# 34

# MULTIMEDIA

## 34.1 EVOLUTION LEADING TO MULTIMEDIA

Multimedia results from the convergence of information technology and telecommunications. Basically, multimedia is the technology of processing voice, audio, text, still and live images, and data in an integrated format for presentation at a common terminal. Multimedia networks give access to databanks, bank accounts, shopping catalogs, educational services, medical assistance, and various other services.

In the 1980s, two early forms of multimedia services emerged, teletext and videotex, with electronic still-image transmission services which provided access to computer-supported databases. In *teletext*, still images were transmitted in several scan lines of a television signal and stored in a memory for subsequent display on a television screen. Teletext is still used in television systems.

In *videotex*, still images are transmitted digitally over the public-switched telephone network. At the receiver, the digital signal is recovered from a modem and stored in a local memory, again for subsequent display on a television screen. The first videotex system was the French Télétel system, which after a decade of development was introduced in 1982. It became very popular. In a unique approach the French administration provided the terminals, named *Minitel*, free of charge to the subscribers. Initially, the service offered an electronic telephone directory and a limited number of information pages. It expanded quickly, and creating a Minitel service became a priority for French businesses. It reached 3.3 million subscribers within seven years and 6.3 million subscribers and over 17,000 servers in 1992.

Minitel use peaked in 1998, and despite fierce competition from the Internet, 26% of French households were still connected with Minitel and only 17% to the Internet at the end of the century. The Minitel services can be divided into four broad categories. Thirty-six percent of the services are practical: timetables, e-commerce, general information, and directories. Entertainment, including chat, dating services known as *Minitel rose*, astrology, and games, accounts for 21%; financial services amount to 22%; and 21% are professional database services.

Even if Minitel, with only 1 million videotex subscribers outside France, was not successful internationally, it obtained worldwide fame. U.S. Vice-President Al Gore, a long-time promoter of global information flow, wrote his thesis on the Minitel system. By the end of the century, videotex, with the exception of Minitel, was integrated into Internet.

In the 1990s, the telecommunication networks went through an evolution whereby in a convergence of *computers and communications* and in interaction with the construction of a *global information infrastructure*, a global network emerged called the *Internet*, which hopefully will unite the world population in a *global village* in which *multimedia* services can give everybody the right answer to her or his question in a matter of seconds at an affordable cost.

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## 34.2 COMPUTERS AND COMMUNICATIONS

The concept of *computers and communications* (C&C) was first presented in 1977 by Koji Kobayashi, then chief executive officer and president of the board of NEC, at Intelcom 77 (International Telecommunication Exhibition) held in Atlanta, Georgia. Kobayashi envisaged that computers would become an integral part of communications networks. He predicted that computers would merge to processors distributed in total communications systems with digitized switching and transmission. He gave lectures in Atlanta and at other international conferences: in 1978 in San Francisco, 1981 in Washington, 1982 in Helsinki, and 1983 at the 4th World Telecommunication Forum held in Geneva. The lectures were compiled in an interesting book published in 1985 by the Massachusetts Institute of Technology (MIT) under the title *A Vision of C&C Computers and Communications*. In that book, Kobayashi also describes the basic principles of information generation, storage, and transfer for the media: voice/acoustics, numerical data, text, still images such as graphics, scanned images and natural pictures, and moving images with animation and natural moving pictures. Most of his vision has been realized in current multimedia systems.

## 34.3 GLOBAL INFORMATION INFRASTRUCTURE

The concept of a *global information infrastructure* (GII)[1] was presented by Al Gore (then U.S. Vice-President) at the World Telecommunication Development Conference of the ITU held in Buenos Aires, Argentina, March 21–23, 1994. In his proposal,[2] Gore set forth five principles that he believed to be essential for successful construction of the GII:

[1] Al Gore presented the idea of an *information superhighway* in 1985 on the occasion of the thirtieth anniversary of the signing of the Interstate Highway Act. In 1991 he wrote: "A nationwide network of information superhighways is needed to move the vast quantities of data that are creating a kind of information gridlock."

[2] Published in *ITU News*, September 1998, "Al Gore's Five Challenges to the Telecom World," pp. 3–7.

1. To encourage private interest
2. To promote competition
3. To create a flexible regulatory framework that can keep pace with rapid technological and market changes
4. To provide open access to the network for all information providers
5. To ensure universal service

Four years later, on October 12, 1998, speaking at the Plenipotentary Conference of the ITU in Minneapolis, Gore reported on the enormous progress made on these five principles in constructing the GII:

1. *Private interest.* Over $600 billion of private capital has been invested in telecommunications, and over 48 telecom operators were privatized.
2. *Competition.* Whereas in 1994, only seven countries had competitive markets for the basic voice service, in 1998 as many as 47 countries either had already full competition or were committed to it. In the United States alone, competition in telecommunications created over 50,000 new jobs.
3. *Regulatory framework.* Additional independent regulatory agencies, promoting competition and investment while protecting the interest of the customers, have been established as follows: 18 in the Americas, 17 in Africa, and 11 in the Asia-Pacific region.
4. *Open access to the telecommunication network.* Open access enabling every user of the GII to reach thousands of different sources of information from various countries, in every language, was in daily practice in 1998 for over 100 million Internet users.
5. *Universal service.* More than 200 million telephone lines could be added worldwide, thus, over the last four years more telephone lines were added than were installed in the first 100 years of telephony.

It is in the United States, U.K., France, Germany, and Japan that plans for broadband information highways are most advanced and a dozen experimental information highways have been launched.

In the United States an *Information Infrastructure Task Force* (IITF) coordinates the technological and legislative activities to construct a *National Information Infrastructure* (NII). In Europe, the European Union worked out guidelines and priorities for a *European Broadband Infrastructure* to interconnect with all the European telecommunications and CATV networks and to provide file transfer, e-mail, video, and other multimedia services to all European Union citizens. In Japan, some 20 companies, including NTT, NEC, Hitachi, and Fujitsu, established a multimedia observatory for the elaboration of a national information network. Taiwan and Hong Kong also implemented national multimedia networks. In China, a nationwide optical fiber network 200,000 km long was installed connecting the Chinese provinces with each other and with the GII.

By the end of the century, much progress has been made on implementation of the GII as described in Chapters 27 and 28. However, the telecommunication infrastructure in developing countries needs substantial improvement to prevent a *digital divide.*



## 34.4 INTERNET[3]

The origin of the Internet can be traced back to October 4, 1957, when *Sputnik* shocked U.S. scientists, engineers, and politicians. President Dwight David Eisenhower appointed James A. Killian (then president of MIT) as presidential assistant of science, and one year later, the U.S. Department of Defense established its *Advanced Research Projects Agency* (ARPA). The origin of the new technology applied in the Internet of *packet transmission and switching* goes back to July 1961, when Leonhard Kleinrock of MIT wrote the first paper on packet-switching theory, entitled "Information Flow in Large Communication Nets." He also published those ideas extended with network design criteria in his book *Communication Nets* in 1964.

The concept of the Internet goes back to August 1962, when Joseph Carl Robnett Licklider and Welden Clark of MIT wrote a paper about a computer network entitled "On-Line Man–Computer Communication." Licklider also wrote memos in which he proposed a *galactic network* with interconnected computers which would quickly provide every user with access to data and programs from any site. In October, ARPA began a computer program and appointed Licklider as first director of its newly founded *Information Processing Techniques Office* (IPTO). Licklider left ARPA in September 1964. A historic meeting then took place at Homestead, Florida, in November 1964, where Licklider could convince his ex-colleague at MIT, Lawrence C. Roberts, of the merits of a reliable computer network based on packet switching. In February 1965, Ivan Sutherland, successor to Licklider at ARPA, placed a contract with Roberts for the establishment of such an experimental computer network. Together with Thomas Marill, Roberts connected a TX-2 computer at MIT Lincoln Laboratories successfully via an acoustic coupler and a telephone line with a Q-32 computer at Santa Monica, California, in October 1965. This was the first time that two computers talked to each other by interchange of packets of information. The results were published one year later in a paper entitled "Toward a Cooperative Network of Time-Shared Computers."

Roberts left MIT and joined ARPA as the chief scientist of IPTO in December 1966 with the task of implementing a reliable computer network. In October 1967, at a symposium of the *Association for Computing Machinery*, he presented a proposal for a packet-switched computer network named *Arpanet* in a paper entitled "Multiple Computer Networks and Intercomputer Communication." At that symposium, papers on packet switching for computer networks were also presented by the British inventor of packet switching, Donald Watts Davies, and Roger Scantlebury of the *National Physical Laboratory* (NPL) of the U.K., and by Paul Baran and others of the American Rand Corporation. Davies, in his paper, introduced the concept of a message *packet*. Baran had already written a paper on secure packetized voice in 1964 entitled "On Distributed Communication Networks," in which he made a proposal for a network configuration that would survive nuclear attacks.[4]

[3] The history of the Internet can be found on the Internet in at least 20 versions with partially confusing contradictory information. In an effort to summarize the history of the Internet as accurately as possible, this section is based primarily on the information presented in the Internet by Internet co-founder Lawrence G. Roberts, the Computer Museum History Center in California, and the IEEE.

[4] From this paper it is frequently claimed that the Internet was created by the military to withstand nuclear war. In his *Internet Chronology*, Roberts clarifies that the Arpanet and Internet stem from MIT work of Licklider, Kleinrock, and Roberts and had no relation to Baran's work.

ARPA released a *request for quotations* (RFQ) in August 1968 for the main packet-switching design element of Arpanet called the *Interface Message Processor* (IMP). The company, Bolt, Beranek & Newman (BBN) in Cambridge, Massachusetts, with a team under Frank Heart,[5] won the RFQ and supplied the first four IMPs in 1969. Arpanet was established with those IMPs in the same year. Leonhard Kleinrock[6] at the *University of California–Los Angeles* (UCLA) made the first node in September with a Sigma 7 computer used as the *Network Measurement Center* of Arpanet. A second node followed in October with a SDS 940 computer at the *Stanford Research Institute* (SRI), which was used by Dough Engelbart's[7] group while working on a project called *Augmentation of Human Intellect*. With the completion of those two nodes, the world's first long-distance computer host-to-host[8] communication was made on October 25, 1969. A third node was connected in November at the *University of California–Santa Barbara* (UCSB), where computer graphics were developed, and a fourth node in December at the University of Utah. The transmission speed was 50 kbps. Arpanet spanned the United States from coast to coast from March 1970 when a fifth node was connected at BBN. In December, Steve Crocker at UCLA completed an initial Arpanet host-to-host protocol, called the *Network Control Protocol* (NCP). Ray Tomlinson at BBN sent the first e-mail, with a program called Readmail in March 1972. For addressing e-mails he introduced the @[9] symbol between user name and host name (being a secure symbol not used in any of those names). In the same year the first public demonstration of the Arpanet was given at the *International Conference for Computer Communication* held at Washington in October. It was a great success and proved the feasibility of packet switching.[10]

ARPA changed its name in 1973 to DARPA, the "D" standing for Defense (the Department of Defense). The University of Hawaii installed a packet-switched radio net, named *Packet Radio Net*, which connected seven computers on four islands using the Aloha mode of access (see Technology Box 29.4). Around the same time a satellite network named Satnet was established. It connected Arpanet with University College, London, via an Earth station at Etam, West Virginia, the Intelsat satellite 4A, and Earth station Goonhilly Downs, Cornwall, U.K. Another connection was with the Norwegian Royal Radar Establishment "Norsar" via the Earth station

[5] The team under Frank Heart that developed the IMP included Bob Barker, Bernie Cosell, Will Crowther, Bob Kahn, Severo Ornstein, and Dave Walden.

[6] The team that produced the software to enable communication between their computer and the IMP consisted of Vint Cerf, Steve Crocker, and Jon Postel.

[7] Dough Engelbarth was also the inventor of the computer mouse.

[8] The term *host* is used for a computer that is connected permanently to the Internet. Internet users, by contrast, create a temporary Internet connection when they log on.

[9] The @ symbol is used in the English language as "commercial a" and as such was already included on the keyboards of the first American typewriters. The origin of this symbol dates at least back to the year 1555, when it was used in Spain as a measure unit for a weight of about 11.5 kg called "arroba." Other contemporary names for @ are "aape staart" (monkey tail) in Dutch, "Affenklammer" (monkey clip) in German, "kanelbolle" (cinnamon pastry) in Norwegian, "kukac" (worm) in Ungarian, "Miukumauku" (cat's tail) in Finnish, "petit escargot" (little snail) in French, "shtrudel" (a "bended" pastry) in Israeli, and "sobachka" (little dog) in Russian.

[10] A highlight of the ICCC was a conversation between Eliza, Joseph Weizenbaum's artificially intelligent psychiatrist located at MIT, and Parry, a paranoid computer developed by Kenneth Colby at SRI.



at Tanum, Sweden. In that year, Robert E. Kahn came from BBN to DARPA, where he developed a protocol for communication between Arpanet, Packet Radio Net, and Satnet in cooperation with Vinton G. Cerf, who was then a professor at UCLA. Cerf and Kahn named communication among the three networks *internetting*, from which the word *Internet* was derived. In September they presented a first paper on the new protocol, called *Transmission Control Protocol* (TCP), at a meeting of the newly formed *International Networking Group* at the University of Sussex, U.K. TCP was developed further into a combination of two protocols named TCP/IP. One was a new TCP controlling transmission and error-correcting functions, and the other was an *Internet Protocol* (IP), controlling the addressing, routing, and forwarding of individual packets.

Lawrence Roberts left DARPA in 1974 and joined BBN, where he directed the world's first public packet-switching company, called Telenet. Licklider agreed to return temporarily from MIT to replace Roberts. Vinton G. Cerf also joined DARPA in 1976 and demonstrated one year later, together with Robert Kahn, the use of TCP for communication between Arpanet, Packet Radio Net, and Satnet. Messages were sent by radio from a van in California, across the United States on Arpanet, then via Satnet to University College, London, back via satellite to Virginia, and through Arpanet to the *University of Southern California's Information Sciences Institute* (USC/ISI).

In 1978, when over 100 hosts were connected to Arpanet, Vint Cerf initiated the foundation of an *Internet Configuration Control Board* chaired by Dave Clark of MIT and an *International Cooperation Board* chaired by Peter Kirstein of University College, London.

In 1980, the *National Science Foundation* (NSF) of the United States established a *Computer Science Research Network* called CSNET, which within six years connected the computer science sites of almost all universities and academic institutions in the United States. The network included an interconnection based on TCP/IP with Arpanet, Telenet, and an e-mail service called PhoneNet.

In January 1983, DARPA finalized the transition from NCP to TCP/IP protocol throughout Arpanet and subsequently separated the Arpanet into a public network, then formally called the Internet, and a new military network called Milnet. In the meantime, various other computer networks were established which all gradually incorporated TCP/IP, and as a loose collection of networks, evolved into the Internet. To facilitate communication among the almost 1000 hosts within the Internet, a *Domain Name System* (DNS) was developed in 1983 by Jon Postel and Paul Mockapetris of USC/ISI and Craig Partridge of BBN. Seven generic *top-level domain* names (TLDs) were allocated as a symbol consisting of a point plus three letters as follows: open or unrestricted: .com, for commercial organizations; .net, for networks; and .org, for organizations; and restricted: .edu, for education; .gov, for government; .int, for international organizations; and .mil, for military. The standard e-mail addressing introduced by Ray Tomlinson in 1972 extended with this domain thus became *name@host.domain*.

In 1985, the NSF added five supercomputing centers to its CSNET, in the meantime named NSFNET, which were accessible by the other computers at a transmission speed of 56 kbps.

The Internet, so far, apart from satellite connections with University College, London and Norsar, was limited to the United States. In 1988, when over 10,000

hosts were connected, the Internet was opened to Canada, Denmark, Finland, France, Iceland, Norway, and Sweden. The domain name system was then extended by a point plus two-letter symbol indicating the country[11]: for instance, ".ca" for Canada and ".se" for Sweden. The next year the following nine countries got access to he Internet: Australia, Germany, Israel, Italy, Japan, Mexico, The Netherlands, New Zealand, and the U.K. One year later, the Internet was joined by Argentina, Austria, Belgium, Brazil, Chile, Greece, India, Ireland, South Korea, Spain, and Switzerland. With this international opening, and also because the NSF opened Internet to commercial use, the number of hosts increased to 300,000 in 1990. In that year, Arpanet was formally closed and its service was taken over by the NSFNET. The transmission speed on the NSFNET was increased to 45 Mbps in 1993, and one year later to 155 Mbps.

Around 1990, a revolutionary contribution toward the worldwide penetration of the Internet came from Switzerland. A British computer scientist, Tim Berners-Lee, working at the European Laboratory for Particle Physics in Geneva, Switzerland, dubbed CERN (from its French name, Conseil Europeen pour la Recherche Nucleaire), developed a concept for a user-friendly navigation method providing access to information wherever it is stored within the Internet. He started in 1989 with the development of a *hypertext markup language* (HTML). In the following two years he developed in cooperation with Robert Caillau the *HyperText Transfer Protocol* (HTTP) and a *uniform resource locator* (URL). Furthermore, he completed the concept with a browser developed by a British student, Nicola Pellow, then a technical student at CERN; and a server developed by Bernd Pollermann of the Computing and Network Division of CERN. Much simplified, using HTML, words, pictures, and sound can be combined on a computer screen using hypertext,[12] whereby individual pieces of text within a page can be given a URL address leading to related text. The term *hypertext* probably was coined by Theodor Holm Nelson in 1963 and used first in his book *Literary Machine* in 1965. Upon activation of that address with a mouse, a browser follows hyperlinks using the HTTP until it has found the related page in a "web" of further pages at a server which may be located at the same or at different hosts around the world. The name World Wide Web (WWW), referring to the web of distributed information, was coined by Tim Berners-Lee in 1990.

In 1992, Marc Andreesen and a group of student programmers developed an improved browser called *Mosaic* on a summer program at the University of Illinois at Urbana–Champaign organized by the *National Center for Supercomputing Applications*. Commercialization of Mosaic soon followed. Jim Clark used it to establish the browser company Netscape Communications Corp. in 1994, followed by the Microsoft Explorer, integrated in Windows 95 in 1995. With this browser facility,

[11] The two-letter code was taken from ISO 3166, a standard of the International Organization for Standardization. At the beginning of the twenty-first century there were 243 country code top-level domains (ccTLDs).

[12] Hypertext became the subject of a patent lawsuit in February 2002. BT claims that the version of hypertext for which it obtained a U.S. patent in 1989 was developed by BT in the 1970s and thus should not have been used without license by the oldest U.S. online access service provider, Prodigy, in 1984 nor subsequently by millions of other companies and persons. A serious argument against the BT claim might be the existence of a video clip in which Douglas Engelbart in 1968 at the SRI demonstrates how by clicking on certain words in a computer program a new page of text appears. This could be the first example of hypertext linking.



Internet found worldwide use on millions of scientific, commercial, and residential PCs and Apple Macintosh computers.

Introduction of the WWW and its browser facilities was a most valuable contribution toward construction of the GII. To reach 50 million subscribers took the telephone close to 75 years, the radio 38 years, TV 13 years, and the Internet less than four years from the introduction of the WWW in 1992. In the same time, Internet evolved from a scientific to a mainly commercial network, but what exactly is the Internet? The *Federal Networking Council* (FNC) of the Internet saw the necessity to answer this question. On October 24, 1995, in a resolution, it defined the term *Internet* (rather heavily) as follows: Internet refers to the global information system that:

1. Is logically linked together by a globally unique address space based upon the Internet Protocol or its subsequent extensions/follow-ons;
2. Is able to support communications using the Transmission Control Protocol/Internet Protocol (TCP/IP) suite or its subsequent extensions/follow-ons; and/or other IP-compatible protocols; and
3. Provides, uses or makes accessible, either publicly or privately, high level services layered on the communications and related infrastructure described herein.

In the same year, the National Science Foundation announced that it would no longer allow direct connection to the NSFNET. It contracted private companies to provide that access against payment. Since that time, thousands of *Internet service providers* (ISPs) worldwide provide access to the Internet on a commercial basis.

Vinton G. Cerf, often called the "father of the Internet," and Robert E. Kahn were awarded the U.S. National Medal of Technology in December 1997 by President Bill Clinton for having founded and developed the Internet.[13]

Around the same time, digital watermarking was introduced to protect copyrights of digital images and to reduce digital pirating. The digital watermark is visible only with special software. It operates two-way: It provides additional information to the user and informs the owner where their images are copied and reappear in the Internet.

To keep pace with this tremendous development and the increasing internationalization of the Internet, the U.S. government decided in 1998 to take administration of the domain name system and some other tasks away from the *National Telecommunications and Information Administration* and bring it under the responsibility of a new independent nonprofit organization, the *Internet Corporation for Assigned Names and Numbers* (ICANN). In October 2000, ICANN had five of its nine directors elected in a worldwide online election which was open to anyone who cared to register for the election. This was the first worldwide democratic election, although as a demonstration of the shortcomings of the Internet: Only 158,000 people registered, only 76,000 of them managed to proceed to the voting, and only 34,035 of them succeeded in casting their vote. One month later, the new board of ICANN selected seven additional top-level domain names for introduction in 2001: .biz, for business

[13] One year earlier, Sigrid Cerf, who was profoundly deaf, got a cochlear implant and could for the first time after 30 years of marriage talk naturally to her husband, Vint Cerf, who is hearing-impaired. The Internet played a vital role in selecting the successful bioelectronics solution.

purposes; .info, for unrestricted; .name, for personal names; .aero, for the aviation community; .coop, for cooperatives; .museum, for museums; and .pro, for professionals.

In the same month, ICANN, in coordination with *the Internet Engineering Task Force* (IETF), extended internationalization of the Internet. It opened the domain name system, which was confined to the English language,[14] to Arabic, Chinese, Japanese, Korean, Portuguese, Spanish, and the Scandinavian languages.[15] Multilingual domain names were first developed at the National University of Singapore. In July 1998, the Asia-Pacific Networking Group started a project called *Internationalized Multilingual Multiscript DNS* (iDNS). By year-end 1999, the results were promoted and commercialized under *www.idns.net*. The first Internet portal in the Spanish language, T1msn, was opened in March 2000 with the cooperation of Microsoft and the Mexican telecommunications operator Telmex. In the same month, the Brazilian media company Globo opened a portal in the Portuguese language under *www.globo.com.br*. One month later, domain name registration began in the Japanese language through the Japan registry service under *www.jprs.jp*. In the same month, *Emirates Internet and Multimedia* of the United Arab Emirates and the U.S. Compac Computer Corporation launched the first Internet search machine in the Arabic language called Arabvista, on *www.arabvista.com*. The service includes Arabic-to-English translation, allowing Arabic-speaking users to search English content on the Internet using their native language, and it offers a virtual Arabic keyboard for non-Arabic systems.[16]

A major milestone was reached in the year 2000 when the ITU and the IETF, after one year of intensive work, agreed on a single standard, H.248/Megaco, for a gateway between circuit-switched networks and IP-based networks. With devices based on this standard it will become possible to make voice calls via the Internet (dubbed VoIP, voice over Internet Protocol) from a conventional telephone. VoIP existed since the mid-1990s, but with nonstandard devices, of which a common version is required for the two participants of a VoIP call. VoIP found limited application because of this limitation, the poor quality, and above all the significant price reductions of telephone calling on the PSTN due to increased competition upon deregulation of telephone services. As further support for VoIP, the IETF released the Stream Control Transmission Protocol (SCTP), which facilitates the transmission of signaling system 7 signals (SS7; see Section 29.3.1) via the Internet.

When the domain name system was introduced in 1983, a universal addressing system was developed to allow any type of user to identify itself on the Internet. For this purpose, a special protocol, named IPv4, was developed using a 32-bit code that offered 4.2 billion addresses. It is expected that there will be a lack of addresses around 2005 due to the introduction of multimedia services on the 2.5G and 3G

[14] DMS was confined to the characters defined by ASCII (American Standard Code for Information Interchange). In an ASCII file, each alphabetic, numeric, or special character is represented with a 7-bit binary number (a string of seven 0s or 1s).

[15] Currently, ICANN is struggling for survival. ICANN's president, Stuart Lynn, concluded in March 2002 that ICANN has failed to meet its objectives and that the most productive course for ICANN's role in Internet affairs would be to discontinue.

[16] Deployment of multilingual domain names since 2001 is promoted by the Arabic Internet Names Consortium (AINC), the Chinese Domain Name Consortium (CDNC), the International Forum for IT in Tamil (INFITT), and the Japanese Domain Name Association (JDNA).



**TABLE 34.1 Internet Development, 1990–2000**

| Year | Number of Countries | Millions of Hosts | Millions of Users | Year | Number of Countries | Millions of Hosts | Millions of Users |
|---|---|---|---|---|---|---|---|
| 1990 | 22 | 0.4 | — | 1996 | 165 | 22 | 54 |
| 1991 | 34 | 0.7 | — | 1997 | 191 | 30 | 90 |
| 1992 | 43 | 1.3 | — | 1998 | 200 | 43 | 149 |
| 1993 | 60 | 2.7 | — | 1999 | 211 | 72 | 231 |
| 1994 | 81 | 5.8 | — | 2000 | 214 | 104 | 315 |
| 1995 | 121 | 14 | 34 | | | | |

*Source: ITU Telecommunication Indicators Update*, January–February–March 2001.

mobile radio systems, the application of Internet for control of "smart houses," and other advanced services. Due to initial generous allocations, IPv4 cannot be used to its full capacity, and a new protocol, IPv6, is being developed by the IETF. IPv6 will use a 128-bit code which can offer $340 \times 10^{36}$ (340 billion billion billion billion[17]) Internet addresses! The new protocol will also improve security, quality of service for real-time data, and facilitate roaming on mobile networks.[18]

Internet started in the brains of scientists at the MIT as an instrument for scientific research and information exchange. It became the world's biggest commercial service network. Now a group of U.S. universities has begun a project named *Internet 2* (I2) with the objective of developing a second-generation Internet. The project is coordinated by the *University Cooperation for Advanced Internet Development* (UCAID), which brings together over 150 universities working with partners in industry and government. One of the priority items will be the deployment of IPv6.

Aiming even further, Vint Cerf, in cooperation with the Jet Propulsion Laboratory at Pasadena, California, is working on the design of an *Interplanetary Internet* (II). With the Interplanetary Internet, each planet will get its own addressing system. One of the challenges is the 40-minute round trip of a radio signal between Earth and Mars. Table 34.1 shows the enormous development of the Internet.

## 34.5 GLOBAL VILLAGE

The idea of the *global village* was first conceived by the Canadian communications theorist Marshall McLuhan (1911–1980) in 1960. Looking at the emerging spread of electronic telecommunications and mass media such as television, McLuhan wrote that these technologies are transforming the world's nations into a global village in which distance and isolation are eliminated. In the global village, McLuhan envisaged that all information will become available for everyone and that local events will acquire worldwide significance.

Despite the tremendous development of the Internet, which connects practically all countries of the world, at the end of the twentieth century the world was far from being a global village. The major reason was, and still is, that a lack of infrastructure

[17] The exact number is 340,232,366,920,938,463,463,374,607,431,768,211,456.

[18] NTT communications started commercial Ipv6 service on April 1, 2002.

**TABLE 34.2 Ten Countries with the Highest Internet Penetration, Year-End 2000**

| Country | Thousands of Users | Percent Penetration | Country | Thousands of Users | Percent Penetration |
|---|---|---|---|---|---|
| Iceland | 168 | 60 | Finland | 1,927 | 37 |
| Norway | 2,200 | 49 | Denmark | 1,950 | 37 |
| Sweden | 4,048 | 46 | United States | 95,354 | 35 |
| Canada | 12,700 | 41 | Australia | 6,600 | 34 |
| Korea (Rep.) | 19,040 | 40 | Singapore | 1,200 | 30 |

*Source: ITU Telecommunication Indicators Update*, January 9, 2002.

and a lack of education cause a *digital divide* between countries that are rich in information and countries that are poor in information. In a study released in May 2000, the UN *Economic and Social Council* observed: "There are more Internet hosts in New York than on continental Africa, more hosts in Finland than in Latin American and the Caribbean, and, notwithstanding the remarkable progress in the application of information and communication technology in India, many of its villages still lack a working telephone." The ITU, in the *Telecommunications Indicators Update* of January 2001, state that in the developed countries almost a third of the people are online compared with less than 2% in the developing countries. Table 34.2 shows the 10 countries with the highest Internet penetration. An impression of the digital divide can be obtained from Table 34.3, which indicates the very unequal worldwide distribution of the 366,611,200 Internet users and the 106,710,508 Internet hosts by year-end 2000.

A further indication of the orientation of the Internet toward the United States is given in Table 34.4, which for the 10 top cities shows the bandwidth capacity of the links that connect those cities on interregional links with each other and with other, smaller hub cities. Although Europe and Asia have major Internet hubs, most Internet traffic between Asia and Europe still passes through the United States.

## 34.6 MULTIMEDIA SERVICES

Subscribers in a multimedia network can access various services on demand, which are offered by different content providers via a multimedia service provider. Figure 34.1 shows the basic configuration of a typical multimedia network. The first multimedia services on the Internet started in the United States in the late 1980s with teleworking, soon followed by telemedicine, telebanking, telebooking, teleshopping, teleconsulting, telelearning, tele-entertaining, and others.

The driving force for teleworking from a business point of view was cost saving. From the residential point of view, it was the reduction of traveling time and a better balance between business and private life. In the United States there were some 8 million teleworkers by 1995 and 35 million by year-end 2000, when Europe had about 9 million teleworkers. The highest rates of teleworking, about 15% of the workforce, was in the northern countries: Finland, The Netherlands, and Sweden, whereas in Italy and France this rate was only about 4%.



**TABLE 34.3 Worldwide Distribution of Internet Hosts and Users**

| Country, Region, or Continent | Population (millions) | Percent Penetration | | Percent of World Distribution | | |
|---|---|---|---|---|---|---|
| | | Users | Hosts | Population | Users | Hosts |
| Africa | | | | | | |
| South Africa | 43.69 | 5.5 | 4.3 | 0.7 | 0.7 | 0.2 |
| Rest of Africa | 748.94 | 0.3 | <0.01 | 12.2 | 0.6 | <0.1 |
| Total Africa | 792.63 | 0.6 | 0.3 | 13.0 | 1.3 | 0.2 |
| The Americas | | | | | | |
| Canada | 30.75 | 41.3 | 7.7 | 0.5 | 3.5 | 2.2 |
| United States | 275.13 | 34.7 | 29.3 | 4.5 | 26.0 | 75.5 |
| Rest of the Americas | 519.26 | 3.4 | 0.4 | 8.5 | 5.2 | 1.9 |
| Total Americas | 825.14 | 15.4 | 10.3 | 13.5 | 34.7 | 79.6 |
| Asia | | | | | | |
| China | 1295.33 | 1.7 | <0.01 | 21.3 | 6.1 | <0.01 |
| Hong Kong SAR | 6.73 | 38.6 | 3.4 | 0.1 | 0.7 | 0.2 |
| India | 1012.40 | 0.5 | <0.01 | 16.6 | 1.4 | <0.01 |
| Israel | 6.27 | 20.3 | 2.9 | 0.1 | 0.4 | 0.2 |
| Japan | 126.92 | 37.1 | 3.7 | 2.1 | 12.8 | 4.3 |
| Korea (Rep.) | 47.3 | 40.3 | 0.8 | 0.8 | 5.2 | 0.4 |
| Malaysia | 23.27 | 15.9 | 0.3 | 0.4 | 1.0 | 0.1 |
| Singapore | 4.02 | 29.9 | 4.4 | <0.1 | 0.3 | 0.2 |
| Taiwan–China | 22.28 | 28.1 | 4.9 | 0.4 | 1.7 | 1.0 |
| United Arab Emirates | 2.61 | 28.2 | 1.3 | <0.1 | 0.2 | <0.1 |
| Rest of Asia | 1105.74 | 0.8 | 0.02 | 18.1 | 2.4 | 0.2 |
| Total Asia | 3648.85 | 3.3 | 0.2 | 59.9 | 32.2 | 6.6 |
| Europe | | | | | | |
| Eurostat countries | 389.44 | 24.2 | 2.3 | 6.4 | 25.7 | 10.5 |
| Russia | 146.93 | 2.1 | 0.2 | 2.4 | 0.8 | 0.3 |
| Rest of Europe | 261.89 | 4.5 | 0.4 | 4.3 | 3.2 | 0.9 |
| Total Europe | 798.26 | 13.7 | 1.6 | 13.1 | 29.7 | 11.7 |
| Oceania | | | | | | |
| Australia | 19.16 | 34.4 | 8.4 | 0.3 | 1.8 | 1.5 |
| New Zealand | 3.83 | 21.7 | 9.9 | 0.1 | 0.2 | 0.3 |
| Rest of Oceania | 7.47 | 2.7 | 0.2 | 0.1 | 0.1 | 0.1 |
| Total Oceania | 30.46 | 25.1 | 6.5 | 0.5 | 2.1 | 1.9 |
| Total worldwide | 6095.34 | 6.1 | 1.8 | 100 | 100 | 100 |

*Source: ITU Telecommunication Indicators: Basic Indicators*, and *Information Technology, Update*, January 2, 2002.

Teleworking produced two new office types: virtual offices and nonterritorial offices. A *virtual office* is any individual place of teleworking: at home, at the beach, at a business lounge of an airport, and others. A *nonterritorial office* is a corporate office where teleworkers can have occasional social contact with their superiors, colleagues, and customers. A nonterritorial office has a few workplaces which are available on a random time-sharing basis and have ample contact zones, such as

**TABLE 34.4 Top Ten Internet Hub Cities**

| City | Internet Bandwidth[a] (Gbps) | City | Internet Bandwidth[a] (Gbps) |
|---|---|---|---|
| New York | 150 | Tokyo | 17 |
| London | 86 | Washington | 13 |
| Amsterdam | 25 | Miami | 12 |
| Paris | 23 | Los Angeles | 11 |
| San Francisco | 21 | Copenhagen | 10 |

*Source:* Data from TeleGeography Inc. as reported in *www.totaltele.com*, October 30, 2001.

[a]The bandwidth capacities indicated apply for mid-2001 and refer to international routes only; domestic routes are not included.

lounges, coffee shops, and rooms for conferences, discussions, and general corporate identity cultivation.

Teleworking also has a positive effect on the environment. AT&T reported that the increased amount of teleworking of their employees in 2000 has avoided 170 million kilometers of car travel, with a subsequent reduction of 50,000 tons of carbon dioxide emission. BT reported that in the same year its staff saved over 240 million kilometers of traveling by means of audio and video conferencing, thus contributing to a saving of 1 million tons of carbon dioxide emission.

Telelearning makes the Internet into a virtual classroom with a very effective sharing of resources. Countries such as Canada, France, Germany, Italy, and the United States have already connected most schools to the Internet. In Germany in 2000, 34,000 schools were connected with the Internet in a free-of-charge program called T@School. In the United States all telecommunication operators contribute to a $4 billion central fund which is used to provide free Internet access for schools and libraries. South Africa launched SchoolNet in 1997, with the objective to train over 2000 teachers in 1035 schools all over the country. The Catholic University in Chile launched an Enlaces program, providing a wireless connection with two computers at schools in remote indigenous areas. MIT launched the University of the World in the mid-1990s as an interactive Master of Business Administration (MBA) learning program for a number of universities, initially in Singapore and in China, and later for other Asian countries. Real-time, two-way, full-motion videoconferencing is transmitted via satellite with large screen projection in the classrooms. Thus, Asian students can have question-and-answer sessions with teachers at MIT without anybody having to undertake intercontinental traveling. In the U.K., there are reported to be more and more MBA recipients who obtained their degree without setting a foot in a classroom; thanks to distance learning they can complete degrees while keeping career and family life in balance.

Telemedicine with teleconsulting, remote medical diagnosis, and even surgery assistance is improving health care in developing countries. As a pilot project in Mozambique, the ITU, through its Telecommunication Development Bureau, established a telemedicine link via radio-relay and satellite between the central hospitals in the capital Maputo and in Beira, the second-largest city at a distance of 1000 km from Maputo. Doctors in Beira can now send x-rays and other medical records



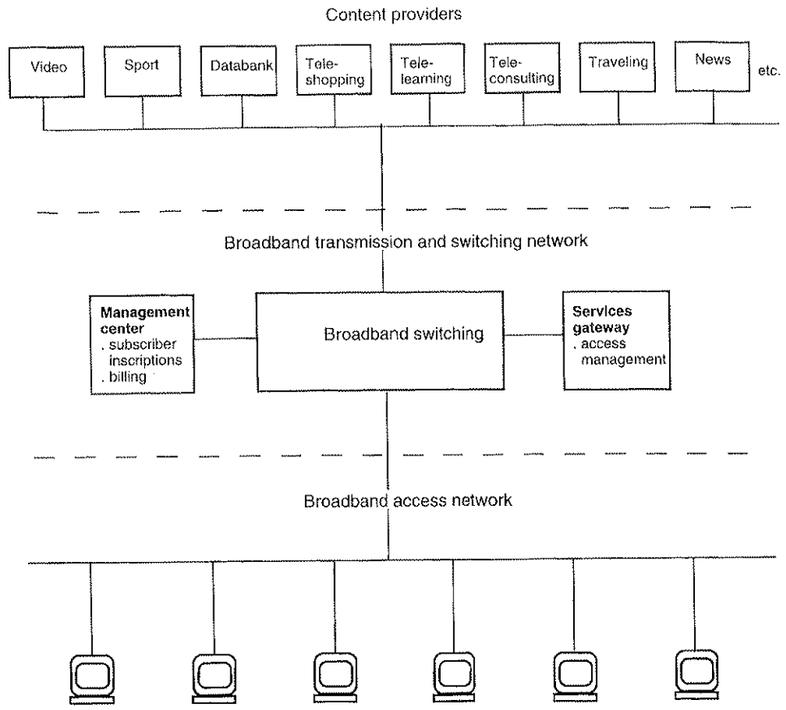


**Figure 34.1** Typical multimedia network.

for immediate advice to experts in Maputo. Similar telemedicine projects are initiated in other African countries. As another example, in Georgia, the Research Institute of Radiology and Interventional Diagnosis at Tbilisi, since 1998, sends medical files, including x-rays, via Internet to the Center of Imaging Diagnostic in Lausanne, Switzerland, which than gives treatment recommendations.

To differentiate Internet services from conventional distance services by mail and telephone, the prefix *tele-* has gradually been replaced by *e-* (electronic). Teleshopping, used successfully to sell consumer products such as books, for instance, introduced worldwide by *www.amazon.com*, evolved to e-commerce with *business-to-consumer* (B2C) and *business-to-business* (B2B) transactions made legally binding by an e-signature.[19] On July 4, 2000, President Bill Clinton gave e-signatures a status

[19] An *electronic signature*, also called a *digital signature*, is a way to authenticate the source of an electronic message by using an encryption system, *encryption* being a way of encoding a message to hide its content from unauthorized persons.

similar to that of handwritten signatures, when he approved the Electronic Signatures in Global and National Commerce Act. Further support for more secure e-commerce came one month later when the *International e-commerce Security Standard* (IES 2000), developed by the *Customers Service Institute of Australia*, received approval from the *International Standards Accreditation Board*. As a measure to prevent a further digital divide, the ITU in cooperation with the Geneva-based World Trade Centre (WTC) and WISeKey S.A. (International Secure Electronic Transaction Organization) started an Electronic Commerce for Developing Countries (EC-DC) project in 2000. Under this project, an e-commerce infrastructure for developing countries is being established whereby participating countries can share secure electronic payment and e-signature facilities in a network covering over 100 countries.

Another variation of e-service, namely *e-government*, also called *e-governance*, is being implemented widely, notably in two of the world's smallest countries; Singapore and Qatar. The government of Singapore began in 1997 a multimedia pilot project called Singapore One in which 5000 households and offices got access to 50 multimedia applications, including government services. In 2000 followed a three-year e-government action, combined with implementation of a *national information infrastructure* covering the country, enabling high-speed online execution of the majority of public services. The Arabian Gulf state of Qatar launched an e-government plan on its twenty-ninth anniversary of independence on September 3, 2000. Under this plan, 10 public institutions and some ministries began to offer online public services such as issuance and renewing of passports (which can then be collected at the Post Office) and residence permits, and collection of fees. Qatar, which did not get its first telephone service with 150 lines until 1953, got the first Earth station in the region in 1976, the first cable television network in the Middle East in 1993, the first GSM network in the Middle East in 1994, and was one of the earliest in the region to get Internet in 1996. E-government services are also being introduced in the neighboring United Arab Emirates in the state of Dubai, where fines for traffic offences are claimed by SMS, and divorces can be settled by a mouse click. In October 2000, the city of Dubai opened the world's first e-commerce free-trade zone, called *Dubai Internet City* (DIC). DIC was developed within 15 months on a 25-km$^2$ desert area just outside Dubai City. Currently, it provides always-on Internet access via optical fiber to 6000 businesspeople. The national operator Etisalat established a regional Internet *network access point* (NAP) in Dubai. This NAP has a direct 155-Mbps optical fiber connection with New York using the Flag undersea cable system. Adjacent to DIC, a new residential town called Dubai Marina is being developed with 100 apartment buildings up to 39 stories each and 4000 houses to attract an additional 100,000 residents. Fiber-to-the-apartment provides the new residents with high-speed Internet access with advanced services such as smart washing machines and refrigerators and e-health service for consulting the doctor using videoconferencing. Dubai Marina is announced to become the world's first fully online city, offering e-government, e-commerce, e-health care, and e-entertainment in all homes, offices, and 3G handsets. A Virtual Internet Academy will cover e-learning for some 5000 students.

An even more impressive example of an ambitious e-government project is the *Multimedia Super Corridor* (MSC) in Malaysia. The Malaysian government initiated the MSC project in 1996 within the scope of its Vision 2020 objective of turning Malaysia into a developed country by 2020. The MSC covers an area of 15 × 50 km between the world's highest Petronas twin towers (452 m) in Kuala Lumpur and a new international airport. Half a dozen new towns will include the city of Putrajaya, which will accommodate Malaysia's e-government, and the city of Cyberjaya, which will be residential and the location of multimedia industries, R&D centers, a multimedia university, and smart schools. A fiber optic ring with a transmission speed of 2.5 Gbps has been installed, and a further 10-Gbps Hypernet Internet backbone was under construction at the end of the century. An area that used to be a mixture of jungle and tin mines and in the twentieth century was cultivated with rubber and palm trees is being developed into a high-technology park that is 60% environmentally friendly green. MSC has the elements to become an example of the global village at its best: with immediately accessible worldwide information, the finest Southeast Asian architecture, and an international multicultural population in a cultivated tropical landscape.



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