electronic information services directly to homes and business offices by utilizing the common-carrier telephone line, television cable, and other interactive network or broadcast systems. These home and business information services, such as trendy videotex, typically provided two basic types of services:

- information retrieval (national news, stock market data, or sports),
- limited transaction services (such as home banking, shopping, and travel agent services, etc.).

For example, a videotex system allowed users to retrieve information stored in computer-controlled databases and have it displayed on their home TV sets or dedicated video display terminals.

Since late 1970s, the North American and European households were turning their attention to home and personal computers. Inexpensive computer modems, such as popular VICmodem for the Commodore VIC-20, allowed a large number of people to get "on-line" and try the electronic mail or browse the pages of local BBSs (i.e. bulletin board systems, see Lecture 11) and commercial information services for the first time such as CompuServe, The Source, Delphi, and Dow-Jones News Retrieval Service.

Some of these services acted as massive libraries of information while other provided a range of services including electronic mail, file exchange, and bulletin boards. All required an annual fee to join plus a fee for accessing a service. Some home computer companies, such as Commodore, were using these services (e.g. CompuServe) to host the information network for its products.

**CompuServe:**

Although the corporate history of CompuServe goes back to the late 1960s, its networking success begins with the dawn of home computing in the late 1970s. By that time the company was already operating its own (and successful) CompuServe data network for corporate clients offering time-sharing services.

Home computers, too, could communicate with other computers (via modems) and CompuServe decided to make its services attractive to home computer owners.

The CompuServe's MicroNET launched in 1979 was the first large-scale public network serving the needs of microcomputer users. The MicroNET was initially designed to give the computer hobbyist the opportunity to link its home computer to CompuServe's network (for free). Later, MicroNET was offered as a payed service exclusively.

In 1981, the charges were \$5/h weekday between 6p.m. and 5 a.m., all days weekends and holidays. However, one had to pay \$22.50/h between 5 a.m. and 6 p.m. weekdays for prime time access. These rates did not include a substantial local and long-distance phone connection charges.

**BY THE YEAR 2000, THE WORLD  
MAY CATCH UP WITH THE WAY  
COMPU SERVE'S NEW ELECTRONIC MALL  
LETS YOU SHOP TODAY.**

**Introducing the first computer shopping service that brings you convenience, savings and enjoyment.**

Here's your chance to expand the practical uses of your personal computer. Sign up for CompuServe and shop in our new Electronic Mall. It's easy to use. It tells you more about the products you're buying. It lets you order faster. And it's totally unique.

**CompuServe's new Electronic Mall offers you all these shopping innovations.**

- It's enormous! So it gives you in-depth information on thousands of goods and services, and lets you buy even hard-to-find merchandise - Its unique "Feedback" service lets you ask the merchants themselves specific questions - It's incredibly efficient in ordering the products and services you want.

- Its special discount opportunities make it economical, purchase after purchase. - And its name-brand merchants assure you of top-quality merchandise.

**The Electronic Mall, a valuable addition to the vast world of CompuServe.**

CompuServe's Consumer Information Service brings you shopping information, entertainment, personal communications and more.

You can access CompuServe with almost any computer and modem, terminal or communicating word processor.

To receive your illustrated guide to CompuServe and learn how to subscribe, call or contact...

**Make the CompuServe Electronic Mall 15-Minute Comparison Test.**

*What you can do in 15 minutes shopping the Electronic Mall way.*

- Call up on your computer screen full descriptions of the latest in computer printers, for instance.
- Pick one and enter the order command.
- Check complete descriptions of places to stay on your next vacation.
- Pick several and request travel brochures.
- Access a department store catalog and pick out a wine rack, tools, toys... any thing!
- Place your orders.

*What you can do in 15 minutes shopping the old way.*

- Round up the family and get in the car.

**CompuServe**

Consumer Information Service  
P.O. Box 20212  
5000 Arlington Centre Blvd.  
Columbus, OH 43220  
**800-848-8199**  
In Ohio call 614-437-0632

The Electronic Mall® is a cooperative venture between CompuServe Inc. and L.M. Berry & Company.

An H & R Book Company

Fig. 5. CompuServe ad, 1984. Source: unknown.

The scope and the number of services offered by MicroNET expanded rapidly which resulted in CompuServe dropping the name MicroNET in favour of CompuServe Information System (or CIS), the name adopted on July 1, 1980. It was also announced at that day that CIS would be sold through the Radio Shack computer centers and outlets.

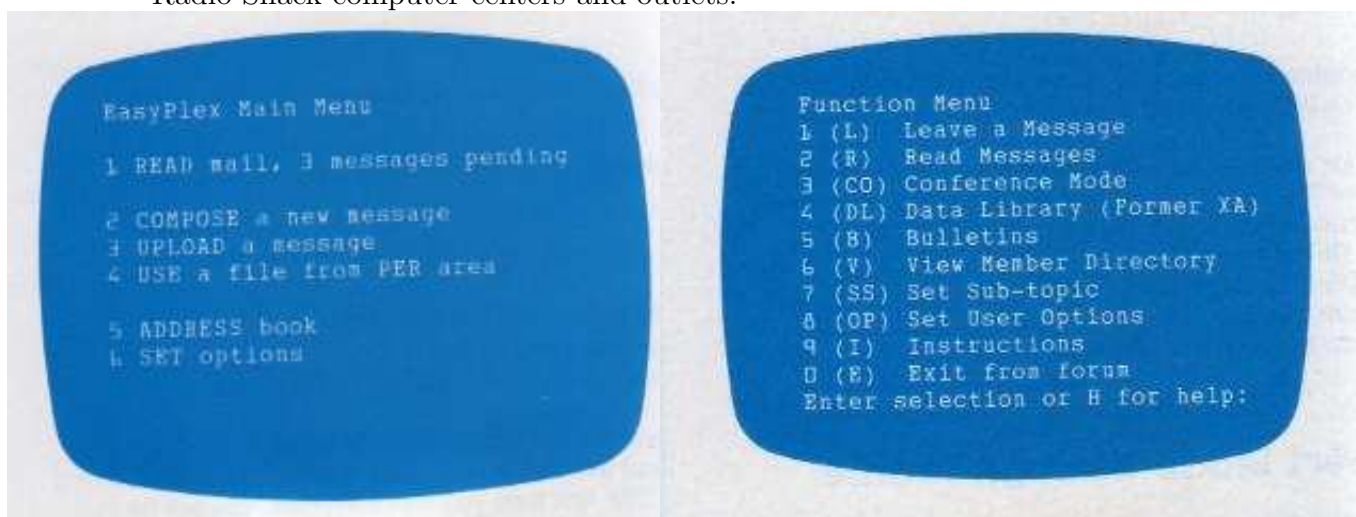


Fig. 6. CompuServe screen shots: *CompuServe Information Service Users Guide*, 1985.

By 1981, CompuServe had over 9,000 subscribers in more than 260 US cities. It offered services in, among other categories: electronic mail and conferences, forums and bulletin boards, data libraries, financial services (quotations and highlights, corporate reports, commodity pricing, investment analysis tools, banking and brokerage services, etc.), electronic travel and shopping services, on-line games (including multiplayer versions) and texting, news, weather and sports, education and reference, home, health and family information.

Buying a new modem was frequently coupled with a free membership to CompuServe or Down Jones and a few free hours of free use of the net. The main problem were high rates of CompuServe and phone companies (especially the long distance charges). It wasn't unusual when a new net user got carried away on the net to the tune of several hundred dollars the first month. Calls on weekends or at night were frequent to minimize costs but that affected the network's response time greatly affected by the number of connections.

By 1984, communications and networking were already the fastest growing areas of microcomputer applications and computer technology. While CompuServe and Source were the two most popular information services, there were many others, including numerous BBS systems and a few but significant large-scale networks that offered home and business users an extensive access to information services, digital entertainment, and even software. British Prestel and Canadian NABU Network provided a glimpse into a new globally-networked digital reality.

**Prestel:**

Prestel was an information service designed and installed by the British Post Office. It operated using existing telephone lines and it was a two-way service (i.e. a user could both receive and transmit information). Ordinary television sets equipped with Prestel decoders (later microcomputers) installed at users' locations were connected to a central Prestel computer via phone lines.

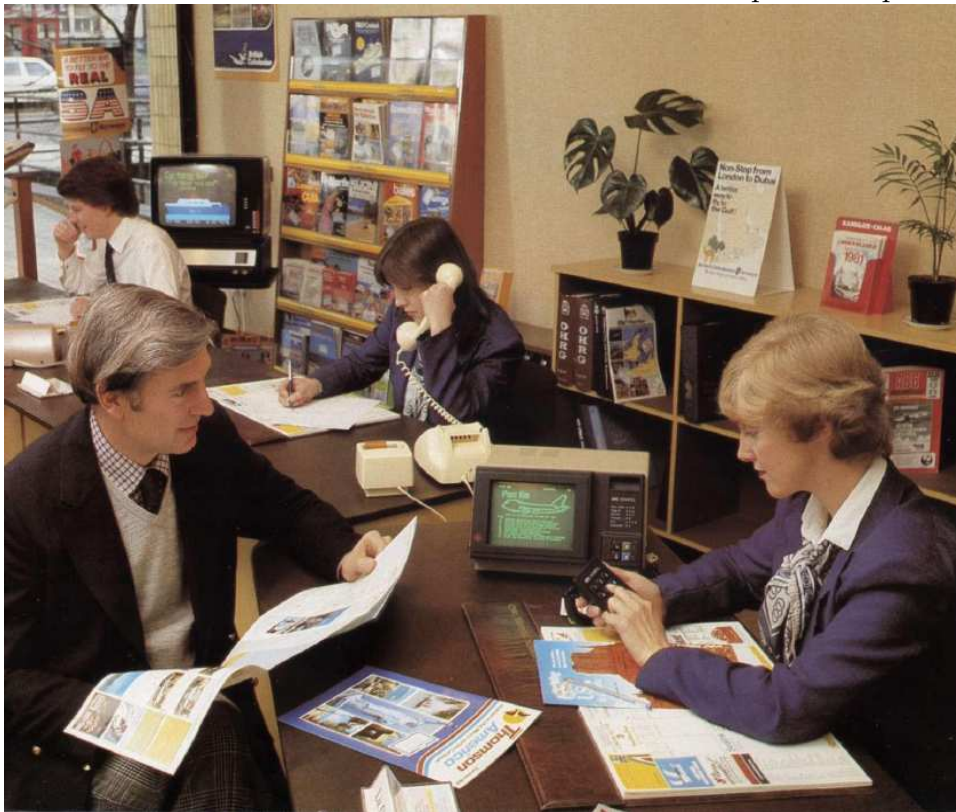


Fig. 7. Prestel terminals at a travel office. Source: Prestel promotional brochure.

The information on Prestel was organized in pages (informally speaking, a page was a screen-full of information). When a user asked for a particular page, the Prestel computer was delivering it via phone line for display on the screen.



Fig. 8. Prestel screen shots. Source: Prestel promotional brochure.

In late 1970s, Prestel served over 180,000 pages of information and was planning on millions of such pages by the early 1980s. Prestel was obtaining information from "information providers" such as the *Financial Times* or British Rail (by 1984, there were over 1000 such providers).



Fig. 9. Prestel terminal. Source: Prestel promotional brochure.

Who was Prestel for? According to Prestel itself

*Prestel is for everyone.*

*Busy mothers can check out prices before they go shopping or their children can use Prestel to help them with their homework.*

*Gardeners will have a constant source of information on what they should be doing at any particular time of the year.*

*Whole families can choose and even book their holidays through Prestel.*

*And of course holidays are not the only entertainment that you can plan. Prestel will provide you with listings for theaters, cinemas, sporting events, exhibitions and just about anything else that may be going on.*

*The introduction of the Prestel service has a special significance for the business community.*

*From market intelligence to airline schedules, from manufacturing and service industry guides to foreign exchange rates, there are literally thousands of Prestel pages with an immediate and very practical relevance to the successful and efficient running of business, both large and small. [from Prestel promotional brochure]*

By 1982, Prestel was serving thousands of clients in Britain (using several Prestel servers installed across UK) and overseas, from large businesses, small firms, schools, colleges, farms, hotels, and retailers to governmental agencies and, of course, individual users at home.



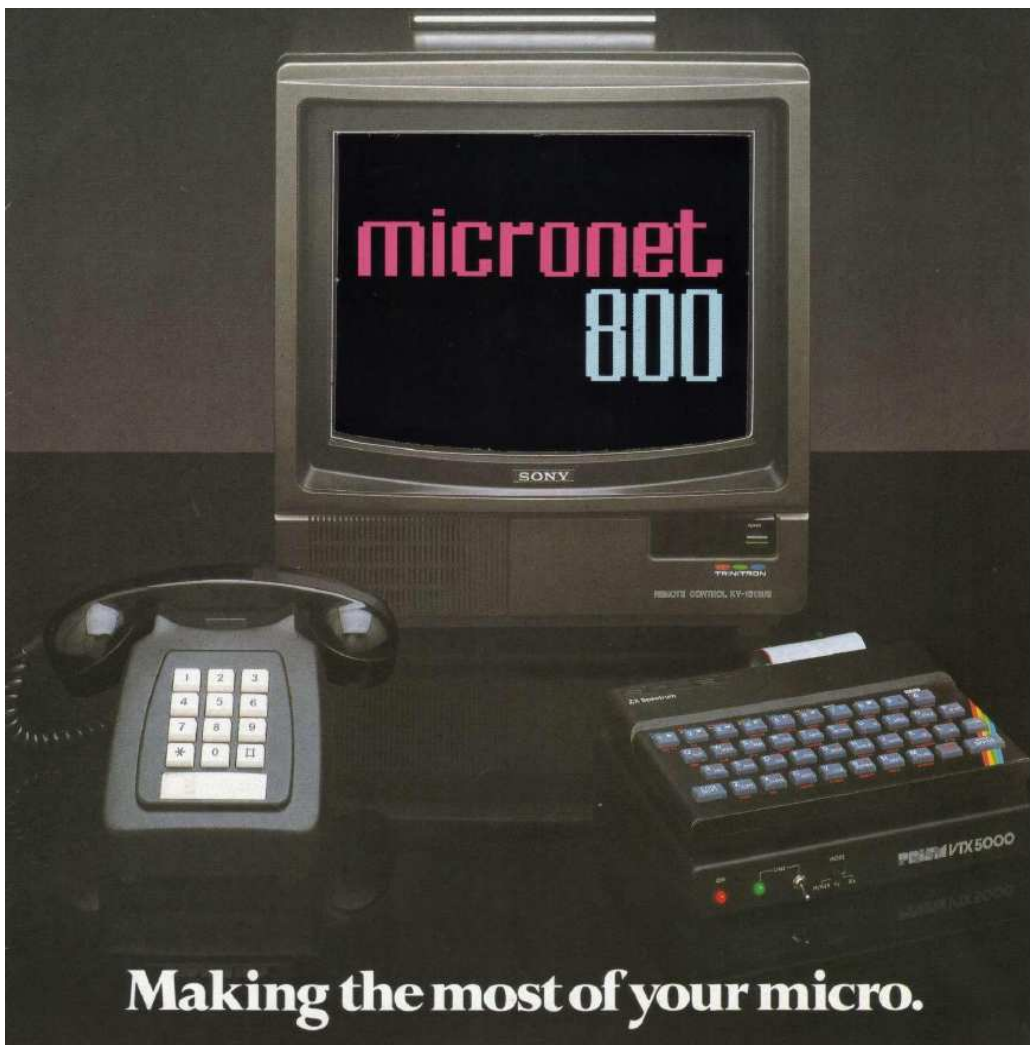


Fig. 10. A ZX-Spectrum computer connected to Prestel. Source: Prestel promotional brochure. In 1983, Prestel introduced its electronic mail system MAILBOX and electronic distribution of software Telesoftware providing programs for the BBC computers.

Almost 100,000 subscribers booked by Prestel by the end of the 1980s, were far below the "millions" of subscribers projected when the service was launched. Financial constraints forced the company to introduce some highly unpopular fee restructuring and that resulted in home users giving up their subscriptions. Prestel closed its operations in the early 1990s at the time

when the first Web pages were being offered on the Internet.

### **The NABU Network**

was designed and implemented by an Ottawa-based company NABU Manufacturing Corp. between 1981 and 1983. The network was a brainchild of a Canadian entrepreneur John Kelly, the president and chief executive of a NABU Manufacturing.

Once connected to the network, a user could choose from various application programs and services in categories including entertainment (mostly computer games), information and guides, education (including education programming for schools), and professional programs (ranging from home financing to programming languages). And all of that for an affordable monthly subscription fee.



Fig. 11. NABU PC. Source: York University Computer Museum.

The programming selection was accomplished by the navigation of various menus. The NABU Network had rudimentary search and help engines.

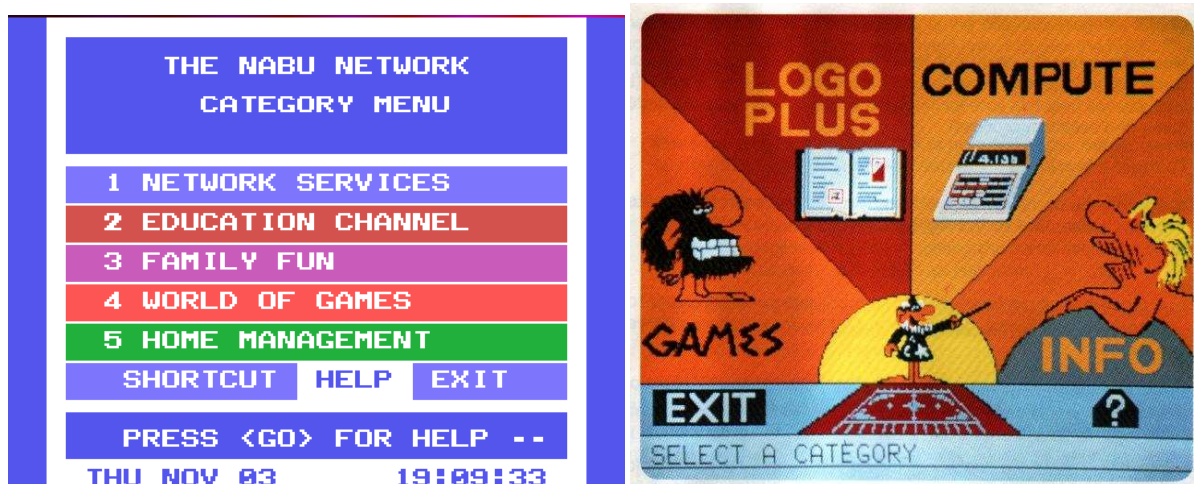


Fig. 12. NABU Network navigation menus: 1983 version (left) and 1982 version (right). Source: York University Computer Museum.

Dedicated NABU magazines, newsletters, programming guides, and user groups provided subscribers with supplementary information and support. The NABU PC could also be used as a stand alone personal computer.

NABU Manufacturing was among the first companies to explore the idea of providing fast and more interactive electronic services to individuals, based on the convergence of microcomputer and communications technologies. NABU considered cable television and satellite communication uniquely ideal technologies to deliver software and data to home computers because of their high bandwidth and networking capabilities.

### NABU time-line

- 1982: NABU network announced during the National Cable & Telecommunications Association conference in Las Vegas;
- 1983, May: NABU transmitted its programming via satellite from Ottawa to NABU computers at the 26th Annual Convention of the Canadian Cable Television Association, in Calgary;
- 1983, October 15: NABU Network was launched on Ottawa Cablevision

Ottawa's Nabu Manufacturing Corp. has launched its Nabu Network, a home computing system that transmits video games, educational software and household information over cable television into the home.

wrote the Ottawa daily *The Citizen* that day.

- 1984, January: the NABU Network made its U.S. debut in Alexandria, VA on Tribune Cable;
- 1985 : NABU signed an agreement with Japanese ASCII Corporation to field test the NABU Network in Sowa
- 1986, August: financial difficulties led NABU to close down its operations. However, the broadcasting technology built up at NABU was acquired, developed, and successfully deployed internationally by International Datacasting of Kanata, Ontario.



Fig. 13. A family surfing the NABU Network. Source: NABU Manufacturing, promotional literature.

NABU's long-term objective was to develop a global North American network interconnecting, via satellite, NABU Network subscribers served by different cable TV providers across North America. Subscribers to NABU services were to interact with each other (e-mail, interactive games played over the network), and with externally located data bases, and anyone else who wished to communicate via NABU Network.

## WWW

Newsweek's special report entitled *How the Internet is Changing America* published on September 20, 1999, begins with the question about the main factor that moved the American society into the information age:

Was there a single moment when we turned the corner? When we moved from a culture centered on network television, phones with wires, information on paper and stock prices based on profit into a digital society of buddy lists, streaming video, Matt Drudge and 34-year-old billionaires in tennis shoes?

The change was sudden—it happened over a short period of two or three years, between 1993 and 1996—but when it came, it "digitized" North America and, soon, the rest of the world.

The Internet has its roots in ARPANET— a 1969 ARPA project. For the next 20 years the ARPANET existed primarily as a research network for universities and governmental agencies. The network "was to be used solely for the conduct of or in support of official U.S. Government business." That, of course, severely limited commercial use of this network (see [5]) and that's why private companies created several networks of their.

In 1986, National Science Foundation (NSF) launched its NSFNET computer network with the purpose of linking American supercomputing centers that were federally funded. Eventually, NSFNET grew beyond supercomputing and connected thousands of computers in academia, governmental agencies, and industry with each other and with ARPANET. It became the backbone of the Internet through which other networks were interconnected.

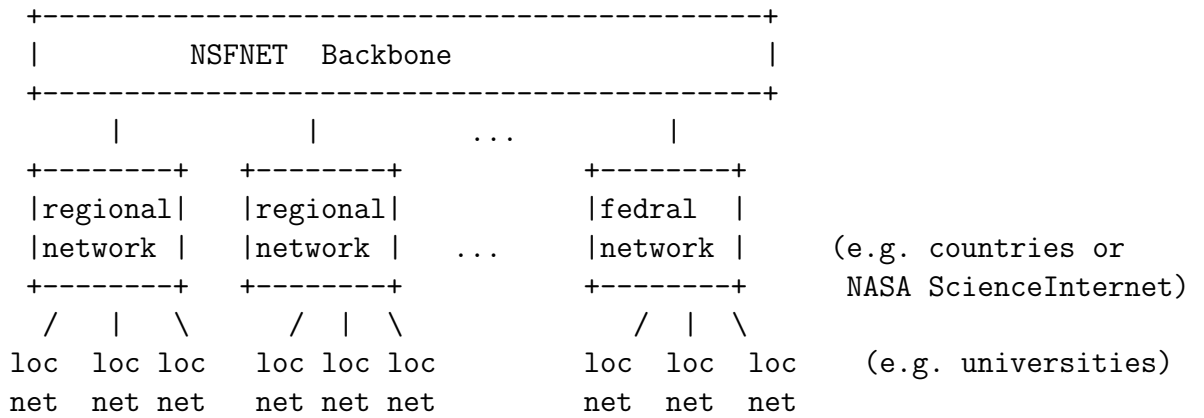


Fig. 1. The architecture of the Internet c. 1991. After [8], Figure 1.

The designers of the NSFNET decided to use the TCP/IP protocol and the idea of the Internet was realized. However, until its privatization in mid 1990s, the network of networks, operated in the US by NSF, was closed to for-profit business.

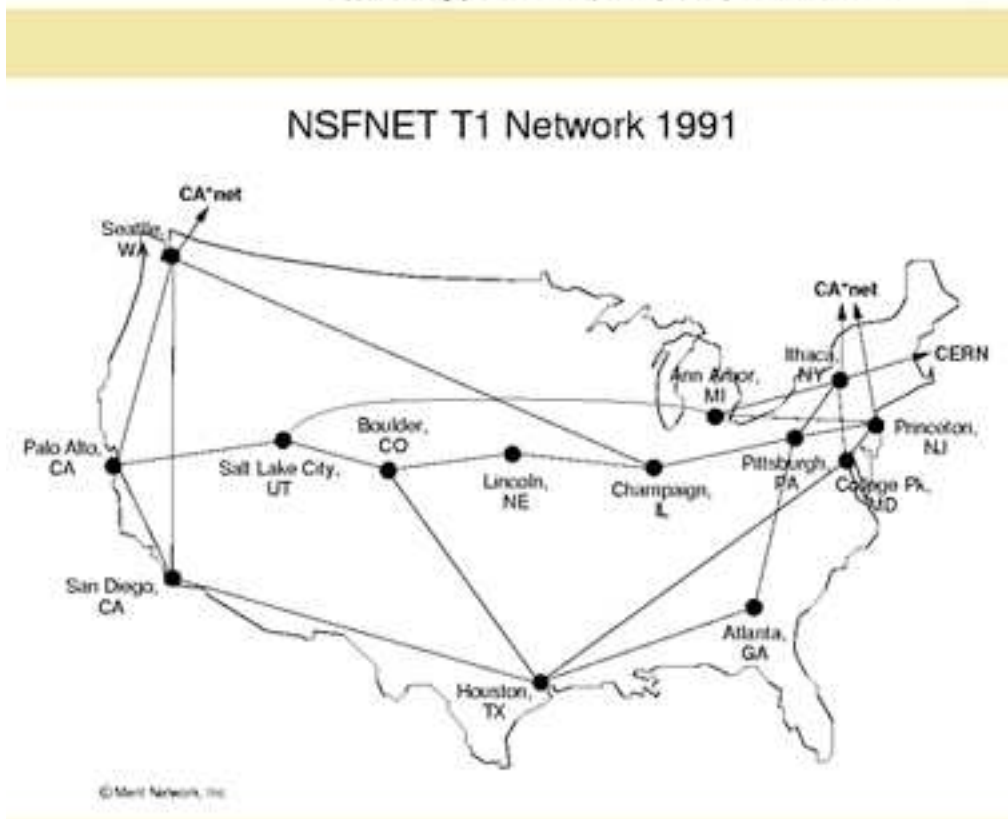
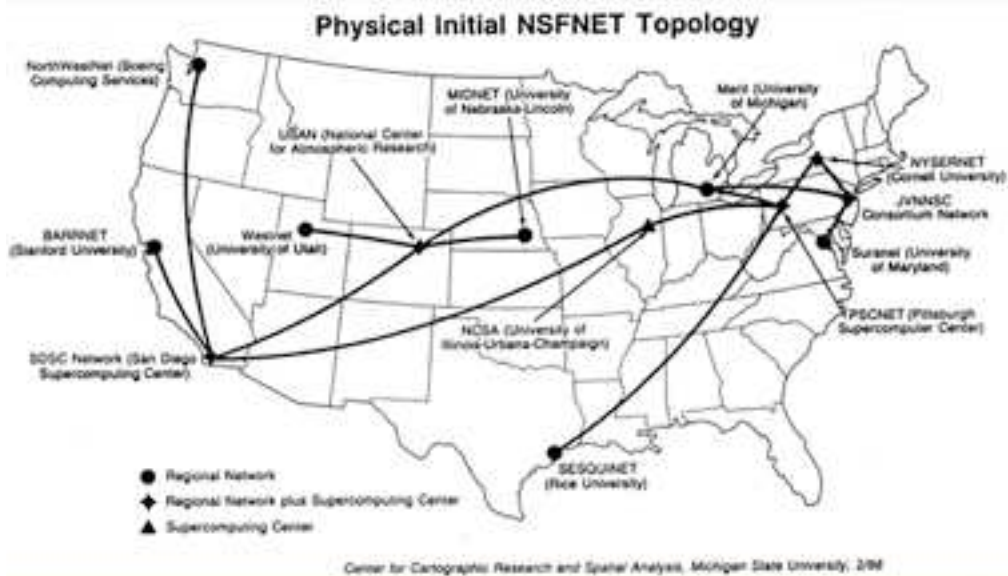


Fig. 13A. NSFNET in 1991. Source: unknown.



After its privatization, the Internet use increased dramatically. In 1985, there were approximately 21,000 Internet users world wide, mostly in academia and governmental agencies. By 1990, the number of Internet users world-wide grew to 2.13 million and, by 1995 reached 45.1 million. By 1999, there were almost 200 million users. In this short period of time, between 1993 and 1996,

the Net became "in effect the world's grandest public utility, driven by a combination of cheap, powerful PCs, a remarkably scalable infrastructure..., and easy-to-use browsing software. [*Newsweek*, *ibid.*]

The dramatic rise in the use of the Internet in the 1990s has other roots as well. In the 1980s, at the time when CompuServe, Prestel, and NABU were offering their extensive on-line networking services, the Internet was still a web of a few interconnected networks following the TCP/IP protocol. Users could use electronic mail and access other networked computers and transfer files using, say the File Transfer Protocol (FTP). They could also access special interest user groups forming the so-called Usenet (still in existence). However, there were no search engines which meant that locating information on the early Internet was not an easy task.

The first programs to help in navigation of the Internet (i.e. locating files) were created in the early 1990s (GOPHER developed at the University of Minnesota to distribute, search, and retrieve documents over the Internet can serve as an example). They were of limited use (text based) but made Internet even more attractive.

The second element of the modern Internet that was missing in the 1980s was some uniform way of organizing and accessing ever-increasing amount of information available on the Net. Such organization was essential to expand the Internet's functionality. The early Internet was focused on file transfer. Folders of files deposited in a computer memory had no logical dependencies other than the fact that they belonged to the same folder. The solution to the information organization problem on the Internet would arrive in 1991 from Europe.

Between 1989 and 1991, at the European particle physics laboratory (CERN) located on the Swiss-French border near Geneva, a British physicist and computer scientist Tim Berners-Lee proposed and implemented a new way of arranging information on the Internet. He called his Internet web system the World Wide Web (or WWW).

WWW has its roots in earlier ideas on the so-called hypertext (V. Bush, D. Englebart, T. Nelson) and in his earlier prototype system ENQUIRE. Hypertext pages rather than files were to be used as "units of information". "In November 1990, Berners-Lee and Robert Cailliau co-authored a design document that explained their view on hypertext. "Hypertext is a way to link and access information of various kinds as a web of nodes in which the user can browse at will." The document also explained how documents (pages) would be interwoven "The texts are linked together in a way that one can go from one concept to another to find the information one wants. The network of links is called a web."

WWW introduced important new networking concepts:

- Hypertext Transfer Protocol (or HTTP), replacing FTP (or File Transfer Protocol);
- Uniform Resource Locator (or URL), to reference ("locate") an Internet resource (e.g.  
`http://www.cse.yorku.ca/museum` ( `protocol://server_name/path`)

locates York University Computer Museum's page; this URL "address" states that the protocol to be used to view the museum's page is http, that the server hosting the museum's page is cse.yorku.ca and that the museum's Web pages are in the folder "museum");

- Hypertext Markup Language (HTML), a language for composing Web pages in such a way that they could be correctly interpreted, composed, and displayed on the screen text; the language also specifies how to link pages (using "hyperlinks") so that a user can "jump" from one resource to another.

So, WWW is a giant web of hypertext pages with links interwoven among them, a hypertext web overlaid on Internet. For example, a document on smartphone use in Canada, and hosted on one of the servers in Toronto, might be linked to one in hosted on a server in New York which, in turn could be linked to a text on Samsung and hosted by a server in Tokyo.

HTML provides a list of tags used to compose (and interpret) Web pages. Here is a simple example of a page with HTML tags and its interpretation by a browser:

```
<b>Example</b>
<br>
<ul>
  <li> numbers,
  <li> calculators,
  <li> computers.
</ul>
To see more <A HREF="nats1700/test1_sample.pdf"> click here.</A>
```

### Example

- numbers,
- calculators,
- computers.

To see more [click here.](#)

Fig. 14. HTML-interpreted sample page.

The World Wide Web was released for use at CERN in May 1991 and announced on several Internet user groups in August of that year. WWW did not succeed immediately. First, in 1991, there was just one Web site at CERN and a few Web pages. Second, early browsers were still text-based and could not handle complex objects such as images. Finally, to satisfy Berners-Lee's objective to create inclusive rather than exclusive Web, the Internet had to be populated with information of interest to microcomputer users and provided with more sophisticated browsers. Although there was much discussion

on the Internet (mostly in hypertext community) about a new way of organizing and accessing information on the Net, but it was the Internet Gopher that was getting most of the attention: it was graphical, available, and could access the existing Internet sites while there were no WWW browsers, no substantial number web pages. The only WWW browser was a single line display-based tool which could not even make use of simple full-screen functions. There were also problems with installation of WWW servers (difficult!)

The first WWW browser that made the navigation of the Web both effective and simple was Mosaic. It was developed by a student Marc Andreessen and a young programmer Eric Bina at the National Center for Supercomputing Applications (NCSA) at the University of Illinois and released in January 1993. Mosaic was free: anybody who could connect to the publicly accessible NCSA computer could download a copy of the browser free of charge. Mosaic was easy to install and could handle not only the new WWW protocol but also most of the significant protocols of the day: FTP and Gopher. Mosaic was simple to operate and could display images. The navigation was done using a mouse; hyperlinks were distinguished from other textual material by their color. The browser was an instant success and its popularity was a significant factor in turning public's attention towards the WWW. The development of Mosaic made accessing sites throughout the world as simple as point and click. Between 1993 and 1995, most leading newspapers such as *The New York Times* helped to popularize Mosaic and the Web browsing. To many users, the Web was synonymous with Mosaic.

By 1995, WWW offered a new and exciting free-for-all model of information accessing and electronic services – an information superhighway. It would be the role of another browser–Netscape Navigator, released in December 1994 as a free download–to gain public's trust and to create the foundations of e-Commerce. The main advantage of Navigator over the Mosaic was that browsing with Netscape could be made secure and that opened the gate to extensive commercial applications of the Internet. Without secure communication, there would be no secure transactions of any kind and no e-Commerce. It was the Navigator and, soon after, the Microsoft's Explorer that opened up the Internet to private users and business.

By 1995, there were 25 major WWW browsers just for the PC and the Mac platforms (including Mosaic, Netscape, InternetWorks, MacWeb, Microsoft Explorer, and WebExplorer). Two Internet killer applications: e-mail and browsers made the Net irresistible. While there were just a few WWW servers in 1993, that number climbed to over 3000 by mid 1994.

Why did WWW win? The flexibility and ease of use of Mosaic and Netscape was one of the major contributing factors to the success of WWW and dethroning other successful protocols such as Gopher. Another was its multiplatform: Unix, Windows, Mac users could have an access to the Internet via Mosaic. Finally, the "seamless integration of linked graphics, audio, and video made creating Web sites and accessing the Web both fun and interesting." [?]

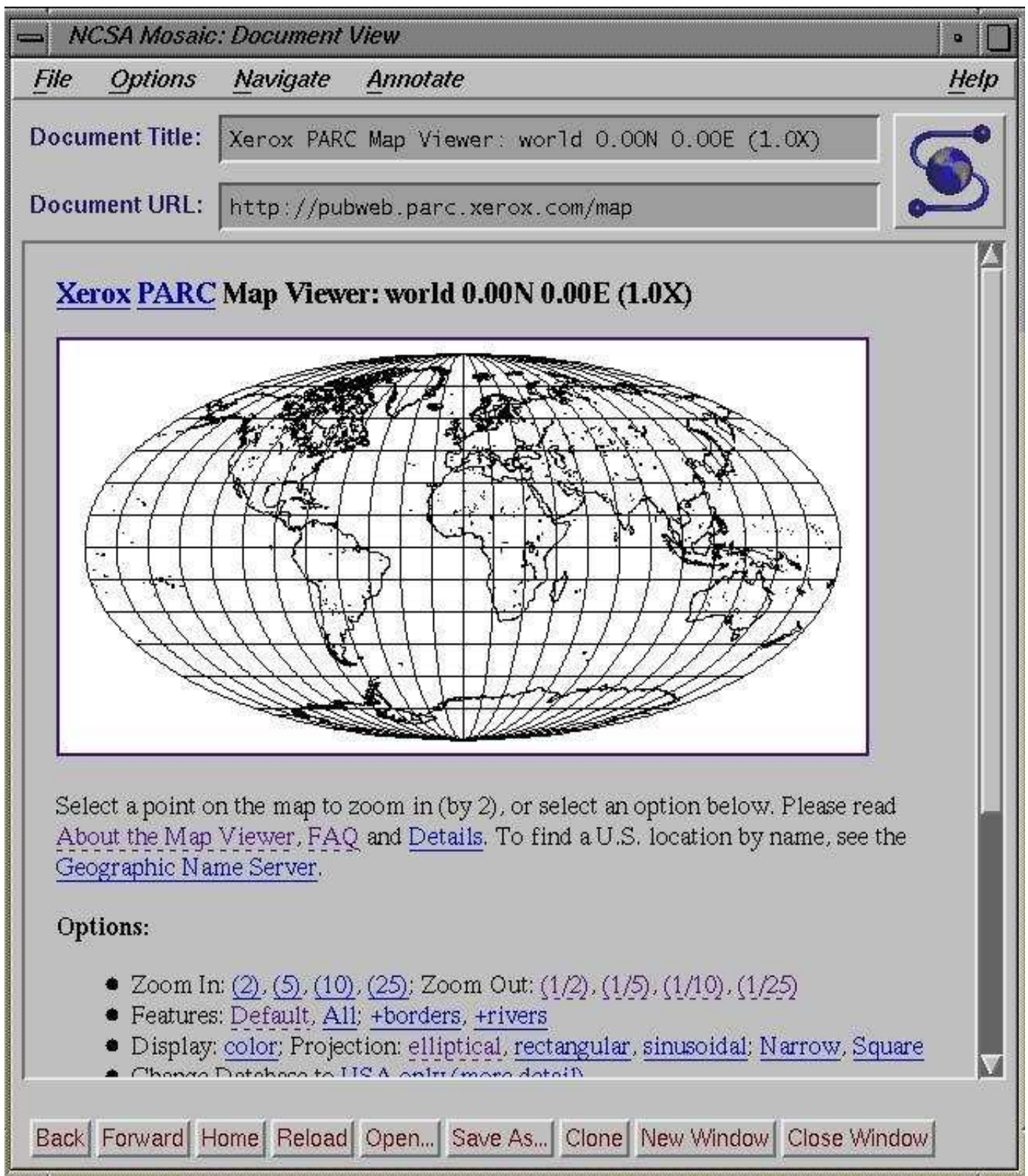


Fig. 15. A Mosaic screen shot. Source:  
<http://www.nic.funet.fi/index/FUNET/history/heureka/en/1993.html>.

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