Telecommunications in the coming decades

An intelligent broadband network will transmit documents and pictures, combine real-time communications and messages, and decide how to reach a call's intended recipient

PERSPECTIVE

COMMUNICATIONS

It's November 25, 1998, and across the United States car retailers are geared up to receive the first of next year's models. Manager Bob Barnes arrives early at his Fareast Motors showroom in suburban New Jersey. Glancing at the screen of his desk terminal (a standard monochrome voice-data set, $89.95 from the local discount electronics store), Barnes scans its windows for the racing results and his "to-do" items for the day. Suddenly, a cartoon figure appears, blinking and waving at the bottom of the screen, signaling an urgent message. Barnes touches the figure, and the screen dissolves into a message header:

25.11.98 to fremont!dealerlist from tokyo!
URGENT
To all North American dealers:
Front-end suspension modification on
1999 North American production run, "E" sedans
Fareast Motor Corp. Design Division

Another touch on the header, and the screen changes again, to a large-type text describing an important safety modification of the suspension on next year's cars. A woman's voice reads the message as it scrolls up the screen, revealing a computer-graphics diagram of the suspension. As the design slowly turns, she discusses its highlights. The screen then shifts to a movie, with sound, of a mechanic modifying a suspension in Tokyo. The message ends with a display of the Fareast logo and a few cheery bars of the company song.

Barnes forwards the message to his branch's service department, with a voice cover memo urging immediate attention. He knows the service manager will save the entire message and make sure that every mechanic sees it, in full color, on the department's large-screen projection system.—Based on optimistic projections of telecommunications specialists.

Sending multiple-media messages is similar in concept to today's electronic mail, but vastly extended in scope and impact. The service will be typical of what public and private telecommunications networks worldwide hope one day to offer their customers. Beyond providing broad transmission channels, future networks will likely complement or merge with office-information systems, home-entertainment electronics, and existing communications equipment and networks. Those integrated systems will remove most geographical and media obstacles from everyday personal and business discourse.

A wide range of communications capabilities will be integrated—functionally if not always physically—through intelligent, broadband, lightwave networks, whose architectures and components are already being researched and developed. The move is toward something that could be called universal communications:

- Communications among people anywhere, any time, in any medium or combination of media.
- Retrieval and sharing of information from diverse sources and in multiple media, including collaboration among people in shared electronic environments.
- Distribution of a wide variety of cultural, entertainment, and educational materials to home or office, virtually on demand.

No one expects this soon, nor is it known what services people will be enthusiastic about and willing to pay for. What's more, international standards for transmission formats are not yet agreed on, although an approximately 140-megabits-per-second "H4" channel rate appears certain to become one of the future standards.

Still, today's worldwide telephone network is already evolving toward a public system for broad communications, unifying telephone, video, and data communications. What is projected will not require throwing out all the existing technology and starting over, but lightwave communications and software control must become widespread and economical if the plan is to work.

Research and development is currently concentrated in Western Europe, Japan, and the United States, in organizations such as France Telecom, British Telecom, Deutsche Bundespost (the West German post and telecommunications agency), Nippon Telegraph and Telephone, AT&T Bell Labs, and Bell Communications Research (Bellcore). In each country, broadband field trials are proceeding, tailored to national markets and tastes—from home video on demand and dating services, to corporate teleconferencing. In many countries, planners hope to have the initial architecture of the broadband integrated services digital network (BISDN) in place within the next 10 to 15 years.

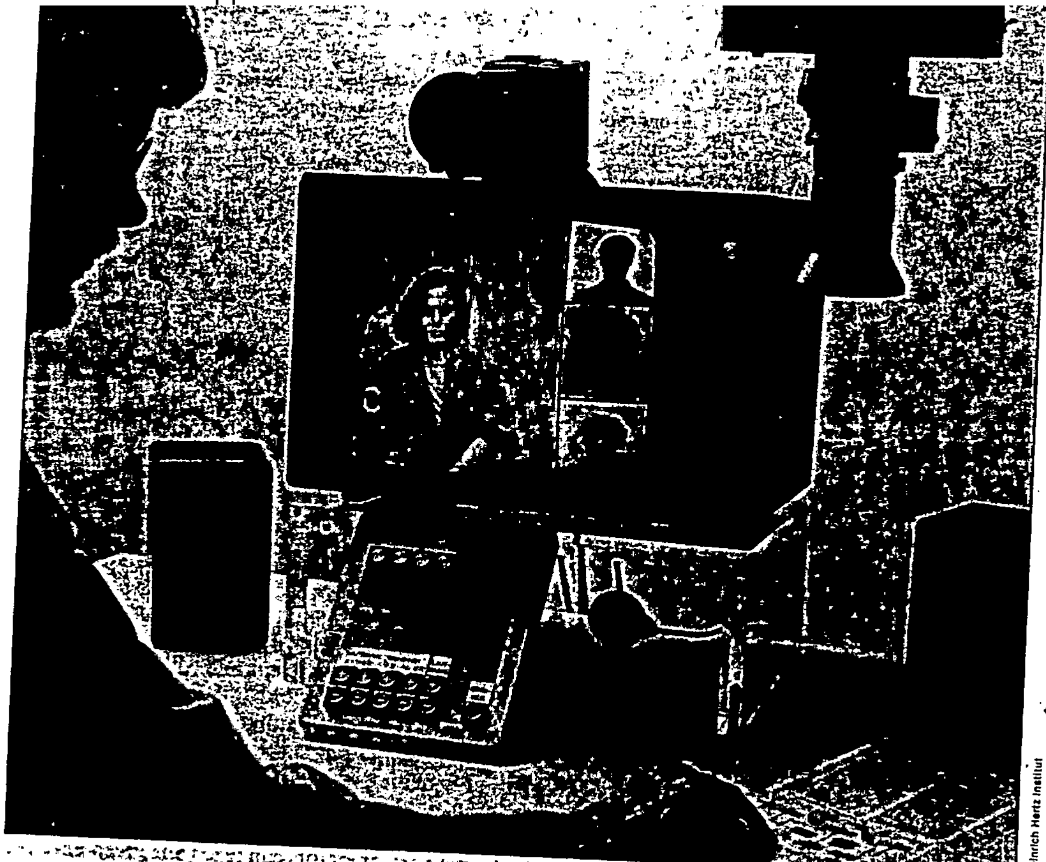
Evolution of the public network

Universal communications is both pushed by technology and pulled by the market. Technical developments driving toward universal communications include lightwave transmission through fiber-optic cables, high-speed switching, and new software to make operation of an integrated-services network both possible and economical. And the market's powerful pull comes from companies with automated offices and factories dispersed around the world, an explosion in consumer electronics, and the needs of sophisticated information and design systems—all of which will soon outgrow what existing communications facilities can do.

Telephone companies, government utilities, and other major carriers offering communications services are not discouraged by past lack of success in small-scale, consumer-oriented trials of new services such as interactive home-shopping, even though inadequate early technology probably played a large part. The carrier companies point out that the most lucrative markets appear to lie in business and commercial communications, infor-

Stephen B. Weinstein Bell Communications Research

0018-9235/87/1100-0062$1.00©1987 IEEE



At a desktop teleconference at the Heinrich Hertz Institut in Berlin, West Germany, the display allows participants to converse as they view graphics picked up by a camera (right) with a zoom lens.

Heinrich Hertz Institut

mation services for the business and academic communities, and entertainment for those at home. With these services in mind, developers of public communications networks are working to make existing networks digital, intelligent, and broadband.

Digital is in

Transmission, switching, and subscriber access through digital circuits are pursued because they yield better transmission quality, easier integration of disparate media, and more economical operation. While any kind of communications traffic—voice, data, graphics, or video—can be represented as streams of ones and zeros, the channel capacity required can vary from a few bits per second, for telemetry, to as many as a billion bits per second, for high-definition television (HDTV). It is that range in demand for capacity, coupled with an equally wide range of holding times, that presents difficulties in integrating different kinds of traffic.

Digital systems have actually become cheaper than their analog alternatives for high-volume communications traffic. Most long-distance telephone calls are already converted into digital streams for transmission through the internal network over copper wires or optical fiber. Major U.S. communications carriers are increasingly installing digital switches at their central offices; higher-level toll offices already have them.

The next major step in digitization worldwide is the integrated services digital network (ISDN) in the U.S. and Europe, and its Japanese counterpart, the information network system (INS). While the INS differs from the ISDN in some important ways, it is expected that it will eventually conform to standards set by the International Consultative Committee for Telephone and Telegraph (CCITT), an adjunct of the United Nations' International Telecommunications Union.

ISDN will provide direct digital services to individual subscribers through a basic 144-kilobit-per-second interface with three channels, two of them so-called B channels, carrying 64-kb/s transmissions of voice, high-speed data, graphics and facsimile, as well as highly compressed video. The third, a 16-kb/s D channel, will carry control information and data. One twisted pair of copper wires is adequate for all those services.

The D channel would provide for control signaling outside the main information signal—much more sophisticated than the simple, stimulus-type mechanisms of a switch hook and 12 pushbuttons. For example, assuming users will own or lease a relatively inexpensive small-screen telephone, the names of several waiting callers, plus brief messages from these callers, could appear on the screen without interrupting an ongoing conversation.

CCITT is working on international standards for ISDN and in 1984 issued initial recommendations on two interfaces, basic, at 144 kb/s, and primary, for businesses, at 1.544 Mb/s in the United States and 2.048 Mb/s in Europe. The CCITT's 1988 plenary is expected to result in agreements on ISDN signaling protocols.

ISDN should bring exciting possibilities for multimedia communications and information retrieval. Two people at different offices, hooked up through ISDN at their workstations, could look at a document with accompanying graphics and photos, and annotate it even as they discuss it. ISDN will move a facsimile page in five seconds as well as provide wide-bandwidth (7 kilohertz) and secure audio, and limited forms of videotelephony.

Of course, data communications and some media integration are possible without ISDN. The logical integration of a PBX or Centrex system, providing voice channels, with a local-area network (LAN), carrying data and signaling information, can provide such capabilities. Private networks with ISDN capabilities may well be operating before public ISDN gets off the ground. The Lawrence Livermore National Laboratory in California, for example, plans to link 12 000 people among the 500 buildings in its complex with a $25 million network. Such bypass could delay a truly public ISDN.

Public ISDN's market viability has been questioned for these and other reasons. It may even turn out that an early demand for broadband data and video services, including HDTV in the residential market, could lead to BISDN leapfrogging ISDN, and being implemented first.

Switching intelligence

Network intelligence means software to define and control services and communications environments. Calls on an intelligent network are not merely connections between subscriber lines, but instead can take the form of inquiries, through a common channel signaling network, to databases with scripts of programmed services.

One example of an intelligent network service already exists. Each of the 4 billion toll-free "800" calls made in the United States each year is an inquiry to a database, which is translated into a telephone number. The number reached may depend on where the caller is, the time of day, and so on: during the day, a call to a credit-card company might reach the local service center; at night, when that office is closed, a call to the same number would be routed to a more distant 24-hour center.

In the future, instructions in the database may relate not only to the whereabouts of the caller and the called number, but also to each party's identity. The network might convey caller identity and provide special services based on programmed instructions. Personal identities rather than telephone numbers might be used. A call request would be screened and treatment given that has been specified by the called party. For example, the called party's identity might be translated into a destination number, depending on whether the called party is at home, at work, in a car, or at any other chosen place. Whether a call is forwarded, for example, from an empty office to a cellular telephone in a car may depend on whether the called party wants to hear from the caller. Reaching parties will become easier, but only if they want to be reached.

The intelligent-network concept also implies separation between such network elements as switches, signaling units, and media-conversion devices, and the high-level software that controls them. Such separation gives network-service designers great flexibility in configuring or reconfiguring a service, and allows customers themselves to change bandwidth, assigned numbers, and other parameters. Large corporate users will be able to set up their own private virtual networks within the public network, either replacing or complementing their private communications facilities. If the price is right, making intelligent-network capabilities available to corporations and other large establishments might further discourage bypass of the public network.

Just as computer-systems users can buy applications software from a number of competing makers, so operators of networks may mix and match the software that controls a network's elements. Software might include a multiparty conferencing package from one manufacturer, a package from another that defines a dialing-from-terminal service, and software from a third providing for data communications in a hybrid cable-television system. Development of software that creates network services may well become a highly competitive business, ending the era in which services are defined only in the software of large switching systems.

But making software-controlled network elements directly available to businesses outside the public network could have an even greater impact on the communications industry. The Federal Communications Commission ruled on a related issue in its June 1986 "Computer Inquiry III" decision. Addressing ways that "basic" and "enhanced" communications services should be separated, and who should offer them, the FCC said telephone companies may sell services such as message storage and protocol conversion, but only if the companies give other businesses access to the basic network capabilities with which they put those services together. Such open-network architecture will likely lead to a proliferation of vendors packaging and repackaging communications services, possibly threatening the operational integrity of the public network.

Broadening the band

Although ISDN cannot by itself carry high-quality video services, BISDN can do so. The realization of BISDN would mean a decisive break with the voice orientation that has characterized the telephone network for its first 100 years.

The basis for that transformation is lightwave-transmission technology, coupled with extremely high-speed switches, at first electronic and later, probably, photonic. In 1985 the voice-circuit capacity of the optical-fiber equipment operating in the United States matched the Bell System's entire 1980 transmission capacity (about 1.9 billion circuit-kilometers). By the end of 1987, fiber installed in the United States will total some 3.2 million kilometers. Long-haul fiber networks already criss-cross the country. Major long-distance lightwave carriers—AT&T, Lightnet, MCI, NTN, GTE Sprint, and the Bell operating companies—expect to have 3.06 million km of fiber in place by the end of the year.

Lightwave systems, almost exclusively digital in the telephone network, have become the most economical choice for carrying even moderately heavy communications traffic. Most internal trunk routes connecting switching offices are optical fiber, and telephone companies are now installing fiber circuits for loop carrier feeder lines that serve a number of subscribers. Fiber for individual subscriber lines still lies mostly in the future, and until it is commonplace subscribers will lack access to interactive broadband services. The present cost of installing optical-fiber connections to individual subscribers appears prohibitive, but the BISDN deployment strategy assumes costs decreasing over time. Large businesses will get broadband capabilities first, but will pay a relatively high monthly charge.

The telephone companies are presuming that, to justify the high installation costs, fiber-optic circuits must bring video-entertainment services as well as ordinary telephone calls and whatever new two-way services prove salable. Rather than the 35 to 50 video channels brought into the home simultaneously, as with present cable television, a subscriber might select two or three channels from a menu of possibilities, with switching done by the network. One pair of fibers could provide the switched broadcast channels, with a two-way, 150-Mb/s channel for interactive communications. And if network operators can reach an agreement with home-electronics manufacturers, subscribers will use the television's hand-held remote control to communicate with the network's video switch.

Fiber lines to the home would be economical if their cost—covering terminal electronics, cable trenches, and labor—were comparable to that of installing cable television and a telephone line: about $1500 a subscriber in capital outlay. And that is not an impossible goal: replacing existing cable-television and telephone lines by optical fibers could be driven by consumer demand for HDTV. The demand may well arise over the next 10 years with the introduction of high-definition videocassette recorders, television sets, and projection systems. With the right technological, economic, and regulatory mix, cable operators may, within 10 years, be providing services on a general-purpose public lightwave network.

It should, however, be noted that the Japanese Broadcasting System's HDTV studio standard, which is fast becoming a de facto standard in the United States and Japan, can be coded in a variety of analog and digital transmission formats for distribution by different media. When received and decoded, the coded signal will be degraded in varying degrees from the studio standard, but the recovered picture, with its 16 by 9 aspect ratio and higher resolution, is arguably HDTV.

Broadcasters in the United States and Japan are testing the analog multiple sub-Nyquist sampling-encoding transmission format, which requires about 1-1/2 normal television channels, and alternatives are under consideration. Cable operators are considering increased use of fiber in hybrid fiber-cable systems, as described later for British Telecom's broadband system, which could eliminate much of the noise and distortion problems of the tree-and-branch coaxial-cable system usual in the United States.

But high-speed digital transmission by fiber—recent work in video coding suggests that a picture approaching the studio standard could be conveyed at 100–150 Mb/s—appears to offer the highest-quality approximation to studio HDTV, and added possibilities for personalization of service.

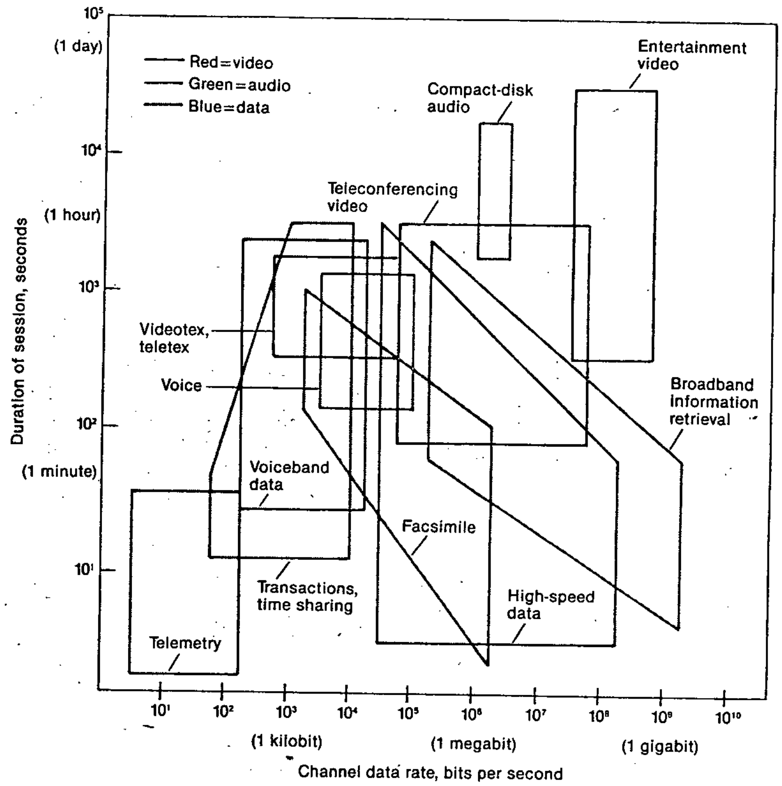
How BISDN will be implemented is being much discussed by the CCITT and by such national standards bodies as the Exchange

Carriers Standards Association in the United States. A 1984 proposal by Bell Communications Research has evolved into two widely-accepted standards for subscriber interfaces: 150 Mb/s for businesses, 600 Mb/s, including three downstream 150 Mb/s channels, for homes. Prototypes of very large-scale integrated cross-point switches for 150 Mb/s circuit-switched lines are being developed by, among others, AT&T Bell Laboratories and Bellcore in the United States, and Siemens and Standard Elektrik Lorenz in West Germany. New kinds of packet switches point the way toward a totally packetized, integrated transport network, which could handle all types of traffic, including HDTV.

Broadband LANs already exist, and are widely used to interconnect computers, printers, and other information devices. Researchers are experimenting with packetized voice and video communication on high-speed LANs.

Metropolitan area networks (MANs) could connect LANs and their equipment around a city. A typical MAN architecture would be a ring network, with packets of information traveling in circles, and gateways to LANs placed as nodes around the ring. A typical network would transmit at 50 Mb/s or more. A current question in broadband-communications development is how to integrate BISDN, a proposal largely of the telephone industry, and the MAN proposals, which are mostly from the computer community. There is no doubt, however, that BISDN will support MAN features.

Future BISDN services will fall into two main categories: dialog communications (such as interpersonal calls, messaging, and information retrieval) and distribution (mainly broadcasting, including two-way interaction). A closer look at future services reveals some of the promise and problems inherent in the system.



Different kinds of video traffic make different transmission-rate and holding-time demands on a network. The immense information content of entertainment video, especially high-definition television, will require expensive optical fiber lines to individual subscribers' homes. Large corporations will get video capabilities first, shouldering the initial cost of a broadband integrated-services digital network.

Adding services

Store-and-forward and real-time communications complement each other and allow calls to be completed that could not go through with real-time communications alone. Messaging is also important as a record communications medium. Facsimile is already a mass-market service, especially in Japan, where there are more than 1.5 million facsimile terminals. High-speed communicating copiers, information services, and color will become part of standard facsimile service.

Various telematics services will transmit text, data, photographs, drawings, and other materials, displacing much present-day movement of paper and magnetic media. Simultaneous use of multiple media will be essential for communications among individuals who want to share materials, just as in face-to-face meetings. Searching, filtering, composing, transforming, editing, and interpreting information will all be simplified and enhanced.

Dissimilar formats and terminals may well present problems, which are already being discussed by standards bodies. A CCITT study group, for example, is studying document architecture and methods for photographic compression and coding, especially the question of compatibility between hard copy—on paper—and soft reproduction—screen display.

Videotex even today provides telephone-network subscribers with a variety of services to their own terminals, including text and graphics display. But transmitting photographs, animation, and audio at the current rates of 1200 b/s or 2400 b/s is far from easy; the channels are just too narrow. As an example, a color photograph, even compressed, can contain 1 Mb of information: at 1200 b/s, transmission would take almost 15 minutes—at least one reason why the service has failed to take off in the United States.

In France, where a government experiment provided hundreds of thousands of people with Minitel terminals, more than 2.5 million users are now served by about 4800 independent providers. Electronic "chat" channels—a dating service—account for much of the connection time, suggesting that personal communications and socializing may be what most people want at home, rather than information services.

Apart from the French experiment, which is unique, information services may initially be directed toward business and professional users, in a quite different format from today's videotex, as in the following example:

A New York architect sits at her powerful workstation, using a mouse to move a pointer across the screen, which shows a floor diagram for a planned office building. Aided by a graphics-tools package, the architect moves walls, windows, and lighting layouts, considering alternatives. Deciding to consult with a colleague in the San Francisco office, she calls up her personal directory, which appears in a window on the screen, and selects his name, along with voice and screen applications.

"Hi, Lynn," he answers, glancing at the caller identity information on his screen. "What's up?"

"Can I see you, Harry?" she asks.

"Sure." Harry appears, playing-card size, in a corner of Lynn's screen.

As their conversation proceeds, Harry transmits a lighting-intensity formula and photographs of a similar conference-room design he has worked on. Looking at one small photo, Lynn drags her mouse across it, enlarging it to see more detail. Harry tells her she can order the fixtures from a lighting catalog.

When they hang up, Lynn calls up a copy of the catalog's recessed-fixtures section, browsing quickly through the pictures until she finds and zooms in on the fixtures she saw in Harry's room. Filling in an electronic order form, she charges the order *to her project and sends it out. She closes the catalog window, stores Harry's small conference room photograph and formula in her file, and goes back to her floor diagram, which once more fills most of her screen.*

The retrieving and sharing of information, particularly in visual media, is one of the most exciting possibilities. Progress in information systems and human interfaces, together with what is happening in transmission technologies, will be required for a scenario like the one above to become an everyday reality. The user interfaces will employ speech, graphics, and machine-intelligence technologies to keep the interactions simple and intuitive.

Physical media will also be important, especially a low-cost 5-1/4-inch compact disk—the CD ROM—with about 4 gigabits of read-only digital optical memory for frequently used and slowly changing information. Information that changes quickly, or material from scattered collections too vast to distribute by CD ROM, will be accessed by high-speed telecommunications. [See related articles on pp. 38 and 40.]

The major distribution service at present is video programming—movies, news, and sports, concerts and comedies, dramas and specials. The more than 7500 cable systems in the United States serve some 43 million subscribers and show that there is a strong consumer demand for wired delivery of broadband distribution services.

Response to offerings of such ancillary services as information and transactions, however, has not been encouraging. Home-shopping channels have done well, but are simply advertising coupled to instant ordering by telephone. Pay-per-view impulse buying of single movies and sports events is only just beginning to be offered.

BISDN would bring in a new era of broadcast entertainment, one that emphasizes personal choice. Pay television today offers all subscribers the same scheduled event, such as a showing of a popular movie like *Star Trek IV: The Voyage Home*. There is nothing now approaching video-on-demand, where viewers could choose any movie from a catalog and see it at any time. Even BISDN would be hard pressed to deliver movies precisely on demand: Chicago has 1 million households watching television on any evening; if each home had a dedicated 50 Mb/s channel to its chosen video supplier, the total transmission capacity for each to have its choice would be 5×10^{13} b/s (50 000 gigabits per second). A more realistic service would perhaps offer 500 movies for each two-hour period, which would require a relatively modest 25 Gb/s transmission capacity from video suppliers to distribution points. Popular movies would then be available to subscribers willing to wait an hour or so.

That would not, of course, rule out deferred delivery of individually chosen video material, such as college lectures. These could be ordered ahead of time by a subscriber and then downloaded by the supplier, at off-peak hours, to a videocassette recorder or other storage point for viewing later. Electronically accessed video libraries may become commonplace.

Reasonably priced digital video equipment, such as digital videocassette recorders and large-capacity optical-storage devices, would lead to new methods of delivering videodata. Some see great possibilities in video-compression coder-decoders, or codecs. With no compression, a normal television signal might encode into a 90 Mb/s data stream; with a 1.5 Mb/s codec, a full movie might be stored on CD ROM. RCA Laboratories recently announced an experimental asymmetric coding system that would allow inexpensive subscriber decoding of highly compressed digital video.

But custom transmission and storage can go beyond the simple delivery of a requested program: subscribers might be able to take personalized, multimedia electronic magazines full of news, entertainment, and other information. Work along those lines at Massachusetts Institute of Technology's Media Laboratory in Cambridge suggests that intelligent interpreters, programmed in the subscriber's equipment, could put together multimedia publications adapted to individual interests.

Others possibilities are personalized broadcasts of sports, entertainment, and professional programs. A viewer wanting background on a certain basketball player, for example, could call it up in an inset television-screen window right in the middle of the game. An engineer could pick one of several ongoing sessions at, say, a power-engineering conference, checking in on the other sessions from time to time through a screen window.

Field trials

HDTV may turn out to be the most important innovation resulting from BISDN. So far, however, field trials of custom video delivery, combined with various information services, have been very modest. Only about 200 000 cable subscribers in the United States are on interactive systems, allowing communication with the cable head end for pay-per-view ordering and other services. More subscribers may soon be found on hybrid systems, combining video distribution by cable television with interactive data communications through the telephone network.

While most CATV system trials have used coaxial cable, fiber was employed for the 1981 Elie-St. Eustache trial in Manitoba, Canada, conducted jointly by Manitoba Telephone System in Winnipeg, Northern Telecom, Mississauga, Ont., and the Canadian Department of Communications. Telephone, television, FM radio, and videotex services were provided to 150 homes, using analog video because of the high cost of digital transmission and coding.

In 1983–84, United Cable Television of Alameda, Calif., built a much larger fiber-delivery system. Based on the Times Fiber Co.'s Communications Mini-Hub switching office, from which subscribers can request one or two video channels at a time, the system offers impulse pay-per-view, videoconferencing, and two-way home shopping. Bell South's new system in Hunter's Creek, Fla., supplies video programming to 300 homes through light-emitting diode-driven multimode fiber, with separate copper wires for interactive data communications. This and other U.S. trials may evolve to end-to-end digital transmission in the next several years.

Most broadband trials have occurred not in North America, but in Europe and Japan. British Telecom's system in the Westminster district of London, set up in 1985, is based on a switched-star architecture. The star is a distribution point to which all programming comes, with spokes radiating out to subscribers. Subscribers request channels via data communications between subscriber and star. The system employs a combination of fiber (to the distribution star) and coaxial cable (to the subscriber) for analog video distribution. British Telecom believes that video on demand is a practical service, and will shortly test to some 40 subscribers an elaborate subscriber-controlled videodisk system for on-demand movies, with a response time of less than 30 seconds. The company is also considering video education and training services.

The French have shown considerable interest in such services as pay-per-view, home-video library, home shopping, video games, an on-line encyclopedia, and a wide variety of videotex graphic services, with field trials under way in Biarritz, Montpelier, and Rennes. The Biarritz network, opened in 1985, now serves 1200 homes and 300 businesses. Montpelier subscribers can reach, among other services, an archive of television programs. All three networks employ the switched-star architecture and, for now, analog video. Signaling occurs over a 2 Mb/s data-communications net linking all elements. The subscriber line provides either one or two video channels, a high-fidelity audio channel, a two-way 4800 b/s data channel, and an ISDN interface at either 72 or 144 kb/s.

In West Germany, telecommunications planners are pushing dialog services, especially videotelephony and teleconferencing, rather than home entertainment. An experimental bridge system developed by the Heinrich Hertz Institut in Berlin focuses on desktop teleconferencing. The bridge is a programmable signal combiner which provides specified mixes of video, audio, and graphics to each conference participant, with a zoom camera mounted next to the video screen to focus on documents as needed. The aim is to provide a continuous presence of all individuals (up to five at present) at a teleconference.

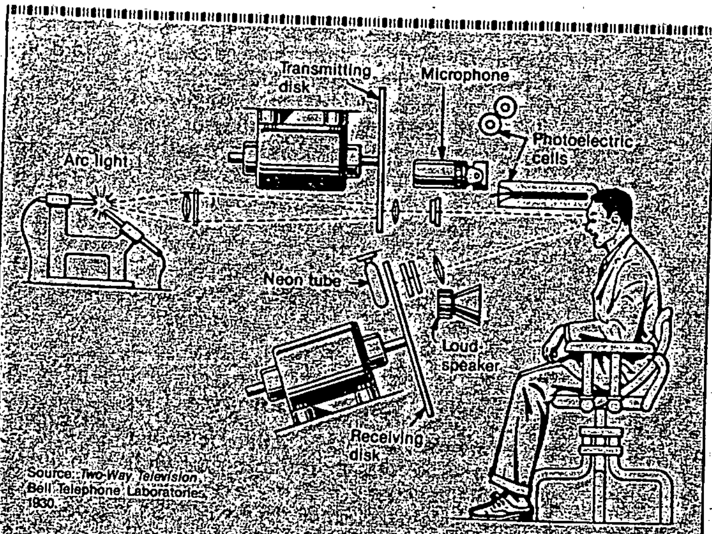
A new 13-city fiber overlay network linking commercial customers across West Germany is to use digital video throughout, with standard 140-Mb/s codecs supplied to teleconference rooms and subscribers. On routes still lacking 140-Mb/s fiber circuits, transmission will go over 2-Mb/s circuits, with transcoders to bridge the gap. German and Japanese telecommunications planners are also very interested in videophone services over 64 kb/s ISDN channels, at a lower quality level.

The Japanese may at present have the broadest services and experience. NTT started a videoconferencing service in 1984, and by the beginning of this year had 39 conference rooms on customer premises. Network access is by analog or 100-MHz digital transmission, with compression in the network itself to 6.3-Mb/s data streams. Also in 1984, NTT started trials of its information-network model system, linking central Tokyo with suburban Mitaka. Some 300 subscribers were tied into a 64-kb/s digital network, which was interwoven with a lightwave broadband network. Metal lines gave 88-kb/s digital access, and services included video distribution, videotelephony, telemonitoring, super-high-speed facsimile, and interactive video response.

Participants in the first tests had the service free. Municipal authorities broadcast city council meetings and issued certificates by high-speed facsimile; teleconferenced seminars took place between university campuses; and medical images sent over the wire aided long-distance diagnosis.

Last year NTT started a second trial of the service in another district of central Tokyo, with fully broadband fiber distribution. The company plans to extend a commercial INS service throughout Japan in stages, starting with ISDN B channels and working up, in 10 years or so, to 140-Mb/s high-definition television channels.

Communications networks must meet the popular expectations raised by advancing home and office communications, information, and entertainment systems. Lightwave, software, and television technologies are making this possible. Manufacturers have already made major investments, and the intelligent broadband network that was a dream only a few years ago has become a certain part of our future—no longer a matter of whether; just of when. Only the dates are left to be filled in as technical, regulatory, and economic questions are resolved.



Developed by Bell Laboratories, this 1930 picturephone, an early demonstration of two-way television, allowed a caller at the laboratory in New York City to speak with—and see—a colleague at AT&T headquarters two miles away. A reporter described that first experience with television:

Through the looking-glass

We saw two examples of television, radio and telephone in the last two days. We watched people wincing as they stepped up before a large camera to be televisioned. They winced as two powerful lights at their right and left hands were flashed in their faces, while the eye of the camera picked up their winces. This phase of television is now on a commercial basis.

Yesterday we saw a much more highly developed form of television demonstrated by the Bell Telephone Laboratories. It was two way television. We sat in a booth at No. 195 Broadway and conversed with Barbara Butler, a Daily Mirror reporter, who was in a booth at the Bell Laboratories, Washington and Bethune Streets. Each was visible to the other, there being no telephone mouthpiece to mar the image. The speech was very clear. An inoffensive blue light was shot across the face of the speaker from the camera's eye and picked up by other batteries around the booth. And yet this marvelous machine is still in the laboratory stage, according to the Bell engineers.—The Daily Mirror, April 10, 1930.

To probe further

Broadband communications, technologies, services, and trials are covered in the July 1986 and October 1987 issues of the *IEEE Journal on Selected Areas in Communications*; in two papers, "Broadband ISDN," by P.E. White, and "Switched-Star Networks," by W.K. Ritchie, in *Proceedings of the 1987 IEEE International Switching Symposium;* and in a series of articles to begin this month in *IEEE Communications Magazine*.

HDTV and other television-technology questions are addressed in an article, "The Evolution of Video Technologies," by H. Gaggioni, in the November issue of *IEEE Communications Magazine*, and in the paper, "Bit Rate Reduction in the Transmission of High-Definition Television Signals," by R. Kishimoto, N. Sakurai, and A. Ishikura, in the February issue of *SMPTE Journal*. The standards issues are described in the article, "Dubrovnik impasse puts high-definition TV on hold," by Joseph Roizen [*Spectrum*, September 1986, pp. 32–37].

Intelligent network concepts are described by Thomas Browne in his September 1986 *IEEE Proceedings* paper, "Network of the Future," and a proposed structure is outlined by Ronald Hass and Robert Humes in their "Intelligent Network/2," in the *Proceedings of the 1987 IEEE International Switching Symposium*.

Services and image technologies are addressed by Charles Judice and Didier Legall in "Telematic services and terminals: Are we ready?" in *IEEE Communications Magazine*, July 1987; ISDN is surveyed in the March 1986 and forthcoming 1987 issues. For a tutorial on ISDN, see "The universal data connection," by Sushil N. Pandhi [*Spectrum*, July 1987, pp. 31–37]. Cable television technologies and services are explained in the book, *Getting the Picture: A Guide to CATV and the New Electronic Medium*, by S.B. Weinstein, IEEE Press, New York, 1986.

About the author

Stephen B. Weinstein (F) is manager of the Network Services Research Division at Bell Communications Research in Morristown, N.J., investigating technical and behavioral questions of future communications services. He holds an M.S. from the University of Michigan in Ann Arbor, and a Ph.D. from the University of California, Berkeley, both in electrical engineering. ◆

The author is grateful to T. Kamae of NTT, M. Reuter of the Deutsche Bundespost, G. Romahn of the Heinrich Hertz Institut, J. Fox of British Telecom, and to many colleagues at Bell Communications Research for materials and valuable discussions.