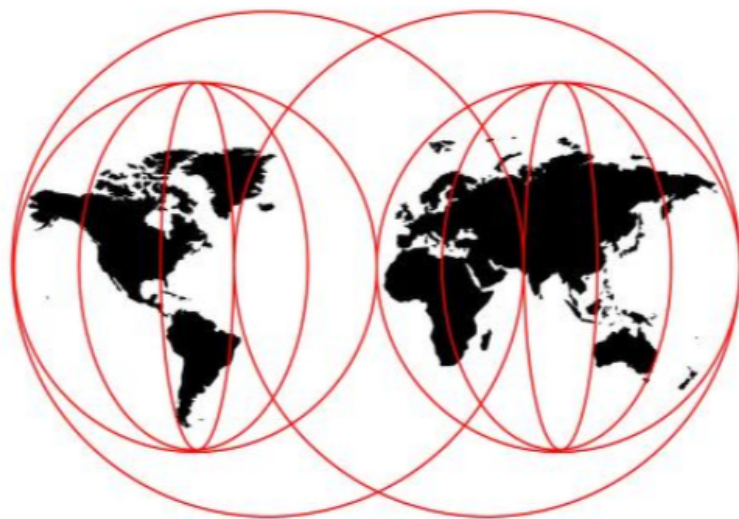




## TCP/IP Tutorial and Technical Overview

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**Take Note!**

Before using this information and the product it supports, be sure to read the general information in Appendix A, "Special Notices" on page 673.

**Sixth Edition (October 1998)**

This edition applies to Transmission Control Protocol/Internet Protocol (TCP/IP) in general and selected IBM and OEM implementations thereof.

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### 1.1.1 Internetworks

Those original designers, funded by the *Defense Advanced Research Projects Agency* (DARPA), of the *ARPANET protocol suite* introduced fundamental concepts such as *layering* and *virtualizing* in the world of networking, well before ISO even took an interest in networking.

The official organization of those researchers was the ARPANET Network Working Group, which had its last general meeting in October 1971. DARPA continued its research for an internetworking protocol suite, from the early *NCP (Network Control Program)* host-to-host protocol to the TCP/IP protocol suite, which took its current form around 1978. At that time, DARPA was well known for its pioneering of packet-switching over radio networks and satellite channels. The first real implementations of the *Internet* were found around 1980 when DARPA started converting the machines of its research network (ARPANET) to use the new TCP/IP protocols. In 1983, the transition was completed and DARPA demanded that *all* computers willing to connect to its ARPANET use TCP/IP.

DARPA also contracted Bolt, Beranek, and Newman (BBN) to develop an implementation of the TCP/IP protocols for Berkeley UNIX on the VAX and funded the University of California at Berkeley to distribute that code free of charge with their UNIX operating system. The first release of the *Berkeley Software Distribution* to include the TCP/IP protocol set was made available in 1983 (4.2BSD). From that point on, TCP/IP spread rapidly among universities and research centers and has become the standard communications subsystem for all UNIX connectivity. The second release (4.3BSD) was distributed in 1986, with updates in 1988 (4.3BSD Tahoe) and 1990 (4.3BSD Reno). 4.4BSD was released in 1993. Due to funding constraints, 4.4BSD was the last release of the BSD by the Computer Systems Research Group of the University of California at Berkeley.

As TCP/IP internetworking spread rapidly, new wide area networks were created in the U.S. and connected to ARPANET. In turn, other networks in the rest of the world, not necessarily based on the TCP/IP protocols, were added to the set of interconnected networks. The result is what is described as *The Internet*. Some examples of the different networks that have played key roles in this development are described in the next sections.

### 1.1.2 The Internet

What exactly is the Internet? First, the word *internet* (also *internetwork*) is simply a contraction of the phrase *interconnected network*. However, when written with a capital "I" the Internet refers to a worldwide set of interconnected networks, so the Internet is an internet, but the reverse does not apply. The Internet is sometimes called the *connected Internet*.

The Internet consists of the following groups of networks (see the following sections for more information on some of these):

- **Backbones:** large networks that exist primarily to interconnect other networks. Currently the backbones are NSFNET in the US, EBONE in Europe, and large commercial backbones.
- **Regional networks** connecting, for example, universities and colleges.
- **Commercial networks** providing access to the backbones to subscribers, and networks owned by commercial organizations for internal use that also have connections to the Internet.

- Local networks, such as campus-wide university networks.

In many cases, particularly for commercial, military and government networks, traffic between these networks and the rest of the Internet is restricted (see also 5.3, "Firewalls" on page 280).

### 1.1.3 ARPANET

Sometimes referred to as the "grand-daddy of packet networks," the ARPANET was built by DARPA (which was called ARPA at that time) in the late 60s to accommodate research equipment on packet-switching technology and to allow resource sharing for the Department of Defense's contractors. The network interconnected research centers, some military bases and government locations. It soon became popular with researchers for collaboration through electronic mail and other services. It was developed into a research utility run by the Defense Communications Agency (DCA) by the end of 1975 and split in 1983 into MILNET for interconnection of military sites and ARPANET for interconnection of research sites. This formed the beginning of the "capital I" Internet.

In 1974, the ARPANET was based on 56 Kbps leased lines that interconnected *packet-switching nodes* (PSN) scattered across the continental U.S. and western Europe. These were minicomputers running a protocol known as *1822* (after the number of a report describing it) and dedicated to the packet-switching task. Each PSN had at least two connections to other PSNs (to allow alternate routing in case of circuit failure) and up to 22 ports for user computer (*host*) connections. These 1822 systems offered reliable, flow-controlled delivery of a packet to a destination node. This is the reason why the original *NCP* protocol was a rather simple protocol. It was replaced by the TCP/IP protocols, which do not assume reliability of the underlying network hardware and can be used on other-than-1822 networks. This 1822 protocol did not become an industry standard, so DARPA decided later to replace the 1822 packet switching technology with the *CCITT X.25* standard.

Data traffic rapidly exceeded the capacity of the 56 Kbps lines that made up the network, which were no longer able to support the necessary throughput. Today the ARPANET has been replaced by new technologies in its role of backbone on the research side of the connected Internet (see NSFNET later in this chapter), whereas MILNET continues to form the backbone of the military side.

### 1.1.4 NSFNET

NSFNET, the National Science Foundation Network, is a three-level internetwork in the United States consisting of:

- The *backbone*: a network that connects separately administered and operated mid-level networks and NSF-funded supercomputer centers. The backbone also has transcontinental links to other networks such as EBONE, the European IP backbone network.
- *Mid-level networks*: of three kinds (regional, discipline-based and supercomputer consortium networks).
- *Campus networks*: whether academic or commercial, connected to the mid-level networks.

#### First Backbone

Originally established by the National Science Foundation (NSF) as a communications network for researchers and scientists to access the NSF supercomputers, the first NSFNET backbone used six DEC