Encyclopedia of New Media

Internet

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The Internet is the global, interconnected network of computer networks that has in the past decade spawned radical changes in the way people communicate, retrieve and publish information, work, shop, and live. Because of the way that the Internet connects powerful computers, PCs have ceased to exist as stand-alone boxes of information-processing tools, and have instead become perhaps the most complete communications appliances ever devised. In recent years, the Internet has slowly spread to other devices such as cell phones, handheld personal digital assistants (PDAs), and laptop PCs, bringing about the promise of a constant connection to a universe of information.

Arpanet

The Internet has its roots in the ARPANET, a small network of unwieldy mainframe computers that, beginning on October 29, 1969, connected two computers—one at the University of California–Los Angeles, the other at the Stanford Research Institute in San Francisco, hundreds of miles away. Other mainframe computers, or “nodes,” were added later at various universities, corporations, and U.S. government installations, so that by 1972 there were some 31 nodes, or host computers, connected to the ARPANET.

The ARPANET was funded by the U.S. government's Advanced Research Projects Agency (ARPA), a small agency under the umbrella of the U.S. Department of Defense that was formed by President Dwight D. Eisenhower in the wake of the Soviet Union's launch of Sputnik, the first telecommunications satellite. The agency was given wide latitude, and the funding to concentrate on whatever projects it wanted. By the early 1960s, under the guidance of the agency's visionary director J. C. R. Licklider, ARPA had changed focus from outer space to unmasking the potential of computer technology as an aid in human problem-solving, even on the grandest of scales. As part of his vision, Licklider foresaw what he called an “intergalactic network” of computers that could communicate and share information all over the planet.

Subsequent ARPA directors, most importantly Robert Taylor, picked up on Licklider's ideals. With one 20-minute conversation, Taylor procured $1 million from his supervisors to build and launch the first long-distance, computerized network to connect ARPA with the various research agencies that it was funding. In 1966, Taylor recruited Larry Roberts away from Lincoln Laboratories, where he had been working on computer graphics, to head up the team that would design, build, and implement the ARPANET. Roberts in turn put the project up for competitive bids, and selected a small Cambridge, Massachusetts, consulting firm, Bolt Beranek and Newman (BBN), to bring the ARPANET project to fruition.

The ARPANET was built on an innovation that would also serve as the basis for the wider Internet. In 1961, an engineer named Paul Baran had devised a system for the transmission of information through phone lines that involved breaking messages up into “blocks”; British researcher Donald Watts Davies independently came up with an almost identical breakthrough, but he referred to divided message bits as “packets,” the name that would stick. Baran's idea was built on the notion that, in order to create a computerized system that would survive a nuclear **[p. 248 ↓]** attack, decentralization was needed. He devised a way to split up information so that it would flow over the phone lines according to the route the served as the shortest and least congested path. A computer on the other end would reassemble the blocks, and present the message to the receiver in a way that could be properly read.

In 1999 Professor Leonard Kleinrock poses with the first network switch, or IMP, created in 1969. Kleinrock is gesturing to his watch to point out that the watch has a more powerful microprocessor than the IMP. (AP Photo/Mark J. Terrill)

Roberts adopted the Baran/Davies packet idea for ARPANET, as well as Baran's notion of decentralization. A problem, however, was that computers at the time were universes unto themselves—most were built with unique operating systems, and even computers made by the same individual manufacturers were often completely incompatible. BBN's solution was to insert computers, interface message processors (IMPs), at various points on the nascent network that had no other function but to intercept message packets, determine where they were to go, check for errors, and then forward the packets onto the receiving machine. To do this, a computer program, or "protocol," needed to be devised to determine how these IMPs would communicate with the computers on either end. This protocol, in turn, made it possible for even incompatible computers to communicate with one another, using the IMP as a kind of silent interpreter. BBN's IMPs, then, were the basis for what eventually became the modern networking router.

The ARPANET went through many changes in the early 1970s, as more host facilities joined the network. One of the most important was the rise of email as the "killer app" (most popular application) of the network; a 1973 study indicated that 75 percent of all ARPANET traffic was made up of email posts.

However, despite its revolutionary traits, ARPANET was limited in important ways. For most, it represented more a sealed fence than an open gateway. Firstly, it had been designed for a maximum of about 19 host sites, and there was a threat of potentially fatal traffic congestion bringing the system down if too many people came onboard at once. Also, the ARPANET was open mainly to research facilities and companies that performed U.S.-government-funded research, most of it for the Department of Defense. One response to these limitations was to begin forming new networks, separate from the ARPANET.

ARPA (now known as "DARPA" for Defense Advanced Research Projects Agency) funded the first new networks, including the radio-based ALOHANET and the satellite-based SATNET; both of them, like ARPANET, relied on the Baran/Davies packet scheme. But neither of the new networks was capable of communicating with the other; each functioned under its own protocols. History seemed to be repeating itself, except that the inability to communicate now impacted entire networks of computers, rather than individual machines.

Networking the Networks

Vinton Cerf, who once had been a graduate student on the original ARPANET project, provided a solution to the new communication difficulty; Robert Kahn, a former member of the BBN team who had moved over to ARPA, helped him. Based on Cerf's initial idea, the duo designed a new networking protocol in 1974 that would allow incompatible networks to communicate with other networks around the world. It was based on two innovations. First, networks would communicate through “gateway” computer interfaces that would understand what each of the networks was saying, and would seamlessly forward information from one network to the next; the end user would never know that the gateway was there.

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Second, Cerf and Kahn refined the packet concept, devising a system in which host computers would send packets in “electronic envelopes” that were specially addressed to reach their destinations. The gateway would read only the envelope, not the content of the message, greatly speeding up transference from one host computer to another. This eliminated the step of re-transmitting data, which had been used by APRANET's IMPs. What Cerf and Kahn were creating was simply a forward-and-store system. If it worked, Cerf and Kahn both knew, the protocol that they dubbed “Transmission Content Protocol” (TCP) could open the world to an unprecedented, interconnected universe of information.

TCP was first demonstrated in July 1977, linking ARPANET, ALOHANET, and SATNET in an experiment that sent messages through all the networks, far overseas and back to the United States, without losing a single packet of information. Later, in 1978, Cerf, researcher Jon Postel, and several others revised TCP by separating out all the pieces of the protocol that dealt with routing packets and combining them into a simplified twin protocol, Internet Protocol (IP). With the rise of TCP/IP, the foundation was laid for today's Internet.

Parallel to Cerf and Kahn's work with what became TCP/IP, a Harvard doctoral candidate named Bob Metcalfe discovered a way to create high-speed networks of computers within a single building, agency, or company. This was Ethernet, which borrowed part of its design from ALOHANET, but which differed in that it was completely “hardwired,” meaning that all of the computers in the facility would be tethered to high-speed data cables. Metcalfe was allowed to test his concept in 1973 on computers at the Xerox Palo Alto Research Center (PARC) in California. The first Ethernet network, then known as the “Alto Aloha System,” was formed there.

Ethernet eventually became one of the key reasons for the Internet's growth; rather than connecting one mainframe computer at a time to networks like the ARPANET, Ethernet connected all computers in a building together, allowing them to share all the information they contained with one another. In turn, a router pointed outward to a larger computer network, vastly increasing the number of host computers capable of communicating with the world. Xerox began selling Ethernet as a commercial product in 1980, and Bob Metcalfe became a rich man.

Gradually, more networks formed. In 1977 at the University of Wisconsin, Larry Landweber created the THEORYNET, which provided email to more than 100 computer-science researchers. In 1979, the online news network USENET launched, connecting Duke University and the University of North Carolina through the Unix-to-Unix Copy (UUCP) protocol. The Packet Radio Network (PRNET) followed that same year. Also in 1979, Landweber organized a conference of computer scientists who were tired of being shut out of the ARPANET, and who wanted to form their own research network. The conference was attended by representatives of DARPA and of the National Science Foundation (NSF); CSNET formed in 1981 as a result, funded by the NSF. While the CSNET itself would be relatively short-lived, it demonstrated for the NSF's board the importance of computer networking, and the role that NSF could play.

Many more networks formed, often firmly relying on the TCP/IP protocol. Among these were the BITNET (Because It's Time Network), the EUNet, the Fidonet, the JUNET, and the JANET. Even within the U.S. government and separate from the ARPANET, NASA had its own network, the Space Physics Analysis Network. Private research institutions and corporations began building networks as well.

The year 1983 was the turning point: In that year, it was decided that every computer on the ARPANET would have to switch from the network's original transmission protocol

(Network Control Protocol, or NCP) to Cerf and Kahn's TCP/IP. The ARPANET was no longer the closed, impenetrable network it had been; now, to borrow Cerf's phrase, “it could go where no network had gone before.” It also became so big as a result of the switch that the ARPANET was split into two pieces in 1983, one for unclassified military information (MILNET), the other retaining the ARPANET name. However, the two could still communicate with one another, making the ARPANET itself a genuine “internet.”

With network communications restrictions erased, the number of networks began to proliferate rapidly. By 1996, Cerf would later write, there were some 100,000 separate networks, almost all using TCP/IP, and almost all capable of communicating easily with all the others.

There was one final development in the 1980s that helped to permanently shape the Internet. After five supercomputer centers opened in 1985, the NSF agreed to build a “backbone network” connecting them. In addition, it allowed regional academic networks to form that could tap into this backbone, **[p. 250 ↓]** NSFNet, for free. Taking advantage of a spine that employed lines that were 25 times faster than the old ARPANET, anyone on a college campus with a computer could connect to the Internet. Researchers now had a choice to make between the ARPANET and NSFNet; not surprisingly, most chose the latter.

There had been no single point at which the Internet had been created, but it was clear by the end of the 1980s that the Internet existed. So robust was this network of networks by the end of the decade that, unable to compete with NSFNet, ARPANET was mothballed. Its unplugging, while unsettling to some of the pioneers who had built it, had no measurable effect on the rest of the Internet, which only continued to grow.

Global Internet

By 1990, the network of networks was a global affair, and to some it appeared that all its important innovations were behind it. Now, it seemed, it was just a matter of getting computers in people's hands so they could take advantage of all that the Internet had to offer—everything from the file-transfer protocol (FTP), which allowed users to shift files from computer to computer, to the Telnet, which allowed users to open sessions on other computers on the network, in effect using other computers through one's own keyboard. There was also Internet Relay Chat (IRC), the first widely used chat program, as well as the thousands of newsgroups on the USENET.

However, the greatest Internet innovation, the one that would spark the Internet revolution, was still to come, in the form of Tim Berners-Lee's World Wide Web, coupled with the Mosaic browser that made viewing the Web and taking advantage of the Internet's full multimedia capabilities a snap—assuming the user had access to sufficient bandwidth. With the evolution of the Web in the early 1990s, the public finally “got it.” Concurrently, in 1993, the NSF, at the urging of the Clinton administration, relaxed its ban on commercial activity on the Internet. The medium exploded.

By the turn of the century, the Internet had spent 10 years morphing from a phenomenon and media sensation into something so popular and universal as to resemble a common household utility, like water or telephone service. Untold millions of people now use the medium to create private Web pages, read news, chat, send instant messages, distribute email, research purchases, buy Christmas presents. It has brought incredible benefits to society, while also adding to its problems.

At the same time that it has brought the Library of Congress to the fingertips of every computer-savvy child, it also has made pornography, anarchic sloganeering, and racial hatred easier to access as well. The Internet has made music available directly to audiences via download, but has also disrupted the music industry, which has seen many songs swapped online by people who aren't paying for the privilege. It has made security and privacy keen issues, and it has created new forms of crime and terrorism. Still, given the Internet's vast and rising popularity, society seems willing to make the tradeoffs to remain online.

The Nielsen/NetRatings firm estimated that the Internet population had risen from a mere 2,000 or so privileged researchers in 1973 to 428 million people worldwide by April 2002. That number can be expected to continue growing in the coming decade, especially as newer, more inexpensive technologies emerge that allow people to carry the Internet with them wherever they go, using cell phones, pagers, Internet appliances, laptops, and PDAs. One of the most profound media innovations of any century, the

Internet shows no signs of being the fad that some critics once accused it of being. The Internet, it now seems clear, is here to stay.

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Related Topics

- Berners-Lee, Tim
- BITNET
- Browser
- Cerf, Vinton
- Cyberspace
- Email
- Human-Computer Interaction
- Hypertext
- Interactivity
- Interface
- Internet Engineering Task Force
- Licklider, J. C. R.
- Peer-to-Peer
- Rheingold, Howard
- Satellite Networks
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- Virtual Community
- World Wide Web

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